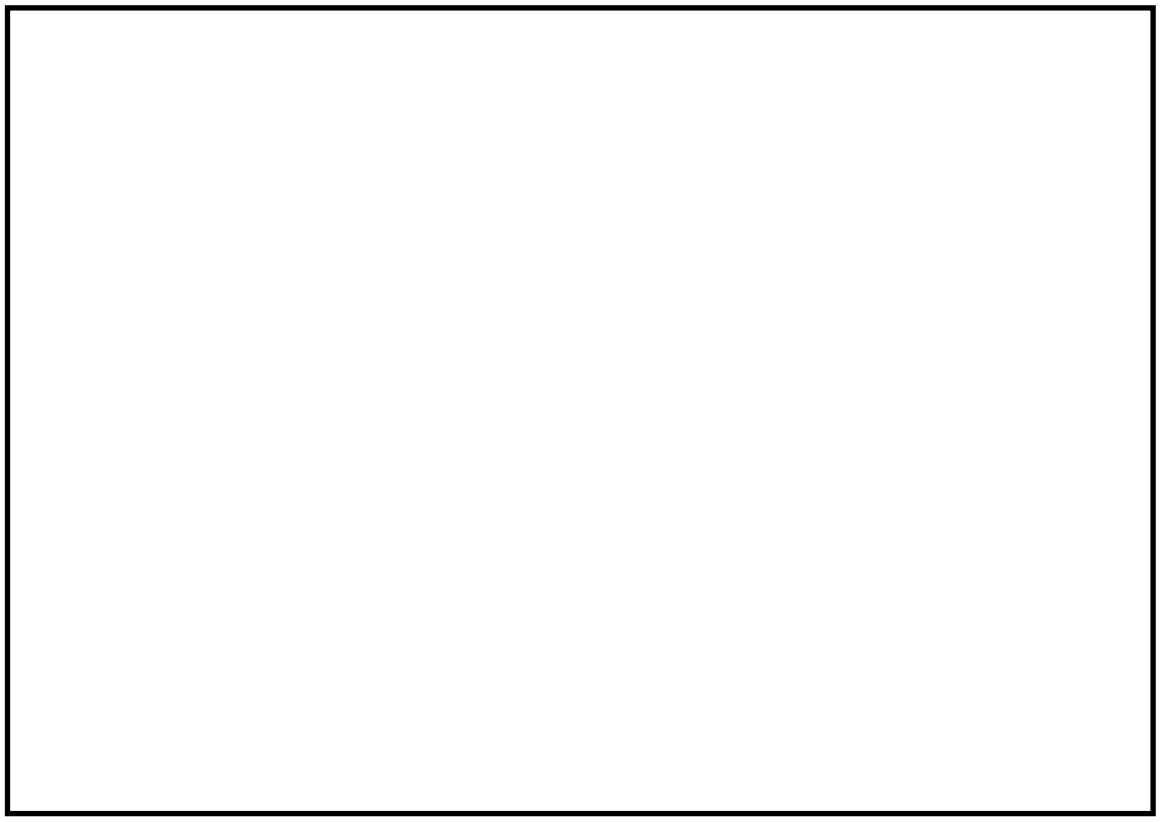
Technical manual of practices and management for Palm

Volume 1

PROPAGA PALMA

Catalog Card



Financier:
Fundo Internacional de Desenvolvimento Agrícola (FIDA)
Ministério da Agricultura, Pecuária e Abastecimento (MAPA)
Governo Federal do Brasil

Project performance area:
Projeto Dom Helder Câmara | PDHC

Entities:
Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba (Codevasf)
Instituto de Políticas Públicas e Desenvolvimento Sustentável (IPPDS)
Fundação Artística, Cultural e
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Presentation

The Propaga Palma Project is the result of a partnership among the International Fund for Agricultural Development (IFAD), the Ministry of Agriculture, Livestock and Supply (MAPA), and the São Francisco and Parnaíba Valleys Development Company (Codevasf). The project takes place within the Dom Helder Câmara Project (PDHC) scope. Its main objective is to reduce rural poverty, increase family farming production, and expand technological innovations in the Brazilian semiarid region via the dissemination of Palm.

Palm is a cactus widely cultivated in the Brazilian semiarid region, given its characteristics of tolerance to drought and adaptation to shallow soils, deficient in water and organic matter. Due to its capacity to store water and energy, Palm represents a food base to supply herds, ensuring a source of income and food for rural families. Furthermore, its cultivation contributes to the conservation and recovery of soils in a degradation process.

The content of this booklet was prepared by a multidisciplinary team of researchers from the Federal University of Viçosa (UFV) to present the project to farmers and guide them on the main aspects of Palm management. All the steps described in this booklet are aimed at the farmer achieving success in the cultivation of Palm. The technologies consist of micropropagation of seedlings in the laboratory, tolerant to Cochineal Carmine, in addition to management techniques, such as soil preparation, planting, irrigation, and area maintenance.

Good reading.

