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Review
PROPAGATION AT NURSERY OF *Cocos nucifera* L. STUDY CASE: BARACOA

Reseña bibliográfica
Propagación en vivero de *Cocos nucifera* L. Caso de estudio: Baracoa

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ABSTRACT. The coconut tree (*Cocos nucifera* L) it is one of the most important and useful cultivations among the tropical palms, it is propagated fundamentally through the seed; however it is very little, dispersed and varied the information about them. With the objective of carrying out a revision of concepts related with the coconut tree and their propagation in nursery, it was carried out the present work that picks up essential aspects of the coconut palm, their taxonomy and the process of seed´s germination, the state of the art on the gamic propagation of this crop and it is deepened in the current situation of the municipality Baracoa, Cuba, where 85 % of the national production is obtained. It is concludes that the knowledge of the methods of propagation of the cultivation of the coconut tree will allow a better handling of the same one in the nursery stage, and that they are diverse the opinions on the plantation distance and the mineral fertilization to use in its propagation, as well as the quality of the plant to be transplanted to field.

Key words: coconut, germination, seed, substrate, sowing

RESUMEN. El cocotero (*Cocos nucifera* L) es uno de los cultivos más importantes y útiles entre las palmas tropicales, el mismo se propaga fundamentalmente a través de la semilla; sin embargo, es muy poca, dispersa y variada la información que se ofrece. Con el objetivo de realizar una revisión de conceptos relacionados con el cocotero y su propagación en vivero, se realizó el presente trabajo, que recoge aspectos esenciales de la palma de coco, su taxonomía y el proceso de germinación de la semilla, el estado del arte sobre la propagación gámica de este cultivo y se profundiza en la situación actual del municipio Baracoa, Cuba, donde se obtiene el 85 % de la producción nacional. Se concluye que el conocimiento de los métodos de propagación del cultivo del cocotero permitirá un mejor manejo del mismo en la etapa de vivero y que son diversas las opiniones sobre la distancia de plantación y la fertilización mineral a emplear en su propagación, así como la calidad de la planta para ser trasplantada a campo.

Palabras clave: cocotero, germinación, semilla, sustrato, siembra

INTRODUCTION

The coconut tree (*Cocos nucifera* L.) is considered one of the most important and useful crops among tropical palms. It has significant applications in the field of medicine, as a natural antioxidant, antidiabetic, antiparasitic, and antimicrobial, anti-inflammatory and in the treatment of diseases such as leishmaniasis and malaria (1). The oil is used in the industrial production of cosmetics, explosives, biofuels, as well as products for health and well-being. Milk, vinegar, honey and wood are also obtained from this plant, as well as coconut water, which is an isotonic drink. All these uses make the coconut tree a unique plant, which has allowed it to be called "the tree of 100 uses" (2).

This crop provides the livelihoods of billions of people throughout the world and is grown in more than 80 countries in the tropics. India, Indonesia, the Philippines and Brazil are the main producing countries, contributing 76.48 % of world production in an area of 9 060 079 million hectares (3).

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The production of coconut in the year 2016 was 59 010 635 tons, with an average yield of 5 t ha^{-1} (3).

In Cuba, this species has spread throughout the country, although the largest traditional areas of cultivation have been located in Baracoa (Guantánamo), Niquero and Pilón (Granma), as well as in several municipalities of Holguín, Pinar del Río and Sancti Spíritus. (4).

The municipality of Baracoa is responsible for 85% of the national production of coconut (5), to which 32.12% (9 427.91 ha) of the agricultural area are dedicated. After the passage of Hurricane Mattew, in October 2016, 9 307.91 ha of the crop were affected (6), so it is very important to produce quality postures that guarantee the necessary material for the renovation and the promotion of new areas.

The quality of the plant is defined as the ability of individuals to adapt and develop in the climatic and edaphic conditions of the place where they are established and it is determined not only by the genetic characteristics, but also by the techniques used for their propagation (7)

The most extensive studies carried out on coconut tree nurseries in the world, date from the period between the first half to the 90s of the last century. Between the most recurrent subjects in the last stage of that period are, the use of the substrata, the germination of improved varieties and the salinity (8).

