



Agroecology applied to coconut agroecosystems (*Coco nucifera* L.) in Baracoa, Guantánamo, Cuba

La Agroecología aplicada a los agroecosistemas cocoteros (*Cocos nucifera* L.) en Baracoa, Guantánamo, Cuba

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ABSTRACT: The work consisted of a retrospective review of the production of coconut nuts (*Cocos nucifera* L.) in Baracoa, the most productive locality of coconut palms in the country and the integral functioning of the agroecosystems dedicated to this crop. A historical analysis was made of the causes of the advances and setbacks that occurred in its annual productions and from the results of the review of written information and surveys carried out on a representative sample of actors, facilitators, decision-makers and people knowledgeable about the crop and the locality, the problems that currently limit the productivity of its Agroecosystems were briefly recorded. A participatory assessment of the current state of the plantations is made and some considerations are provided for their restoration. It concludes with a proposal that can contribute to visualizing the problems and actions to be carried out, to raise the quality of life of the population, the resilience of agroecosystems, productive diversification, and marketing of productions and the care of natural resources as a basis for environmental protection. It is suggested that a participatory research be carried out to strengthen the path to the prospective sustainable development of coconut trees in Cuba, under agroecological principles.

Key words: Sustainability, resilience, agrobiodiversity, multiple crops, environment.

RESUMEN: El trabajo consistió en una revisión retrospectiva de la producción de nueces de coco (*Cocos nucifera* L.) en Baracoa, localidad más productiva de cocoteros del país y el funcionamiento integral de los agroecosistemas dedicados a este cultivo. Se hizo un análisis histórico de las causas de los avances y retrocesos ocurridos en sus producciones anuales y, a partir de los resultados de la revisión de la información escrita y las encuestas realizadas en una muestra representativa de actores, facilitadores, decisores y personas conocedoras del cultivo y la localidad, se registró de forma resumida los problemas que actualmente limitan la productividad de esos agroecosistemas. Se hace una valoración participativa del estado actual de las plantaciones y se brindan algunas consideraciones para su restauración. Se concluye con una propuesta que puede contribuir a visualizar los problemas y las acciones a realizar para elevar la calidad de vida de la población, la capacidad de resiliencia de los agroecosistemas, la diversificación productiva, la comercialización de las producciones y el cuidado de los recursos naturales como base para la protección medioambiental. Se sugiere la realización de una investigación participativa que fortalezca el camino al desarrollo sostenible prospectivo del cocotero en Baracoa, bajo principios agroecológicos.

Palabras clave: Sostenibilidad, resiliencia, agrobiodiversidad, cultivos, medio ambiente.

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INTRODUCTION

The coconut palm (*C. nucifera* L.) is considered one of the most important and useful crops among tropical palms. Its production supports millions of people in the world and it is cultivated in more than 80 countries in the tropics (1). The main producing countries are Indonesia, Philippines, India and Brazil, which contribute 78.7 % of world production, corresponding to 61.5 million tons, with an average yield of 5 t ha⁻¹ of nuts (2).

This species, established in Cuba as a crop in the 18th century, has spread throughout the country. It is typical of the environment of farm houses created during the first half of the 20th century, although the largest areas of this crop are located in Baracoa, responsible for more than 80 % of the national production of dry coconut (nut), there are also plantations in Niquero and Pílon (Granma), Villa Clara, Holguín and Pinar del Río (3).

This crop has gone through fruitful and unsuccessful periods due to different factors. Although its greatest productive splendor is located in the middle of the XIX century, the productive record of coconut nuts in Baracoa locality occurred in 1990, with a production of 27,600 tons (4), after that, it has not been possible to reach that production.

Factors that have influenced the gradual decrease in the yield of nuts have been associated to: aging of plantations, scarce renovations, sanitary affectations, severe meteorological events and above all, the lack of an appropriate technology to the current circumstances, where agroecosystems require productive sustainability with socio-cultural respect and environmental protection, strengthening the capacity of resilience and adaptation to climate change (5).