Federal University of Viçosa

CONTENTS

CHAPTER 1

The Palm

The Brazilian semiarid region is characterized by climatic instability, and water scarcity is a limiting factor for developing agricultural activities in the region. The rain concentration in a few months during the year interrupts the production cycle of crops, reducing forage availability in the dry period, causing serious socioeconomic consequences. In this scenario, the Palm stands out and is currently widespread in the Semiarid region due to its resistance to drought and shallow soils, being well adapted to the conditions of the scenario in question.

Figures 01, 02, 03, and 04. Semiarid region' images.
Source: Project collection.

The Palm is a cactus that can store a high content of water and energy, being used as a food source that enables the herds' management in the Semiarid. Its nutritional value is superior to most bulky foods used in animal feed in the Semiarid region. It can even be superior to corn silage, which is considered one of the best components for feeding lactating cows. As a result, the cultivation of Palm also represents a source of income for rural families, who, through livestock, ensure the production of meat, milk, and dairy products.

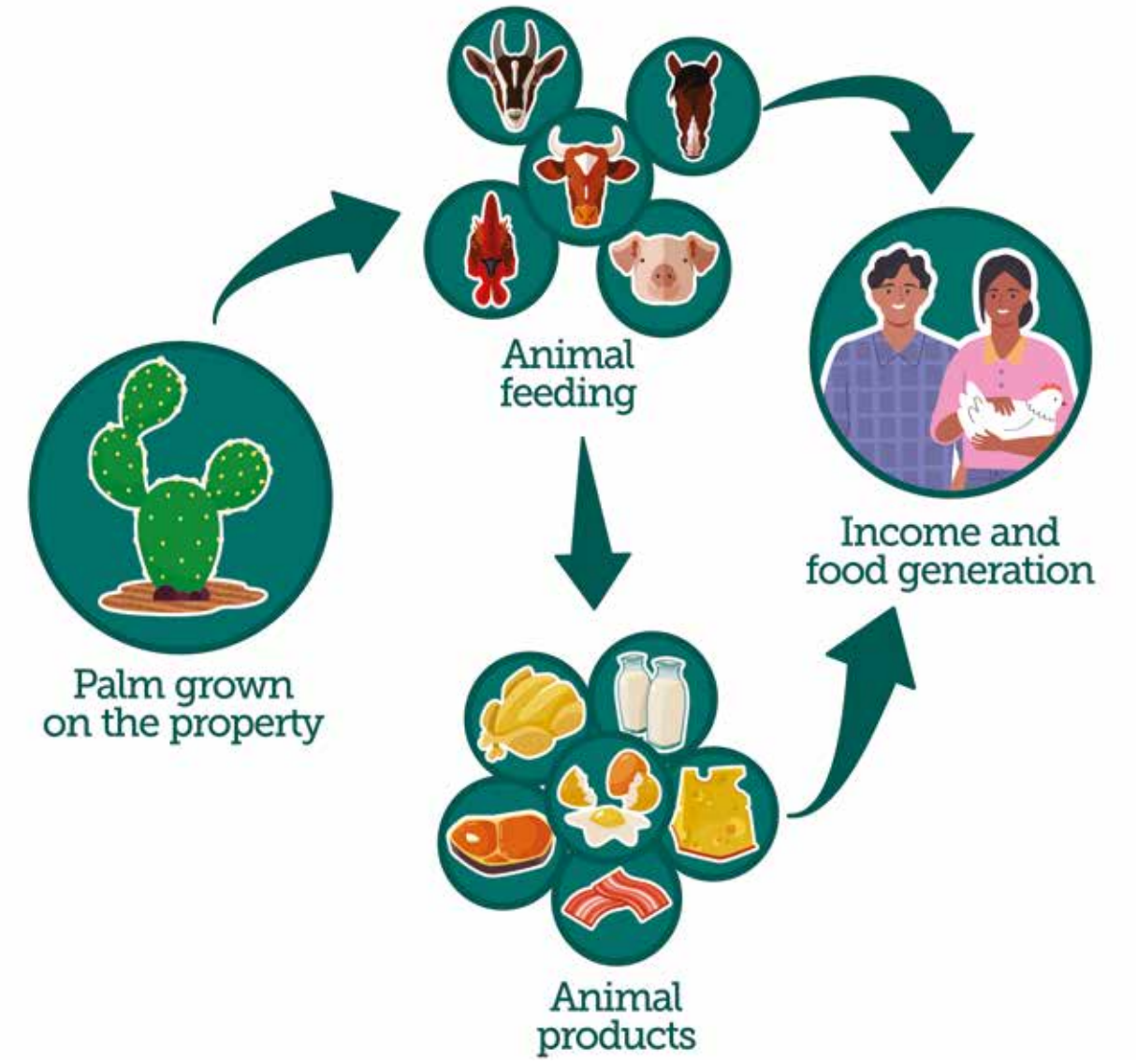

Figure 05. Various uses and applications of Palm.
Source: Project collection.