In Cuba, there are few published agricultural research results on nursery management for this crop. The research carried out in nurseries in the Granma province on the use of the filter cake (9) and an article on the effect of Azotobacter on the germination of seeds (10) constitute the first results carried out under the Cuban conditions, which have been published. In addition, there are three technical instructions that offer very general information that coincides with international research, without taking into account the specific socio-economic and socio-economic conditions of the Cuban producer, which indicates the need to generate scientific information that serves as a basis for making efficient management proposals for the production of quality postures in this crop in Cuba.

In the present work, a review was made of aspects related to the coconut tree and its propagation in nursery with emphasis on the management used in the municipality of Baracoa.

DEVELOPMENT

Coconut cultivation

The coconut palm (*Cocos nucifera* L.) is a tropical perennial crop, which grows in around 80 countries. It belongs to the family Arecaceae and is the only species of the genus Cocos, whose botanical classification is as follows: Kingdom: Plantae, Subreino: Tracheobionta, Superdivision: Spermatophyta Division: Magnoliophyta, Class: Liliopsida, Subclass: Commelinidae Order: Arecales Family: Arecaceae, Subfamily: Arecoideae, Tribe: Cocoeae, Subtribe: Butiinae Genus: Cocos, Species: C*ocos nucifera* L. (11).

The coconut tree is a monodoric plant that measures 12-25 m high. The fronds of the leaves reach a length of 1.8 to 6 m; They are pinnacled with leaflets 60 to 90 cm long, with male and female flowers gathered in an inflorescence (12).

It grows in the tropics and in most subtropical regions. The ideal temperature for its growth is between 27 and 32 ºC with abundant lighting and rainfall between 1 250 and 2 250 mm per year well distributed. It reaches a good development in well-drained soils, with pH between 5 and 8, presence of organic matter and good aeration (12).

The coconut palm has a great value as a multipurpose plant, being in the twelfth place in the list of species of food plants most important to man, besides being one of the most beautiful. The propagation of this species is mainly based on the fruits (12).

VARIETIES

The high levels of genetic diversity in the coconut tree are the result of natural evolution and adaptation, as well as the performance of man in the exploitation of the species, they have been classified by their habit of growth and by the morphology of the fruit (13).

Due to its habit of growth, the species is classified into two varieties, 'tall' coconut trees (*C. nucifera* L. var. Typica) and 'dwarf' coconut trees (*C. nucifera* L. var. Nana), while the tall cultivars are predominantly cross-pollination, with increases in height throughout the year; the dwarfs are preferably autogamous, with organs of small size and present precocity in the emission of inflorescence and fructification (2).

Classical analyzes of the coconut fruit morphology reveal two predominant types of fruit, the'niu kafa' (wild) form interpreted as the most ancestral morphology and the'niu vai' form (domesticated) that reflects selection under cultivation (13).

There is a great morphological diversity in the coconut palm that is expressed, particularly in the characteristics of its fruits, by color, size and shape, which has caused a controversy about the terminology used in the description of several populations of the palm of coconut (14).

The term "cultivation" seems to be quite adequate since almost all coconut palms have been sown and cultivated by man. However, to distinguish traditional crops from more recent ones, the terms ecotype and hybrid for this species are used. The ecotype is defined as a group of individuals in the same environment and with morphological similarities, while the hybrid, in its broadest sense, defines the individuals obtained from the crossing between two structures (population, family, or individual) corresponding to ecotypes different (14).

Studies made with 21 green coconut ecotypes from the Baracoa region, in Cuba, showed the existence of wild type and domesticated forms and within the latter identified three ecotypes, among which is the Ecotype Indio Verde-1, composed of the genotypes 'Verde Cobrizo de Nibujón', 'Enano Verde de Duaba', 'Criollo del Pino', 'Indio Verde Fino', 'Indio Verde del Rodeo', 'Hondureño Verde', 'Indio Verde de Nibujón', 'Enano Verde de Sabana', 'Alto Verde de Maisí' and 'Indio Verde de Maisí' (4).

