



# PHYSIC NUT (*Jatropha curcas*) CULTIVATION IN HONDURAS HANDBOOK



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DAJOLKA



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## **PRESENTATION**

"Countries lacking energy sources require the inclusion of alternative ones, with a high impact on the country's economy. This is the case of renewable energy and biofuels in particular."

This manual embodies the efforts made by the Honduran Foundation of Agricultural Research (FHIA), Strohalm Foundation, and lately the Green Drop Project. Gota Verde, as known in Spanish, tries to determine if the Piñón plants (*Jatropha curcas*) could adapt to the dry tropic conditions that dominate most of the Honduran territory. After two years of testing this oleaginous plant, we can say that some of the wonders attributed to its cultivation are true; but others are conditioned by factors such as soil preparation, the plantation's objective, its variety, and so on.

In this manual, because of our short experience, we have considered (as contributors) the results obtained with Piñón in other countries. That is why we consider this a preliminary version, to be improved as research and cultivation experiences advance.

The name of the products mentioned in this manual are used as examples for phytosanitary control and they don't constitute, in any way, a preference of the same.

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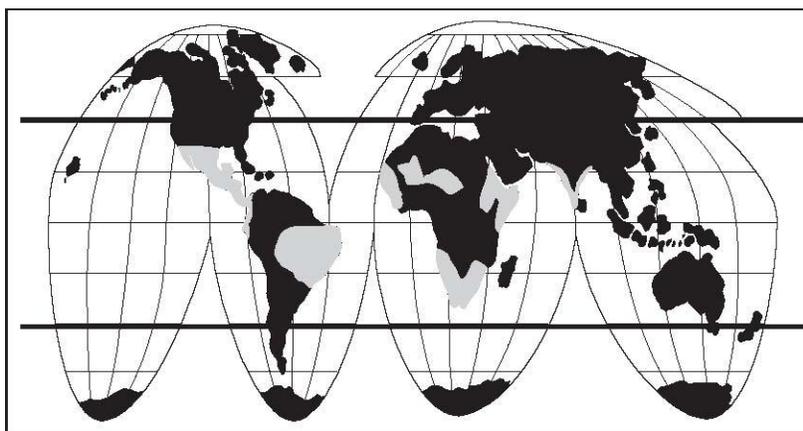
## **Physic nut (*Jatropha curcas*) cultivation in Honduras – Handbook**

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## 1. INTRODUCTION

Oil has been the main source of energy used by humanity to produce energy. The damage to the environment and the imminent demise of this fossil fuel have forced many countries to carry out research on alternative sources such as oleaginous plants. In the humid Honduran tropics, the efforts to obtain oil have been based in the cultivation of humid tropics adapted plants such as the African palm (*Elaeis guineensis*) and ethanol from Sugarcane (*Saccharum officinarum*). For the dry tropics represented in the central and southern parts of the country, the most promising crop is the Piñón (*Jatropha curcas*).



Tropical areas suitable for growing Piñón

## 2. BACKGROUND

During 2006, the Honduran Foundation for Agricultural Research (FHIA) was contracted by the Dutch Foundation STROHALM, to establish a series of tests with different oleaginous crops (Piñón, *ruprechtia apetala*, sunflower, and forage turnip) to determine the most appropriate conditions to develop these crops in two areas of the Department of Yoro. Although experiments have not been completed, the most important experiences are included in this manual as a guide for producers and technicians who incursion into the cultivation of Piñón.

## 3. ORIGIN, TAXONOMY, MORPHOLOGY, AND BOTANY

### 3.1. Origin

It is an oleaginous bush with more than 3500 species grouped in 210 types. It is originally from Mexico and Central America, but grows in most tropical countries. It is grown in Central America, South America, Southeast Asia, India,

and Africa. *Jatropha* comes from the Greek words *iatrós* meaning medical and *trophé* meaning food.