Palm, like any other plant, like any other plant, is susceptible to attack by pests and diseases. The presence of pest insects such as the Cochineal Carmine (*Dactylopius opuntiae*) constitutes a limiting factor for production.

What is Cochineal Carmine?

It is an insect that feeds on the plants' sap and can also introduce viruses or toxins that turn the plant yellow and wither. Cochineal can destroy the Palm within a few months if not quickly controlled.

Figure 06. Palm infested by Cochineal Carmim.
Source: EMBRAPA (Liliane Bello).

Thus, the importance of using varieties resistant to Cochineal Carmine is in maintaining crops in the Brazilian Semiarid region to guarantee the management of herds and income. For this reason, several types of research have been promoted to identify resistant varieties to these pests, such as the Mexican Elephant Ear (*Opuntia*

stricta Haw), IPA Sertânica (*Nopalea cochenillifera*), and Miúda or Doce (*Nopalea cochenillifera* Salm Dyck).

Mexican Elephant Ear (*Opuntia stricta* Haw)

The Elephant Ear variety is a less demanding species in terms of soil fertility. However, it has many thorns that can be removed post-harvest. This is one of the varieties that are resistant to Cochineal Carmine and will be used in the Propaga Palma Project.

Figure 07. Mexican Elephant Ear Palm (*Opuntia stricta* Haw).
Source: Project collection.

CHAPTER 2

Palm Micropropagation

The production of seedlings in the laboratory, also known as *in vitro* propagation or micropropagation, is one of the most important steps in the project, which allows for obtaining plants with high quality and uniformity. This technique has been used successfully for seedlings' production of various species in commercial laboratories and so-called biofactories. It provides large-scale production of identical, healthy, and uniform plants (clones), ensuring high-quality seedlings to serve the material demands for planting in the field.

Figure 08. Palm micropropagation scheme. (1) Plants in the field; (2) Planting healthy rackets in a greenhouse; (3) Selection of young rackets for in vitro introduction; (4) Section of rackets without damaging the buds; (5) Buds in Petri dish; (6) Elongated buds in glass jars are cut in half; (7) Buds fragments in a glass flask containing nutrient medium; (8) Formation of shoots from bud fragments; (9) Elongation of shoots after cultivation in the absence of light; (10) Acclimatization of elongated seedlings in pots and cultivation in a greenhouse.
Source: Project collection.

Collection, planting, and selection of rackets

Healthy rackets are chosen and collected in the field. After cutting, the rackets undergo a curing period in the shade, where the healing process of the injuries caused by the cut in the field begins. Then, the rackets are planted in pots that have been placed in a greenhouse.

Figure 09. Racquets planted in pots in the greenhouse.
Source: Project collection.

The rackets planted in pots will be the new matrices. Each new sprout that is born in the matrix is called a racket, and this will be used for the next steps to be carried out in the laboratory.

Figure 10. Sprouting of palm rackets.
Source: Project collection.

Surface cleaning and introduction of *in vitro* shoots

In the laboratory, the young rackets go through the disinfection process. Then, a second stage is carried out in a contaminant-free chamber where the sprouts are immersed in 70% alcohol and rinsed in contaminant-free water. After cleaning, the young rackets are cut into smaller pieces without damaging the buds.

Figure 11. Cutting step performed in the laboratory.
Source: Project collection.

Figure 12. Transfer of Buds to Petri dishes containing nutrient medium. Source: Project collection.

Next, the buds are dipped in a fungicide solution and then placed in Petri dishes containing nutrient medium and hormones, which allow them to grow and develop. These Petri dishes are kept in the growth room for 30 days.

The growth rooms are controlled environments where optimal conditions for the growth of buds are offered, such as artificial light and temperature. Then, the buds are transferred to flasks containing nutrient medium and kept in a growth room under the same conditions mentioned above, where they will remain for another 30 days.

Figure 13. Growth room.
Source: Project collection.

Development, multiplication, and elongation of shoots *in vitro*

Figure 14. Cutting of new buds.
Source: Project collection.

After these 60 days, the buds develop and increase in size. In sequence, these buds are cut and transferred to new flasks containing a culture medium with hormones to allow the formation of new

shoots. Thus, it is possible to produce a large number of plants in a short period.

In 30 days, there is a rapid multiplication of shoots. Thus, the sprouts go to the elongation phase, where the seedlings are cultivated in the absence of light for 15 days, followed by another 15 additional days under lighting in a growth room.

Figure 15. Shoot multiplication step.
Source: Project collection.

Transfer of seedlings to the greenhouse

After elongation, the seedlings with a size between 3 and 4 cm are selected and planted in biodegradable containers (pots) with fertilizer and substrate. Then, the seedlings are taken to a greenhouse, where they will stay for 60 days. Finally, the seedlings will be transported to the polo nurseries, undergoing the acclimatization phase.

Figure 16. Seedlings in biodegradable pots.
Source: Project collection.