The coconut tree in the world and in Cuba

Internationally, there are many coconut producing countries; however, in the countries of Asia, due to the climate and humidity conditions, 83.13 % of world production is concentrated (15).

The Asian countries show very similar production systems for cultivation, which is a process of ancient tradition (manifested in their religious beliefs) and is characterized by the existence of small orchards interspersed with fruit trees, as well as the intensive use of the hand of work and little or no agricultural technification (16).

Brazil and Mexico stand out in the production volumes in Latin America, with 4.48 and 1.96 % of the total world production in 2016 (3). In these countries of Latin America, the situation of the coconut tree is described as critical; because the number of producers is less and less and each of them works their units to the best of their ability (17).

The causes of these problems are based on the low price of coconut marketing and the high cost of labor at the time of harvest. Despite this, in 2014 in Mexico, a strategic program was proposed to promote the coconut value chain, with the aim of achieving better plantations and yields (17).

In the case of Cuba, a diagnostic study carried out showed the low germination rates obtained in the main nurseries (40 %) (18). It was also identified that the coconut tree is fundamentally a monoculture, which causes the areas to be lacking in planned spatial arrangements that provide optimal use of the soil with the crop. On the other hand, most producers have very low technological levels and try to invest as little as possible in the farms, playing tradition an important role, since the production techniques are transferred through generations (18).

In spite of the existing problems, Cuba has the possibility of achieving a development of the same, given that it has areas with edaphoclimatic conditions suitable for its growth and development, in addition there is the political will to do so (18).

Methods of propagation of the coconut tree through seed

Little has been reported in the literature on nursery management in this plant species. However, there are two methods to propagate the coconut tree in the nursery, the pre-nursery method as an alternative for selecting seedlings and the conventional nursery method (19).

Pre-nursery: The seeds are germinated in germination beds and then transferred to the nursery in soil or in bags to be transplanted to the field. The beds will be 1.5 m wide and as long as you want. The seeds will be made a notch (superficial longitudinal cut) where the plumule should come from. The transplant to the nursery is done when the seedlings have started germination (19).

Conventional nursery: The seeds are sown directly on the germination beds and the germinated plants will remain there until they are selected for transplant to the field. It will be constituted by a group of beds of 20 cm deep, 1 m wide and 20 m long. The seeds will be placed side by side (19).

In the technological package for the Mexican state of Colima, reference is made to the pre-nursery method in bags, for which the incorporation of nutrients is considered, through organic fertilization, only after the transplanting of the plants of the germinator to the bags (20).

In the coconut palm technical manual for Honduras they refer to the spread of the coconut tree through the conventional nursery

method, also with the modification of the use of organic fertilizer instead of mineral fertilization (21).

In Cuba, the MINAG Technical Instructions of the years 1990 and 1998, propose the propagation of the coconut tree by the pre-nursery method, while the Technical Instruction of the year 2011 proposes the use of the conventional nursery, with organic fertilization and the option of perform notching of the seed (22).

Studies carried out in the nurseries of Baracoa showed that the coconut tree spread was carried out by the conventional nursery method, and the producers reported that germination by this method was faster and with higher percentage than in the pre-nursery method; even so, the studies showed low levels of germination (18,23).

In general, it can be concluded that knowledge of the coconut propagation methods in nurseries will allow a better management of this in this stage, achieving high germination percentages and development of the postures, for which it is necessary to specify the production technology more efficient for the municipality of Baracoa.

The climate in the management of the coconut tree nursery

Regarding the effect of the climate on the growth of the coconut tree in nurseries, there are very few works that refer to the subject, which indicates that it is an issue to be deepened.

The requirement of water in the coconut tree is strongly influenced by environmental factors such as the distribution of rainfall in the year, the availability of water in the soil, the temperature, the relative humidity of the air, as well as the frequency and strength of the winds. Although the irrigation of the germination bed cannot be excessive, it needs to be sufficient to keep the soil and the husks moist, so that the plants can be watered when there is little rain (14).

