Scientific Paper

Technological and socioeconomic diagnosis of the establishment of Psidium guajava *L. and* Teramnus labialis *in Ciego de Ávila, Cuba*

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ABSTRACT: In order to characterize the establishment of the polycrop of guava tree var. enana roja cubana and *Teramnus labialis*, a study was conducted during seven months, in 1,66 ha. All the investments in the area were monitored, as well as the agrotechnical activities and the costs of the system, which allowed to observe that: a) the agrotechnical activities performed on the guava tree were similar to the ones carried out on the fruit tree in the traditional system, and 12 % of the total work time was dedicated to the establishment of the legume; b) it is essential that there is water availability throughout the area, as well as 0,008 ha of seed bank of the legume to guarantee the planting in each diversified hectare; c) most of the work time is dedicated to irrigation, which can be combined with the manual control of weeds and the formation pruning of the fruit tree; d) the cost of the diversified hectare was approximately 26 000 CUP, from which 70 % was related to the acquisition of the guava seedlings and the irrigation system, while 28 %, to salary and fuel expenses. It is concluded that the guava-cover legume polycrop system differed little in agrotechnical management and in costs from the traditional system which is currently used to cultivate the guava tree in Cuba.

Keywords: sustainable agriculture, intercropping, fruit trees

INTRODUCTION

The popular use of guava (*Psidium guajava* L.) in the elaboration of products, such as nectar, juice, preserves, jams, fruit slices in syrup, foodstuffs for children, soft drinks, dairy products and bakery, turn it into one of the favorite fruits of thousands of millions of people throughout the world. Its world production is around 1,2 million tons, from which India and Pakistan contribute 50 %, Mexico 25 % and the rest is produced in other countries such as Colombia, Egypt and Brazil (Yam Tzec *et al*., 2010; Parra-Coronado, 2014).

In Cuba guava is considered among the fruit trees with great perspectives, reason for which many enterprises have promoted and developed its cultivation increasing its extension from the attainment and introduction of the variety enana roja cubana and its different cultivars and/or lines, which guarantee a high productive potential in this species (Anon, 2012).

In spite of the increases of the areas of this fruit tree, many factors have incidence at present on the decrease of its yield. Among them the incidence of pests (Rodríguez-Santana *et al*., 2016), the use of technologies which are not the most adequate for intensive production, stand out, along with the lack of knowledge and motivation for the production of the crop (Fornaris *et al*., 2011); as well as plant management violations, which bring about high infestation with weeds propitiated by an inefficient control strategy.

The elimination of weeds greatly increases the production cost of the guava crop, from the excessive resources that are allotted to the acquisition and disproportionate application of herbicides, because really the manual and mechanical control of the weeds is still insufficient (Gómez *et al*., 2003).

Other options are sought to decrease the indexes of incidence and affectation by weeds in the guava areas, because the indiscriminate use of soil tillage and agrochemicals have brought nefarious consequences, not only in Cuba (Gómez *et al*. 2003), but also in other regions of the planet (De Lacroix *et al*., 2010). They include specially: loss of the physical and chemical properties of the soil; development of pesticide-resistance, with fast multiplication of pest

organisms; serious losses of biological diversity; and environmental contamination.

The establishment of legume covers is a sustainable option which has allowed to counteract such effects in coconut ((Pérez-Carmenate *et al*., 1996) and citrus fruit crops (Pérez-Carmenate, 1998; Gutiérrez, 2003; Fontes, 2007).

From studies in guava tree plantations, Navia (2005) and Negrín (2007) reported that *Teramnus labialis*, among other herbaceous legumes, forms covers that reduce the presence of weeds in the plantations, besides contributing organic matter and nitrogen to the soil, for which they consider this species a viable alternative to recover the agroecosystems of the fruit tree in the Ciego de Ávila province. Nevertheless, such authors could not characterize from the technological and socioeconomic point of view the establishment stage of the polycrop, which constitutes the objective of this research.

MATERIALS AND METHODS

The study was conducted, during seven months, in 1,66 ha of guava tree and on a compacted Ferralitic Red soil (Hernández *et al*., 1999). Such area is located in the Research Station Dr. Juan Tomás Roig, belonging to the Center of Bioplants (in the Ciego de Ávila province, Cuba). For planting the guava tree var. enana roja cubana, the technical handbook for this variety (MINAGRI, 1985) was taken into consideration, while for planting the legume *T. labialis* the protocol described by Fontes (2007) was followed.

On the other hand, in order to perform the diagnosis in the establishment stage of the diversified system, all the investments in the area under study were monitored, as well as the agrotechnical activities carried out daily, on the guava plants and the cover legume.

The farm workers and managers who worked in the area were also interviewed; and the records of expense indicators in salary, energy and water were reviewed.