CHAPTER 3

Planting and management of the Palma crop

The improvement in cultivation practices directly influences the production of Palm. Therefore, in this chapter, the main technical aspects regarding the cultivation and management of Palm will be discussed, such as soil preparation and fertilization, planting methods, frequency of irrigation and harvesting, pest and weed control.

Planting area selection

This step can determine the success of palm cultivation, mainly due to the soil's physicochemical characteristics. It must be carried out judiciously to avoid possible expenses in the future. The farmer must give preference to land with smooth topography, that is, places with a small slope. Suppose areas with small slopes are not available. In that case, there is no problem because when cultivated correctly, the Palm can be planted in sloping places and constitutes a good option for erosion control, favoring soil conservation and degradation recovery.

Soil type - Avoid stony, saline, and acidic soils and prefer clayey and clay loam soils.

Access to water and energy - Choose areas close to access to water and energy.

Terrain slope - Prefer terrain with smooth topography, low slope.

Land size - In the Propaga Palma Project, the area destined for planting is 2500 m^2 or 0.25 hectares.

For planting success, it is extremely important to obtain the soil physicochemical characteristics to identify the sediment granulometry (soil texture), macro and micronutrients,

organic matter concentration, among other aspects. This will make it possible to know the main demands of the soil, whether liming will be necessary, and guarantee the palm crop performance.

TIP

During selection, the farmer can choose areas in which annual crops have already been cultivated, as once the needs of this area are known, the easier its management will be.

Soil preparation

This step aims to provide the plant with better root development. Thus, soil preparation must be carried out using agricultural techniques. The soil preparation steps are cleaning the area (avoiding the use of fires), subsoiling or plowing, analysis and correction of the soil, and opening of furrows.

a) Soil preparation

This agricultural practice aims to remove all vegetation from the area, as clean land provides greater planting efficiency. The cutting can be done manually or mechanized, and the main operations are cutting plants, removing wood and stones from the surface. Cleaning must be carried out in advance, between one to three months before planting.

b) Subsoiling or plowing

This practice is recommended for areas with compacted soil, in which soil decompaction is promoted without causing soil inversion. The implementation of this stage enables the seedlings' root development and improves soil drainage. It is recommended to

Figure 17. Agricultural tractor preparing the soil.
Source: AGEITEC (Claudia S. da C. Ribeiro).

carry out deep plowing towards the terrain level curves or cross subsoiling.

c) Soil analysis and correction

Once the need for soil correction has been verified, it is necessary to apply lime in the correct amount, by technical recommendation, based on the soil physicochemical analysis. This step will improve the uptake of nutrients supplied to the plants during planting and maintenance fertilization.

Figure 18. Manual soil correction.
Source: AGEITEC (Claudia S. da C. Ribeiro).

Figure 19. Soil furrowing for planting.
Source: AGEITEC (Claudia S. da C. Ribeiro).

d) Furrows opening

This practice is intended to open the ground for crop planting. The advantages of planting in furrows are a greater number of plants per area and easier weeding and crop management. The openings must have an average depth of 30 to 40 cm and be made following the recommended planting row spacing. Following the terrain level curves, this step can be performed with a tractor furrower.

e) Pre-planting and maintenance fertilization

Soil organic fertilization can be carried out with cow, goat, or sheep manure, and the amount applied is between 10 to 20 tons per hectare, which is equivalent to 1 to 2 kg per pit. This fertilization must be repeated at the beginning of the rainy season. If the farmer opts for mineral fertilization, soil analysis is necessary to know what levels of Nitrogen, Phosphorus, and Potassium should be applied and if there is a need to lim the soil.

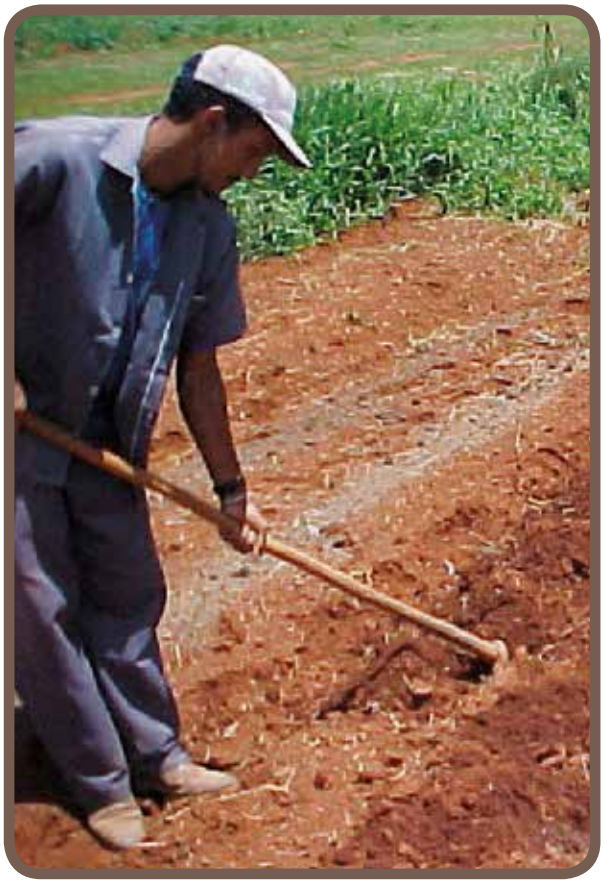

Figure 20. Digging and fertilizer mixture in the pits.
Source: AGEITEC (Claudia S. da C. Ribeiro).