In the Technological Package for hybrid coconut palm in the south-southeast of Mexico, it is stated that immediately after sowing is done in the germination beds, a heavy but slow irrigation should be given, and then the risks will be lighter and every three days (24)

On the other hand, for the Caribbean region it is stated that the application of irrigation will be subject to weather conditions. Germination beds will apply 0.5 liters of water every three to four days for each germinated seed, and 1 liter of water per plant will be applied every two days in the nursery, in both cases depending on the behavior of the weather (25).

In studies carried out on other environmental conditions of nurseries in India, it was demonstrated that a high illumination in the coconut poses causes a stress, which causes photo-inhibition in photosynthesis, causing damage to the chloroplasts and the cell membrane, followed by a reduction in the foliar area. These effects could be greater in the presence of moisture stress (26). The results indicate the need to provide plants in the nursery with partial shade.

For the conditions of Cuba, the Technical Instructions states that the germinating planting must maintain a humidity level between 65 and 80 % of the field capacity, so it must be watered on alternate days (22). However, in the municipality of Baracoa, the physical-geographical characteristics of the same and the influence of the trade winds give rise to exceptional climatic conditions, causing a behavior as if it were coastal in almost all its extension, while abundant orographic rains originate, which favors that it rains abundantly both in the mountains, and in low altitude areas close to the coast, throughout the year (27), so it is not necessary to irrigate in nursery conditions.

It is important to highlight the need to deepen the studies on the effect of climate on the response of plants in the nursery, which allows the evaluation of the necessary levels of shade, as well as the management of organic matter in the face of changes in the soil atmosphere to carry out studies on other climatic variables that could influence the normal growth of plants in this phase.

Some factors to take into account in the propagation of the coconut tree

Among the aspects to be considered for propagating and successfully developing nursery plants are: propagation material (botanical or agamic seed), management (substrate, planting framework, fertilization, water requirements, biofertilization). These factors are determinant in the quality of the new plants in terms of height, stem diameter and number of leaves (28).

Seed. Germination and quality

The fruit of the coconut tree is a three-sided drupe with lignified endocarp or “walnut” that encloses a single seed. The endosperm or food reserve of the seed is formed by an albuminous portion and coconut water. Encapsulated in the endosperm is the embryo (12).

The germination begins with the taking of water by the seed and ends with the beginning of the elongation of the embryonic axis. At the beginning of germination, the embryo grows in two directions: the plumule and radicle to the outside, and the other part to the inside of the nut to form the "haustorium" (absorbing spongy organ) that grows slowly until filling the central cavity occupied for water (21).

Through the haustorium, which digests progressively the albumen of the nut, the young palm absorbs nutrients, water in the cavity and the endosperm. When the part that is outside the endocarp swells and enlarges, the sprout of the plumule occurs, through the cotyledon, to become the outer bud (21).

Simultaneously, the primary roots begin to grow through the shell, followed by secondary roots that develop at the base of the seedling, which grow downwards and to the sides through the shell (14).

On average, the period from the beginning of germination to the emergence of the seedling is 60 to 120 days and five weeks, then the first leaf is unfolded (22).

The growth of the coconut seedling continues to use the nutrients contained in the endosperm, but around three months after germination begins, the first leaf appears outside the shell and the process of photosynthesis begins (29).

Among the factors that affect coconut seed germination are mass, maturity, genetic factors (variety) and environmental conditions (14).

There are many opinions about the mass and degree of maturity that the coconut seed should have at the time of harvest, although generally, fruits that have reached full maturity (9 to 12 months of age) must be selected. (21).

In Cuba, the fruit that will be destined for seed must be harvested when the epidermis begins to dry (9 months), the nut must be oblong, longer than wide, must not be damaged by mites and must weigh between 0.9 and 1.0 kg (22).

Because a seed does not germinate until it has absorbed a certain degree of moisture, the dryness of the cover when it is mature produces inactivity (30), so a common practice to improve coconut germination is to cut part of the back of the shell, at the end of the stem of the fruit above the germinative pore (14), despite the advantages that this method has, it is not used by the nurserymen in Baracoa.