This problem requires a comprehensive review of coconut agroecosystems, from a retrospective viewpoint, to determine the current status of the three main dimensions of sustainability and to provide the necessary information for the development of a participatory restoration proposal based on agroecological principles and in accordance with the Systems Trajectory methodology (6).

SCIENTIFIC BASIS OF THE REVIEW MADE

The agrarian sector of Baracoa, the most important coconut growing locality in Cuba, is going through a period of integral restoration whose purpose is to sustainably increase the productivity of coconut plantations. For this, it is necessary to know the problems that limit the reach of this objective, which requires the use of efficient scientific methods, in correspondence with the most innovative current trends.

In principle, Agroecology is the science called upon to provide solutions to local problems in developing countries

(7) because of its systemic and dialectical approach, directing its actions to the solution of problems from the three main dimensions of sustainability (8-11).

On the other hand, the Systems Trajectory methodology considers as key elements of the systemic approach, the transformation over time of the structure of the system and the evolutions of its purposes, goals or objectives in the long term, given the random changes that occur in response to the evolution of the environment, agricultural policies or unexpected natural events, among others (12).

For the purposes of this review, the main premises were outlined, framed in the following objective needs: (i) the need to increase the quality of life of the local inhabitants (ii) the restoration of agroecosystem and main crop productivity and (iii) the protection of natural resources for greater resilience of local agroecosystems, in accordance with agroecological precepts (13).

The ultimate purpose is to improve the economic, ecological and social sustainability of agroecosystems, with a proposed management system in correspondence with the local resource base and with an operational structure in accordance with existing environmental and socioeconomic conditions (14).

To achieve this, it is necessary to approach the problem from a retrospective analysis in order to elaborate a prospective development proposal towards sustainability.

REFERENCES ABOUT COCONUT CULTIVATION AND ITS TRAJECTORY IN CUBA

The coconut tree, known as "The tree of life", seems to have had a double introduction in Cuba; one, directly by large landowners from the West of the country and another, which points to its natural introduction in Baracoa, through the sea currents from Hispaniola or directly from West Africa (15). Its presence in the coat of arms of Baracoa city granted by Royal Order in 1838, presupposes its local economic importance, since the end of the XVIII century. The accelerated development and economic rooting of this crop in Baracoa territory, which comes from an ancestral culture on its use, induces the inhabitants of the locality to the conservation of the traditions of its consumption, both in natural and processed form.

The versatility of the utilitarian values of the edible and inedible part of the coconut, places it without a doubt among the fruit species of special demand on an international scale, which is understandable by its utilitarian values and richness of its chemical composition (16).

But the most important product of its processing is the oil¹, which is obtained in an artisanal way and an appetizing doughnut called "Cucurucho"², very consumed by natives and foreigners. The cake or residual flour is used for human and animal feed.

¹According to the actors interviewed, to elaborate the cone called "cucurucho" the fresh coconut mass is grated, wrapped in long cloths and hot water is added, it is squeezed hard and a "coconut milk" is obtained that is put to cook and little by little, it loses the water, changes color and what remains is oil. When hot, it is deodorized in various ways to eliminate strong odors.

However, this crop has suffered several affectations that have interrupted its sustainability over time. The documentation preserved in the archives of the Library of Baracoa, describes that at the end of 1870 the "Lethal Yellowing" disease of the coconut tree occurred, which caused economic losses amounting to a third of its total production. It is a devastating disease of the crop that was studied and defined by Fermín Valdez Domínguez in 1890), member of a team of scientists of the time, led by Dr. Carlos de la Torre y Huerta who reported to the Academy of Sciences, the results of the research conducted on this pest and that was published in the newspaper El País, in 1891.