The following activities were monitored: harvest of the legume seeds in the bank, mechanized land preparation for the plantation of the guava seedlings, acquisition and planting of the seedlings, fertilization of the guava plants, acquisition and setting up of the sprinkler irrigation system, chemical and mechanized land preparation for planting the legume, seeding of the legume, formation pruning in the guava plants, pest and disease control, weed control during the establishment of the guava and the legume, and irrigation of the diversified area.

Likewise, the time used by the field workers in the different agrotechnical and investment activities was counted; and the salary expense was calculated, from the time used in each activity and the coefficient of salary earned by the worker.

The expenses in energy, specifically of fuel and electricity used in the land preparation activities and irrigation were also taken into consideration; as well as the expenses which were incurred for the purchase and setting up of the irrigation system, the purchase of the guava seedlings and the application of chemicals for the control of weeds, pests and diseases.

RESULTS AND DISCUSSION

Technological diagnosis

According to the results of the diagnosis, the soil preparation started in early May and included plowing up, harrowing and plowing. The guava seedlings were planted in early June, with a 4 x 2 m planting frame, taking advantage of the rainy season.

In early September the semi-stationary low-angle sprinkler irrigation system was installed and the herbaceous legume *T. labialis* was subsequently planted as cover of the guava area. For the planting the systemic herbicide Glyphosate, in dose of 5 $L.ha^{-1}$, was applied in the strip (between the guava rows). Ten days after the application the soil was prepared with multi-plow, in order to eliminate the dry grasses in the row and loosen the soil; furrows were later made without passing the harrow. The planting was done by the drilling method, with a density of 4 kg of seed per hectare, for which a small seed bank of 0,008 ha with sprinkler irrigation was needed.

The weed control in the guava row was done with an application of Glyphosate, in dose of 3 Lha^{-1}, and for the control of the grasses between plants Leopard was used at a rate of 1,5 L ha^{-1}, twice; which allowed the successful establishment of the legume in a period of five months (Hernández, 2013), lower than the one needed by this same plant (six months) to become established in citrus fruit plantations (Fontes, 2007). Manual weed control was also carried out twice, between the guava plants as well as between the rows where the legume was established, activity that was sometimes combined with the irrigation of the area.

The guava plants were fertilized with full formula at a rate of 180 kg ha^{-1} in two applications. A leaf beetle outbreak occurred in guava, which was identified by Lucielle (2013) and controlled with DECIS in doses of 2 L ha^{-1}.

During the whole establishment period of the guava tree, which was achieved six months after planting, when the plants reached the indicated size to produce (MINAGRI, 1985), formation prunings of the trees were made, eliminating the sprouts after the fourth pair of leaves. This activity was generally combined with the irrigation of the plantation.

Socioeconomic diagnosis

Table 1 shows the hours worked in the diversified plantation of guava tree. The highest amount of time (around 50 %) was dedicated to the change of the irrigation laterals, activity that the field workers alternated with manual weed control and the formation pruning of the tree. Such tasks are habitually performed on the guava tree monocrop too.

The time dedicated to the planting and establishment of the legume was 160 hours, that is, twenty working days of eight hours of work, which represented 12 % of the total work time in the planting.

Tables 2 and 3 show the input and energy carriers used in the establishment of one hectare of the diversified system. It was found that with a minimum amount of herbicide, insecticide, fertilizer, fuel and electrical energy consumed in the irrigation, the diversified system can be established. The highest quantity of herbicides (76 %) was applied to achieve success in

Table 1. Time in the different activities during the establishment of the diversified guava tree with legume.

Concept	Hours worked	Percentage of the total
Seed harvest of the legume	24	2
Mechanized land preparation	31	2
Planting of the guava trees	36	3
Fertilization of the guava trees	10	1
Acquisition and setting up of the irrigation system	82	6
Chemical and mechanized land preparation	24	2
Planting of the legume	39	3
Formation pruning	96	7
Insecticide application	10	1
Manual weed control in the guava trees	248	18
Mechanized weed control in the guava trees	12	1
Chemical weed control in the guava trees	10	1
Chemical weed control in the legume	77	6
Irrigation	304	22
Irrigation plus formation pruning in the guava trees	202	14
Irrigation plus manual weed control in the guava trees	195	14
Total	1 399	100

Table 2. Inputs in the establishment of the diversified system.

Concept	Glyphosate (L)	Leopard (L)	Insecticide (L)	Fertilizer (t)
Fertilization of the guava trees	-	-	-	0,18
Chemical and mechanized land preparation in the legume	5	-	-	-
Insecticide application	-	-	2	-
Chemical weed control in the guava trees	3	-	-	-
Chemical weed control in the legume	-	4,5	-	-
Total	8	4,5	2	0,18

Table 3. Energy carriers used in the establishment stage.