Another important factor in the germination and later development of the plants is the substrate, since the seeds present different physiological responses with different substrates, since the external factors that affect the germination of the seed, such as humidity, aeration, temperature and humidity will depend on it. (31).

Substrate

The substrate is all material or its combination that, not being toxic, provides support, adequate cationic exchange capacity, as well as an effective moisture retention for the plant that will grow in it, with a porosity that guarantees a correct aeration for optimal development radical (32).

The selection of one or another substrate component is subject mainly to its availability, ease of mixing and cost in the region where the nursery is located, in addition to the experience of the nurseryman in its use (33).

The technological package for the state of Colima in Mexico refers to the incorporation of nutrients in the nursery in bags, through organic fertilization, with the use of the soil mixture: sawdust (1:1) (22).

In the technical manual of the coconut palm for Honduras, it is proposed to add to the bags a mixture (3: 1) of soil and rice husk (21).

In the south-southeast region of Mexico, for the production of hybrid coconut plants, they propose the use of 6 kg of the compound mixture in 60% of fertile soil, 20% of dry and decomposed manure and 20% of rice husk or sawdust decomposed in nurseries in bags of 0.35 x 0.35 m (24).

In conventional coconut nurseries in Cuba, the formation of *in sit*u beds is conceived without the use of supports or side walls and the application of a substrate consisting of a mixture of soil with remains of coconut pruning, organic fertilizer or sand (1:1:1), with which they are filled approximately 5 cm from the flower bed and then used to cover the seeds after they are located in the germinator (22); however, in everyday practice, this mixture is not used, but only soil is used.

In general, the proposals of existing substrates for the management of the coconut tree nursery indicate that the type of substrate used is very variable, which is dependent on soil conditions, as well as the availability and costs of the substrate components ; hence the importance of conducting research to support its use. Among the components of substrate available in Baracoa region, earthworm humus obtained from bovine and ovine manure and coconut shell are found in greater abundance.

Earthworm humus

The earthworm humus is a type of organic fertilizer with an effectiveness, in many cases, superior to that of others such as natural manures (34).

Its quality will depend on the food supplied to the worm culture during the vermicomposting process (33).

It is characterized by being very rich in enzymes and having contents in N, P, Ca, Mg and microelements in quantities at least five times higher than those of a fertile soil (35).

It has been shown that its addition to the soil produces a significant decrease in the bulk density, an increase in the stability of the aggregates and the water retention capacity, as well as an increase in the concentration of organic carbon and in the total amounts of essential nutrients for plants (34).

This fertilizer has a phytohormonal activity that provides advantageous conditions in the increase of the speed and percentage of germination of the seeds, improves the growth of the plants and absorption of nutritious elements. Its richness in microorganisms also allows it to supply energy due to the large number of mineralizing organisms that reactivate sterile soils, since it regenerates bacterial populations, in addition to regulating the increase and activity of nitrates in the soil (36).

In Baracoa there is a center that produces organic matter, where earthworm humus is produced from different materials available in the municipality, such as sheep and cattle manure, crop residues and pruning remains.

Coconut shell (mesocarp)

The coconut shell is the fibrous mesocarp that is between the exocarp or outer shell and the endocarp or hard shell, constitutes approximately 53 % of the total weight of the mature fruit (37) and can be 1 to 5 cm thick, varying according to variety. It is acidic and contains lignin and cellulose in almost equal amounts (40-45 %) and 8-12 % of soluble phenolic compounds related to tannins. The density of the dough is very low due to the high porosity and the capacity of water retention is very high (14).

It is considered an alternative material to peat, both for environmental reasons and for presenting good physical characteristics (high aeration capacity at the expense of less water retention of easily and total available types) and chemical (high cation exchange capacity) related directly with the granulometry of the material (38).

It is a material of great durability, which makes it recommendable for use in perennial crops. In Cuba, the use of coconut fiber (FC) is recommended to improve the physical state of the substrate, as it is a material that is difficult to decompose, due to the high C/N ratio (39). It constitutes an excellent and novel material to be used as structural and water retention corrector (38).