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f) Crop planting

The Palm seedlings distributed by the Propaga Palma Project already have a developed root system due to the period of acclimatization (in a greenhouse) and acclimation (in a seedling nursery), which increase the chances of success.

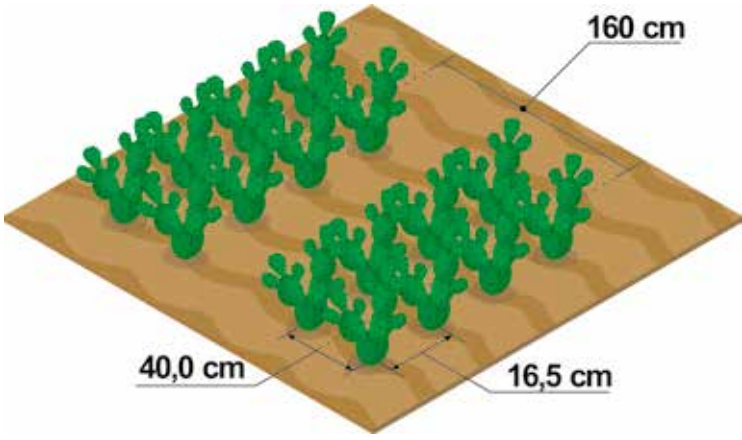

Figure 21. The spacing model for planting Palm.
Source: Project collection.

Seedlings planting is carried out using the dense method, which uses a greater number of plants per area. Planting is done in a double row,

with a spacing of 40 cm between rows, 160 cm between each double row, and 16.5 cm between each palm seedling (or six plants every 100 cm). The adopted spacing facilitates cultural treatments, pal harvesting, and density between 40 to 60 thousand plants per hectare.

As it is a matter of planting with close distances between the plants and in a straight line, you can use planting templates made of wood to facilitate positioning and standardize distances.

During planting, the seedling must be placed vertically and the pot placed inside the furrows, obeying its height in relation to the ground. It is unnecessary to remove the pot, as it is made of biodegradable material, not generating any waste during this step. Then only the pot must be covered with soil.

g) Irrigation

Palm crop irrigation boosts results and productivity and is therefore strongly recommended. For the planting of Palm, the sprinkler or drip irrigation method can be used.

Some climatic factors can affect the sprinkler method, such as wind, relative humidity, and temperature. The main advantages of this method are:

- Little need for system maintenance;
- Uniform distribution, more frequent irrigations, and less water consumption;
- Possibility of carrying out crop fertigation;
- It can be installed on land with a slope of up to 5% to not harm the irrigation system.

This method allows for better plant development, as it allows for total irrigation of the area intended for planting. This

system is composed of a motor-pump set, piping, and sprinklers. Considering a fixed system, the pipes are buried, and the sprinkler moves in the lateral line, requiring a low-pressure motor-pump set.

In drip irrigation, water is applied punctually through drops directly to the soil. These drops, when infiltrating, form a wetting pattern called a "wet bulb." The sizing of the wet-bulb helps properly estimate the number of drippers per plant and their location in relation to the plants or rows of plants, directly influencing irrigation project costs and the productivity of the crops.

Figure 22. Palm crop irrigation using a conventional sprinkler system. Source: Project collection.