Concept	Fuel (L)	Electrical energy (kW)
Mechanized land preparation in the guava trees	118	-
Planting of the guava tree	19	-
Acquisition and setting up of the irrigation system	14	-
Chemical and mechanized land preparation in the legume	10	-
Mechanized weed control in the guava trees	23	-
Irrigation	-	2 696
Irrigation plus formation pruning in the guava trees	-	1 797
Irrigation plus manual weed control in the guava trees	-	1 733
Total	184	6 227

the planting and establishment of the legume; however, once the cover was established these products were not needed, because one of the functions of legumes in this system is weed control (Navia, 2005; Negrín, 2007).

The fuel used in the agrotechnical activities to establish the legume represented only 5 % of the total fuel spent in the system (table 3). On the other hand, the total electrical energy was consumed in the irrigation of the area, which guaranteed that the water was also used by the cover legume.

In localized irrigation technologies, which are sometimes used for guava trees in monocrop (MINAGRI, 1985) as well as associated to other fruit trees (Fornaris *et al*., 2011), the water is only supplied to the tree, for which the area between rows and between plants cannot be used in the polycropping. This irrigation system, in spite of representing water saving for the monocrop, constitutes irrational use of 75 % of the land that could be dedicated to polycropping, with a planting frame of the fruit tree of 2 x 4 m, like the one used in this work.

When doing an economic appraisal (table 4) of the establishment of the diversified system, from

Table 4. Costs during the establishment of the diversified guava tree area.

Concept	Expense	
	$	**%**
Seed harvest of the legume	45,78	0,18
Mechanized land preparation in the guava trees	2 980,66	11,57
Planting of the guava trees	13 030,87	50,59
Fertilization of the guava trees	160,84	0,62
Acquisition and setting up of the irrigation system	5 719,49	22,20
Chemical and mechanized land preparation in the legume	289,09	1,12
Planting of the legume	73,25	0,28
Formation pruning	183,13	0,71
Insecticide application	77,27	0,30
Manual weed control in the guava trees	471,57	1,83
Mechanized weed control in the guava trees	604,37	2,35
Chemical weed control in the guava trees	21,16	0,08
Chemical weed control in the legume	207,80	0,81
Irrigation	819,52	3,18
Irrigation plus formation pruning in the guava trees	546,34	2,12
Irrigation plus manual weed control in the guava trees	526,83	2,05
Total	25 757,98	100

the unitary costs of salary, inputs and energy carriers (table 5), it was proven that the establishment cost of one hectare of the fruit tree diversified with legume was approximately $ 25 700 CUP from which 50 and 20 % were related to the planting of the guava tree and the irrigation system, respectively, expenses which are also essential in the monocrop (table 6).

On the other hand, the expenses related to the planting and establishment of the legume represented less than 3 % of the total costs and around 10 % of the costs when the expenses referred to the irrigation system and the guava tree planting are excluded.

The results showed that it is economically feasible to diversify the guava tree cultivation with the legume *T. labialis*, under the conditions of Ciego de Ávila and other regions of the country, which is in agreement with the economic dimension to achieve sustainable agriculture (González *et al*., 2016).

Other works indicate the reconversion of fruit tree monocrop areas in the province to associations of guava and citrus fruit trees with beans, cassava and watermelon; and report that the sustainable food production without affecting the environment is a challenge for the contemporary society, which forces to transform the conventional systems of agricultural exploitation to agroecological systems in the productive forms (Hernández *et al*., 2013).

CONCLUSIONS

The guava-legume polycropping cover system differed little in the agrotechnical activities as well as the costs, from the traditional system which is currently used to cultivate the guava tree in Cuba.

The establishment of the diversified system was achieved with a total cost of approximately 26 000 CUP, within which the purchase of the irrigation system and the guava seedlings represented about 70 % of the expenses incurred.

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Table 5. Unitary prices per different expense concepts.

Concept	Measure unit	Price ($)
Operator salary	monthly	395
Field worker salary	monthly	395
Electrical energy (irrigation)	kW	0,80
Fuel (oil)	liter	24,75*
Fertilizer (full formula)	t	791,81
Insecticide (DECIS)	l	29,48
Herbicide (Glyphosate)	t	4 321,36
Herbicide (Agil)	l	24,92
Herbicide (Leopard)	t	11 343,11

* Converted value from CUC to CUP at a rate of 1 CUC = 25 CUP

Table 6. Investment on the diversified hectare of guava trees.

Concept	Characteristic	Quantity	Price ($)	Expense ($)
Seedlings	Planting distance 4 x 2 m	1 250	10	12 500
Irrigation system	Semi-stationary	1	5 206	5 206
Total				17 706

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