Despite the disadvantages of coconut husk for its decomposition, originated by the physical properties of the fiber and its long durability, its accumulation in the field, without adequate management, makes it a contaminating material, because attracts rodents and pests of the coconut tree.

Undoubtedly, it is an abundant and low-cost source in the area of Baracoa, which makes it an economic and ecological alternative to be used in the cultivation of coconut. In these moments, studies are carried out to evaluate how to reduce the composting period, as well as its use in the production of earthworm humus. On the other hand, the mixture of coconut fiber with earthworm humus would improve the aeration and moisture retention in the rhizosphere of the plants and with it a better radical development.

Planting frame

In the germinative bed by the pre-nursery method in Sri Lanka, the nuts should be spaced at 5 cm between walnuts and 20 cm between rows, allowing a planting density of about 16 nuts m^{-2}, while in the germinating bed in The conventional nursery will be located forming five rows of nuts at 15 cm between rows for a total of approximately 10 nuts m^{-2} (8).

In the bed of germination of the pre-nursery in Asia the fruits can be sown very close, because the time of permanence is short, saving space, water and work, to then be transplanted to the nursery at a distance of 0.15 x 0.45 m on the ground and 0.60 x 0.60 m in quilts in the bags (14).

Spaces in the nursery of 60 x 60; 80 x 80 and 100 x 100 cm for periods of permanence in the same six, nine and twelve months, respectively, are proposed for the Caribbean region (17). For the conditions of Cuba it is described that in the germinative beds of the conventional nursery the seeds are placed in rows of four, so that they are spaced and not affected at the moment of the service (22).

In the coconut tree, during the nursery stage, a very high density of planting can cause the appearance of pests such as *Aspidiotus destructor*, as well as the obtaining of spun postures, deformations in stem and leaves, and small stem diameter, due to competition between plants through the living space. On the contrary, the use of low planting densities allows a greater development of each individual but also a lesser

use of the land, so it is important to choose a plantation framework that allows to optimize the land and the final production (14).

Mineral fertilization

Mineral fertilization in coconut pre-nurseries is very little addressed by the literature and there is no consensus opinion regarding the need or not for the addition of fertilizer at this stage.

Some authors have stated that it is not necessary to fertilize in the nursery, since germination is done at the expense of the reserves contained in the seed itself (22); however, others report that during the development of the plant the foundations are laid for many years of future production and that although it receives nutrients from the endosperm during the first months after germination, it is essential to fertilize (14).

The most important nutrients in this stage are nitrogen (N), which acts in the development of leaves and stems (22) and keeps a clear interaction with phosphorus, which has a specific function in the germination of seeds, metabolism of the plants and the formation of the roots. The order of nutrients required for young trees is N>P>K>Mg, while for adult palms it is K>Mg>N>P (40).

It is recommended to apply monthly mixtures of urea, dicalcium phosphate and potassium chloride in a ratio of 1:2:2. The doses per plant are made according to the age of the same: 1-2 months of age 15 g; 3-5 months of age 30 g; and more than 5 months of age 37.5 g (14).

For the Caribbean refer fertilization will be done with a mixture of urea, dicalcium phosphate and potassium chloride at 1:2:4, applied to levels of 30 g per plant after two months after germination and 60 g per plant in the fourth and sixth months (24).

In Cuba it is proposed that from the first month of the transfer of the postures to the bags, fertilization will be done with a complete formula every two months (22); however, there are no scientific articles that support results in this regard. In spite of this, in the municipality of Baracoa the practice of fertilization is carried out occasionally, due to the scarce availability of mineral fertilizers, for which a greater emphasis is placed on the use of organic fertilizers.

Interaction of the coconut tree with microorganisms the soil

During a study conducted in the rhizosphere of the coconut palm, a diverse population of symbiotic and asymbiotic beneficial bacteria was found capable of fixing N, solubilizing phosphates and reducing the incidence of plant diseases in the root zone. Among the nitrogen fixers found in the rhizosphere of the coconut tree were identified: Beijerinckia, different species of *Azospirillum* spp., *Azoarcus* spp., *Bacillus* spp., *Burkholderia* spp., *Herbaspirillum frisingense* and *Arthrobacter* spp. A low number of endocritic *Bacillus* spp was also observed, in the root and leaf tissues and in coconut plantations in association with other crops, higher contents of these microorganisms were found than in areas where it was cultivated as monoculture (41).