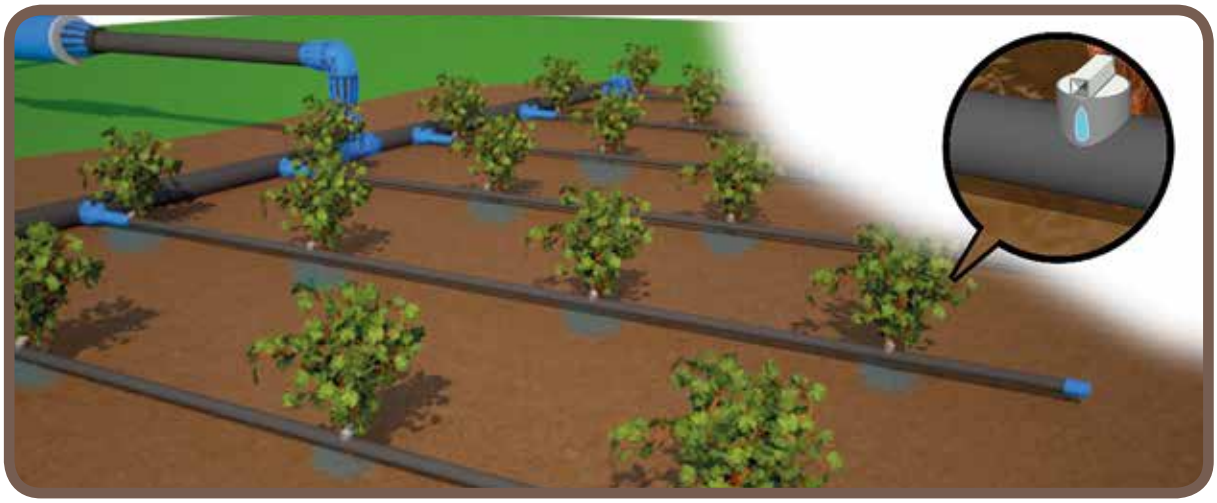

Figure 23. Irrigation of forage cactus crop using a drip system.
Source: Project collection.

This system is ideal for presenting low water flow, not generating waste. In addition to the high efficiency, only the area near the dripper is irrigated, reducing weeds' appearance and evaporation losses.

Among the main advantages, it is possible to highlight the productivity with less water applied, uses low pressure in operation, does not irrigate the rackets, operates in crops implanted in soils with low infiltration capacity, has no topographic limitations, and can be automated.

Weekly, the total volume destined for irrigation is 14,000 L per hectare, but the crop's irrigation frequency depends on the soil type destined for the Palm cultivation. Over irrigation tends the plant to rot. Therefore, crop irrigation should be carried out during day periods with milder temperatures, thus reducing evapotranspiration losses. However, below this value, the plant develops with difficulty for budding.

The ideal irrigation depth for cultivation in sandy soil is 2 mm per day, and the frequency is every two days or three times a week. The water depth is 14 mm per day for clayey soil, and irrigation can be done only once a week. These values will vary with the region's temperature where palm cultivation is established.

	General characteristic	Daily volume applied	Weekly frequency
Sandy soil	It has a greater amount of sand than average, is very porous and permeable	4 mm/day	3 times per week
Clayey soil	Soil formed by grains smaller than those of sand, and therefore more compact	14 mm/day	1 time per week

h) Cutting and harvest frequency

Manual harvesting is the most recommended, despite the labor cost of this process, as it preserves the crop better. Cutting frequency and intensity are directly related to crop productivity. The main precautions during cutting are cleaning the knife to reduce possible contamination risks and diseases spread.

After reaching the first year of planting, a palm harvest must meet certain criteria according to conditions observed during the crop development. The mother plant, or the base plant, corresponds to the plant that is in contact with the soil and, therefore, has roots that absorb all the water and nutrients distributed to the whole plant. The 1st order rackets correspond to the first shoots that occurred on the plant and have direct contact with the matrix.

Thus, the 2nd order rackets are shoots that happened in the 1st order racket and so on, and the link between each of the parts of the plant (matrix and rackets) is called a common joint.

The first harvest is done one year after planting and preferably during the winter, but this time can be reduced to eight months for irrigated crops. From the second year onwards, the cut must be done soon after the end of the rainy season, and the Palm must be harvested from furrow to furrow and offered daily to the herd.

Between the first and fourth harvests, keep all 1st order rackets, plus a 2nd order racket for each 1st order one. This will allow for more uniform production of the crop.

If the plant has many first-order shoots, leaving between two to three rackets in each mother palm is recommended. It is not recommended to prune the matrix in these first harvests, as it reduces the regrowth area and the plant's energy reserve.

After five to seven years of cultivation, the matrix tends to become woody, and shoots decrease. In this case, it is recommended to make a cut leaving only 5 cm of the plant concerning the base of the primary rackets next to the matrix racket, thus promoting an over-sprouting of the matrix rackets. These new shoots, after growing, should be covered

Figure 24. Palm cutting diagram.
Source: Project collection.

with soil to allow the plant to take root, transforming it into new matrix rackets.

i) Crop productivity

For irrigated plantations, with an average density of 60 thousand plants per hectare and under irrigation, yields of 380 tons per hectare are expected. After harvesting, the Palm can be used immediately for consumption by the animals, being provided in feeding troughs. In addition, it can be kept in the shade for 16 days without losing its nutritional value. For storage for longer periods, the Palm must be dried in the sun for 60 hours and can be used or stored for a period of up to eight months.

The Palm can still be supplied to the herd mixed with other foods. Usually, sugarcane bagasse, hay, silage, sorghum, corn, bean, or even dry grass stubble are used, as well as protein sources. This eating strategy improves fiber and nutrient intake.

j) Cultivation

Integrated pest management is recommended to check for the presence of insects such as ants, grasshoppers, and mealybugs, as well as rodents. Although the Palm supplied by the Propaga Palma Project is tolerant to Cochineal Carmine, the main pest of the Palm in the Brazilian Semiarid, there is a wide variety of species that can host this plant, such as the Cochineal Scale.

Insect control can be done chemically, biologically, or mechanically when the infected plants are eliminated to prevent the pest from spreading. The Palm can also have some diseases caused by bacteria and fungi that enter the plants with holes caused by insect attacks. Applying limestone can also help with pest control.