Other major damage has been caused by meteorological events, causing severe damage to the crop. The last destructive hurricane, which occurred in October 2016, caused significant losses of coconut plantations that demanded immediate restoration, establishing new plantations throughout the locality, as well as the development of an investment process by the Cuban State. This materialized in the acquisition of several industries to strengthen the production chain, such as: (i) coconut shredding for the use of shell "carapazón" to obtain substrates, (ii) long and short vegetable fibers, (iii) activated carbon industry (obtained from the shell of the fruit); oil extraction factory for human consumption and for light industry (soap - cosmetics) and (iv) factory for the production and marketing of various sweets (4).

The environmental, economic and social impact of the establishment of these industries has become visible; however, their sustainability will only be possible if the principles of agroecology are harmoniously established in coconut agroecosystems, with the application of scientific knowledge and respect for highly efficient ancestral techniques, sustained by local farmers, as part of participatory action for development. This aspiration requires research still to be carried out (18).

ROLE OF BIODIVERSITY S INUSTAINABLE AGROECOLOGICAL SYSTEMS

Agrobiodiversity includes functional and associated diversity (19), which is part of biological diversity and takes into account all living beings, including the genes that give rise to new species (20).

Agrobiodiversity is the fundamental principle of Agroecology and as part of the complexity that guarantees, in addition to human and animal nutrition, environmental protection, (22) something that was also advocated as the

basis of a productive strategy strongly linked to food sovereignty (23).

In principle, coconut plantations have been developed in Baracoa under the principles of high-input agriculture, that is, in monoculture. However, the impossibility of maintaining spaces totally free of weeds due to lack of labor force, prevents monoculture, per se, by generating at the same time, certain levels of biomass of different species and composition that balance the agroecosystem. On the other hand, the diversity of microorganisms is more diversified the greater the diversity of plant species; they also demonstrated that each species of weeds, depending on the type, hosts in its roots an unusual diversity of microorganisms (24).

To promote the increase of species diversity in agroecosystems, an Agrobiodiversity Index (ADI) has been proposed, based on the enrichment of four groups or sub-indices according to their function in the agroecosystem. Its use in practice has contributed to the diversification of agroecosystems (25).

Diversified agricultural systems develop ecological properties that increase their capacity for self-regulation and the possibilities of maintaining equilibrium due to the multiple relationships between their components (26). The set of all living organisms that exist in the agroecosystem constitutes the basis for sustaining life on the planet (27, 28).

BIODIVERSITY OF COCONUT SPECIES *C. NUCÍFERA* (L.). EXISTING COCONUT GERMPLASM IN BARACOA

This crop has a rich diversity within the species *C. nucifera*, (L.). In terms of genotypic characteristics, two types are recognized, the wild "niu kafa" and the domesticated type "niu vai", distributed in America on the Atlantic and Pacific coasts (29).

In the region of Baracoa - Maisí, until almost a decade ago, there was a great diversity of coconut tree types left over from the cultivation of the so-called creole coconut and also by genetic materials introduced from producing areas in Central America and the Caribbean. In these introductions there were tall and dwarf, red, green, yellow and copper coconut trees; whose multiplication of these types, caused their free growth, obtaining a great variability of types and colors, and forms, among which the "Inmune" and the so-called Indio Verde 1 were distinguished. Of the latter, a seed mass was identified, evaluated and certified (30).

²Locals report that the dough for the cone is obtained by cooking a mixture of water, grated fresh coconut, sweetened with sugar and/or honey, salt, lemon peel and generally different fruits are added (pineapple, guava, papaya, orange and others), giving it different and exquisite flavors. This dough is stirred so that it does not stick to the casserole. Previously, a cone (cone) has been made from cuttings of the fibrous tissues from the wood of the royal palm "yagua", it is filled with the mixture and covered with these cuttings and tied in a typical way that offers security and original beauty. Other products, very appreciated in large national and international markets is the "Shredded Coconut in Syrup" in addition to other diverse coconut sweets, more handmade and of local consumption, including the Coconut Nougat. These activities constitute today the source of employment and economic sustenance of an important part of Baracoa population and has a wide demand on the part of practitioners of the Yoruba religion of the whole country, in diverse ceremonies of religious cut. All this is closely linked to the identity of the Baracoa's people.