Isolates of N-fixing microorganisms obtained from soil in the rhizosphere of coconut plants grown in nursery were more efficient for nitrogen fixation than non-rhizospheric soil isolates, which indicated that root exudates stimulated the proliferation of these groups bacterial and suggest the possibility of increasing these populations in coconut palm nurseries by inoculation (14).

In addition, studies conducted in the rhizosphere of adult coconut plantations have demonstrated the mycorrhizal dependence of this species, since it is known that the coconut roots are colonized by arbuscular mycorrhizal fungi (42). Thus, a high density and diversity of species of mycorrhizal fungi (*Glomus* spp., *Gigaspora* spp., *Sclerocystis* and *Acaulospora* spp.) has been found in the coconut rhizosphere and the highest colonization rate was observed in high varieties and in the intercropped cultivation with ranks of 40.4 to 154.5 spores in 10 g of soil (21).

In the roots of the coconut tree a very diverse beneficial microflora is developed, which indicates that the use of microbial inoculants in the crop is possible, which would allow to reduce the doses of mineral fertilizers and recommend to the producers management based on the use of these products for the nutritious supplement of the plant.

In Cuba, despite the existing experience in the use of different types of biofertilizers in agriculture and its known effect in the reduction of doses of mineral fertilizers and organic fertilizers, there are few studies on its use in the cultivation of coconut trees, specifically for the nursery stage.

In the only article that appears published on the subject, a study was carried out to evaluate the influence of the concentration and application form of Azotobacter on the germination of coconut seeds, finding a positive response of the by-product when it is used at 30 % of its concentration and applied by immersion of the seed and by direct spraying to the soil (10).

Characteristics of the plants to be transplanted to the field

Many are the morphological characteristics of the coconut plant that can be evaluated in the nursery to select the plants that will be transplanted to the field, among them, the height of the stem and the diameter of the root neck are the most commonly used classification criteria, while for the physiological attributes the concentration of macronutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sulfur) is considered (43).

The most important aspects to be evaluated in the nursery during the selection of coconut plants are early germination, vigor, as well as the incidence of pests and diseases. Proper selection in the nursery ensures a 10% improvement in yield (44).

With respect to the characteristics that the plant must have for its definitive transplant to the field, there are several references and although there is no general rule, it can be accepted that a suitable plant for field planting will have a height of 1.20 m from the seed to the youngest leaf not folded and 20 cm of perimeter on the stem (45). Other authors state that the plants are ready to be transplanted to the field when they reach the stage of three to four leaves, usually 25 to 30 weeks after germination (19).

In Mexico, they specify that the plants propagated by the pre-nursery method can be taken to the field when they have a pennate leaf (20), while in Honduras and El Salvador, in the conventional nursery method, it is suggested that they should be tall greater than 0.75 m or more than four months after germination (21).

In Cuba, in the pre-nurseries in bags, the postures apt to be taken to the field will have at least a height between 0.60 m and 1.0 m, while for pre-nurseries with bare roots they must have reached a height of 0.30 m. The selection will be made, fundamentally, taking into account the vigor of the plant, its vegetative development and the color of the variety (22). It is proposed that conventional nursery transplant be performed when the plants reach 15 cm in height (22).

Considering that the coconut tree is a perennial crop with a useful life of 60 years, it is important to select plants of optimum quality to be taken to the field, since the future yield of the plantation will depend on it.

CONCLUSIONS

The knowledge of the propagation methods of the coconut tree culture will allow a better management of the same in the nursery stage, either through the propagation by pre-nursery or conventional nursery, although there are different opinions on the distance of sowing, the quality of the plant to be transplanted to the field and the mineral fertilization to be used in the propagation of the coconut palm by means of a gm, so it is necessary to deepen the studies on the different aspects that influence the obtaining of quality postures in Cuba produced through the gamete propagation.

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