Figure 25. Cochineal Carmine in Palm.
Source: CNA INSTITUTE (Rafael Barbosa).

Figure 26. Cochineal Scale in Palm.
Source: Senar/SE (2020).

For weeds control, weeding is recommended superficially or mowing, only during the first year of planting, because after this period, weeding can damage the palm' root system. Conscious herbicide use is also recommended, especially after the first year and between double rows.

The application frequency should be 3 to 4 times a year via manual or mechanized spraying. After the weeds die, part of the dry residue can be kept in place, as this will provide organic matter for the Palm, reduce water losses through evaporation, in addition to providing a more aerated soil and favor the pest's biological balance. The application of selective herbicide with systemic action of the chemical groups Urea (Diurom) and Triazinone (hexazinone) is recommended, as indicated by a qualified professional.

CHAPTER 4

Main uses of the Palm

Currently, Palm is part of the food base of herds in arid and semiarid areas due to its characteristics of high palatability, biomass production, and resistance to drought, making this plant a valuable food for the region's herds. However, the genus Opuntia stands out, and it contains the main species associated with human and animal nutrition and, probably because of this, it had greater success in the processes of distribution, dispersion, and multiplication.

Palm is traditionally used for ruminants such as dairy cows and goats, cattle, beef goats, and sheep in animal feed. However, the use of palm bran in the feeding of swine and poultry has been increasing.

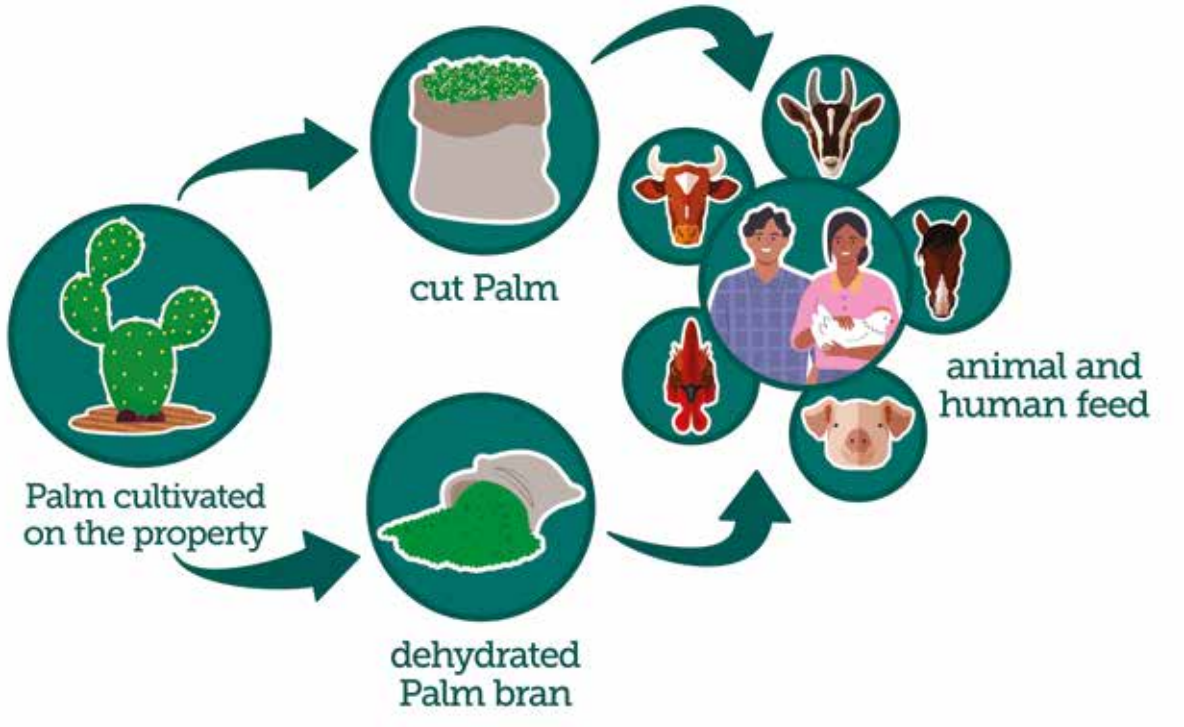

Figure 27. Uses and applications of Palm.
Source: Project collection.

In feeding ruminants, the Palm can be used in several ways. However, the method of use may vary depending on the availability of labor, machinery, and material. Harvested palms are usually chopped with a knife or processed into forage. Cutting

with a knife does not expose the mucilage, while with forage, this mucilage is exposed and mixed with other foods.

The most common method of use is the supply of the chopped Palm to the animals, but they can also be dehydrated and transformed into bran, ensiled, in addition to direct grazing. For dairy cows, the Palm is offered in the minced form in the trough without mixing it with any other food provided at the time of milking. As for poultry feed, Palm is provided in the form of bran and can increase the proportion of protein in the meat, providing an alternative to feed broiler birds.