The "domesticated type" coconut palm, disseminated through human selection, planting and dispersal, contributed to the genetic flow between different populations. This high diversity obtained has provided high resilience to the crop, against negative causal agents, and has allowed its survival even in the presence of the Lethal Yellowing disease (31-33), a disease endemic to the Caribbean and present in Cuba for more than 150 years. Part of this identified and evaluated diversity could have been affected after the 2016 hurricane. Therefore, it will be necessary to recover as much as possible of this existing diversity, identify it, protect it and use it appropriately in the new projection of the crop. Similarly, the establishment of a varietal policy that responds to the interests of internal and external marketing and to the solution of traditional problems of preferences and needs of local families.

CROP ASSOCIATION IN THE COCONUT GROVE IN BARACOA

The association of crops without interspecific competition, constitutes a type of efficient and sustainable productive system, diversified and with greater protection of the biodiversity of food options or of spiritual satisfaction (34); therefore, better results must be expected in a system of association than a monoculture, as long as they are conveniently combined in space and time following the principles advocated on the rotation of crops, in order not to exhaust the basic elements of the main crop (17).

To evaluate the efficiency of polycultures, a simple formula was used (35) that establishes a relation of monocultural vs. associated production, so that the sum of the relations will be consistent if they exceed the value of the unit. For associations larger than two crops, it is evaluated in the same way by adding the values of the ratio of the crops involved in the association. In the same way, the Competition Rate (CT) was used, which defines which of the crops should benefit more from the total space, according to economic interests.

However, the most important aspect of the association is the integral effect of all its benefits beyond the partial economic analysis without considering the valuable contributions of the association from the ecological and environmental point of view (36).

Regarding the use of associated crops and their agroecological importance, facilitators, decision-makers and actors with a lot of experience due to their years of work in the locality, point out that there are manifestations of the use of this ancestral technique in Baracoa. However, very little has been written about it and even less research has been carried out to obtain precise information due to the lack of research on the use of agroecological techniques (16).

The actors in the Baracoa locality state that the most repeated associations among those who practice it are: (i) coconut-cocoa (*T. cacao*); (ii) coconut-plantain (*Musa* spp); (iii) coconut-fruit trees, such as citrus (*Citrus* spp.) and guava (*P. guajaba* L).

The coconut-citrus association has to highlight its economic and technical repercussion, since, at the beginning of this century, grapefruit and coconut trees were harvested in areas certified internationally with the Bio Swiss Seal as Organic and later successfully commercialized in Switzerland (37).

The most popular associations are related to the use of short-cycle crops such as yams (*Dioscorea rajania* L.); cassava (*Manihot sculenta* (L.)), sweet potatoes (*Ipomoea batata* L.) and grains, mainly beans (*Phaseolus vulgaris* L.), whose main objective is to ensure family self-support and also for local sale.

A production modality widely used in Baracoa is the use of animals in interspecific coexistence after the productive stability of the crop, which occurs after 8 years of its establishment. However, there is no study that shows which of the associations are the most convenient, consistent and opportune from the economic, ecological and socio-cultural point of view (38, 39)

Some leguminous plants, such as glycine, tropical kudzu and centrosema are well represented in the agroecosystems of Baracoa for their exploitation in soil management and their productive diversification by associating animal husbandry within coconut plantations (15).

One of the strongest alternatives for any agroecosystem is the bees. They are considered pollinators par excellence, they are highly efficient, they visit only one type of flower in each trip and in a single day they can visit thousands of flowers of the same type. They favor biodiversity through cross-pollination (40).

It would be very convenient to evaluate in depth the establishment of apiaries in the context of coconut plantations and they could be more efficient even when we are talking about coconut plantations with other crops. The non-use of chemical products for pest and weed control is an ideal scenario for bee survival. This new design, with a future scope towards sustainability, justifies taking into account the possibility of establishing honeybee apiaries, which can be very effective for the pollination of coconut trees and other transitory crops within the associations.