It is important to note that foods high in non-fibrous carbohydrates, such as palms, can cause several rumen disturbances when given separately and in large amounts. To avoid this problem, complete rations have become a common and important procedure in regulating the diet composition, providing an adequate balance of nutrients.

The choice of the complement to be associated with Palm must be made considering, mainly, the balance between non-fibrous and fibrous carbohydrates. The inclusion of Palm in animal diets directly affects the meat's nutritional quality but without affecting its organoleptic characteristics.

Palm's average crude protein content is generally low, 4.5%, which practically does not supply the activity of cellulolytic microorganisms in the rumen, requiring complementation with other sources of nutrients. This complementation can be done with real protein from protein foods or through the administration of non-protein nitrogen such as urea.

New possibilities are being explored in developing the potential use of Palm in animal feed. Among the alternatives,

there are ways of better use, correction of deficiencies, enrichment of its nutritional value, and new forms of use, in which the Palm is no longer a resource only in drought times and becomes a daily component of the animal feed throughout the year. This reduces costs and increases the producer's competitiveness in the globalized market.

Palm is of great importance in human and animal nutrition and stands out in medicine, the cosmetics industry, and the production of natural additives. Furthermore, represents an income alternative for populations in arid and semiarid regions in different parts of the world.

In addition to being used as forage, we find other uses in some regions, such as in Mexico. In some regions of Latin America, Opuntia is cultivated for fruit production. In some countries in Africa and even Mexico, palm rackets are part of the human diet. In Asian countries, the Palm is used as a medicinal plant, entering the composition of natural medicines. Palm cladodes or rackets and fruits are often consumed fresh or processed in human consumption.

Selling possibilities and other uses of Palm

Palm has been used in the cosmetics industry, manufacturing shampoo, soaps, moisturizers, lip balm, and creams. In agriculture, Palm protects and conserves soils, hedgerows, windbreaks, and organic matter.

The palm fruit is considered anti-diarrheal, anti-dysenteric, pectoral, anti-asthmatic and bechic, diuretic, cardiotonic, bladder, and urethra anti-inflammatory in the medicinal field, relieving the burning sensation caused by cystitis and urethritis. Palm is also applied cut into thin slices on burned skin or bumps.

Figure 28. Other uses for the Palm.
Source: Project collection.

Distribution of seedlings and rackets to producers

In the first distribution phase, selected farmers will receive palm seedlings to carry out planting in the previously selected area within their properties, becoming multipliers.

When the plants reach a height of 15 to 20 cm, approximately 1 year after planting the seedlings, the 1st stage multiplier

farmers must donate the same amount as they received, but in rackets, to the 2nd stage farmers of the project. These, in turn, will pass on to other farmers, and so on.

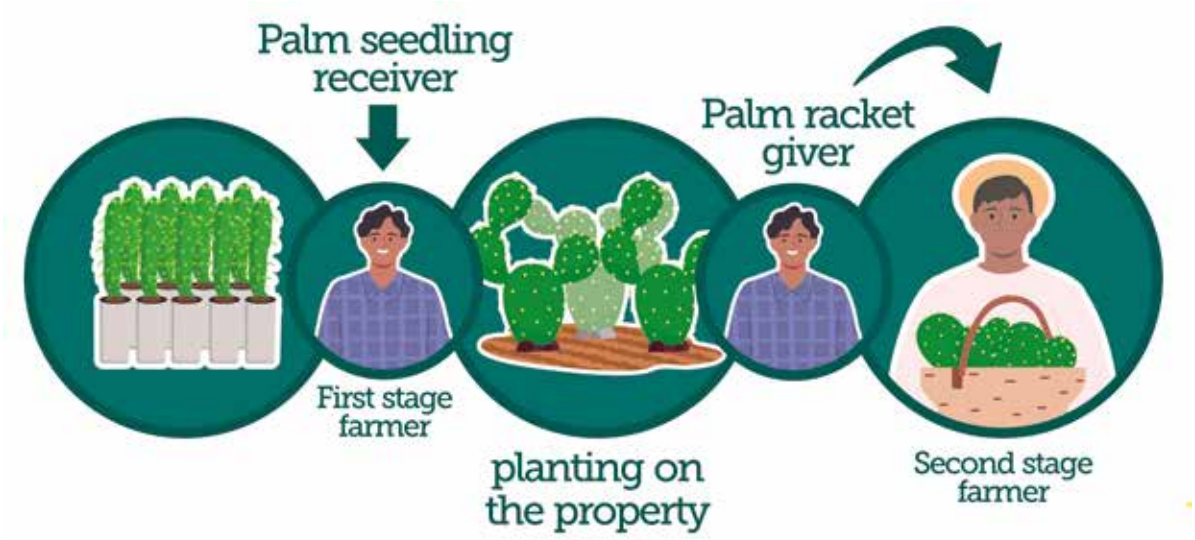

Figure 29. Distribution of seedlings to the farmer.
Source: Project collection.

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