INTERSPECIFIC RELATIONSHIPS WITH WEEDS

Weeds, or species that grow in crops, proliferate in the coconut agroecosystems of Baracoa, in high frequency and abundance. When these species are not managed opportunely, in the initial phase of their growth and development, there are losses in the productive capacity of crops, due to the interspecific competition that occurs in the period preceding the beginning of their fruiting (41).

According to the opinion of Baracoa locality actors, in the coconut plantations proliferates a high diversity of species of weeds that have not been classified. Nor have any references been found of studies carried out to evaluate their damage in the relationships of coexistence with coconut plantations. However, the presence of weeds in

coconut agroecosystems contributes to increase the natural ecological balance that is generated, given the multiple interactions that occur, generally beneficial (42).

The most significant fact of analysis is that weeds only manifest a direct effect on the crop when they surpass the threshold of the critical period of interference (43); therefore, their total elimination from the sowings causes negative effects in the ecological balance.

In general in Baracoa, according to the opinion of the local actors, coconut trees are managed in accordance with the requirements of agroecological principles; manual cleanings are carried out with mowing to regulate the population of weeds without elimination and combined with the cover and the living cover, which at the same time play an important role in the protection of the soil before the direct impact of the rains and the conservation of the humidity of the soil and with it avoids its degradation.

The essential thing is to regulate weeds to avoid economic and environmental damage (43). Sometimes in perennial crops, by a process of species succession, native leguminous species appear and develop, as happened in Mexico with the species *Ipomoea tiliacea* Willd. Choisy was established in a plantation of Rambutan (*Nephelium lappaceum* (L.) to play a soil protectionist role, as a protective living cover against weeds (44).

PROSPECTS BASED ON THE REVIEW CONDUCTED

The importance of this review of coconut cultivation in Baracoa lies in its systemic approach. It is intended to channel the actions of those involved in agricultural production towards a closer approach to agroecological sustainability, based fundamentally on agrobiodiversity, in order to increase the productive efficiency of the coconut tree and the resilience of the agroecosystem. Raise the quality of life of local stakeholders, for which it will be necessary to develop the locality with a multidisciplinary approach (16).

From special connotation would be to open new job options, where young people and women have a praiseworthy space and can make use of their experience and creativity, improve the environment, radiating the joy that imprints the youth and female presence in the productive processes. It is proposed:

- a. The elaboration and implementation of comprehensive short courses (theoretical-practical), on Agroecology and coconut trees, for decision-makers, actors and facilitators of all communities with the participation of local and external Professors.
- b. Use of the agricultural space of coconut trees over time. Use of crops and animals associated with coconut trees with high use value that do not damage the main crop, according to local experience. Produce food based on Food Sovereignty and utilitarian values of the food composition of the production (Forming, Energetic and Regulating).
- c. Conservation of biomass residues without burning them, avoiding tree felling, protection of aquifers, soil protection measures, innovating unproductive agricultural techniques and establishing the maximum possible plant and animal biodiversity in each Agroecosystem, including bees.
- d. Creation of a novel and functional guide that protects the quality of life of the Actor and his family: strengthen the productive chain, with the processing of diverse residues as an added value to coconut production, promote the confection of new and old marketable foods, introduce precedent results, stimulate artistic creativity; create comfortable housing and pleasant and diverse environments, communication routes, and attention to their demands, work implements, recreation, gender equity, promote innovation and gender equity. To attend to youth and their creativity and to inculcate among them ethical values and human solidarity.

CONCLUSIONS

- Updated information is provided on the state of the art of coconut nut production in Baracoa municipality, Guantánamo province.
- The current level of complexity of coconut tree cultivation and its local agroecosystems is described, from the three main dimensions of sustainability and the vision of the actors, decision makers and facilitators who lead them.
- A prospective development proposal is made based on agroecological principles in favor of a closer approach to sustainability.

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