**Common names in different countries:**

Piñón, tempate, yupur, coquito, capate, piñoncito, piñol, piñón botija, higos del duende, barbasco, piñones purgativos, higo de infierno, purga de fraile, tua tua, Piñón, pinhao manso, piñónparaguayo, piñón de purga, piñón de cerca, purgante de caballo, manduigaçu, mandubiguaçú, higo del infierno, purgueira, pinhão croá, etc.

**3.2. Taxonomy**

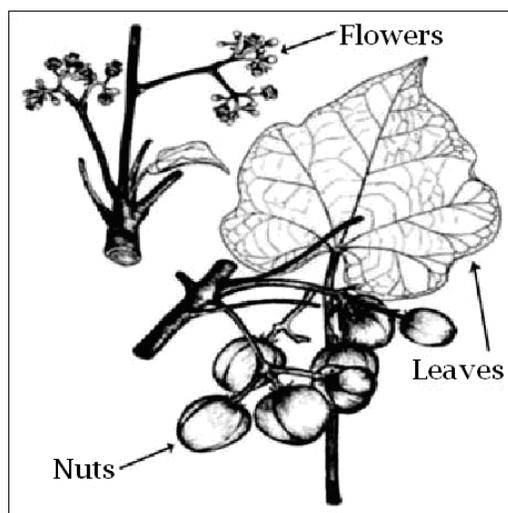
- Kingdom: Plantae
- Sub Kingdom: Tracheobionta
- Division: Magnoliophyta
- Class: Magnoliopsida
- Subclass: Rosidae
- Order: Euphorbiales
- Family: Euphorbiaceae
- Genus: *Jatropha*
- Species: *curcas*

The Piñón is a close relative of the Castor oil plant (*Ricinus communis*), cassava (*Manihot esculenta*), and the Para rubber tree (*Hevea brasiliensis*).

**3.3. Morphology**

It is a large bush, fast-growing, with normal high from two to three meters. In special conditions, it can reach up to eight meters. Its trunk presents a low altitude branched column and a smooth crust of soft wood; a developed soft; nearly 20 cm in diameter; greyish white; and phloem with long channels that stretch into the roots circulating latex, a milky juice that comes out with abundance from any wound.

### 3.4. Botany



Leaves, Flowers, and Nuts of the Piñón

#### 3.4.1. Root

The Piñón plant has short and little branched roots. Normally, the seedlings have 5 roots, 1 central and 4 on the periphery (2 secondary and 2 tertiary). When growing from vegetative material (asexual), the new plant does not have pivoting root and the forming roots are superficially inserted.



Piñón root

#### 3.4.2. Stem

There is no uniformity in the stems' growth, which seems to be a varietal characteristic. For example, the native variety presents a straight stem without much branching and also different leaf's shape, compared with the Cabo Verde and India-Salvadorean varieties which branch more expontaneously or in a natural way, from the base. The trunk or stem is divided from the base in long

branches, with numerous scars caused by its leaves' fall in the dry season. Leaves regrow after the first rains (Cortêsão, 1956; Brazil, 1985).

### **3.4.3. Leaves**

The Piñón leaves are green, wide and brilliant, long and alternate, in the form of hairy palms, mostly from 7 to 16 cm long and around the same width, with whitish veins embossed on the back, almost hairless below the veins. They are normally formed with 5 to 7 acuminate lobes, shallow and big, with long petioles from 10 to 15 cm. The Piñón is a tree of seasonal falling leaves (deciduous), according to Cortêsão (1956) and Brazil (1985). It is very common to see leafless stalks during the summer (December to April) in Yoro.



Piñón Leaves

### **3.4.4. Flowers**

Flowering is Monoecius, presenting male and female organs on the same plant. Inflorescences are terminally formed in the leaves' axis on the branches. Both flowers are small (6 to 8 mm), greenish yellow on the diameter, and pubescent. Each inflorescence curd shows a cluster of about 5 to 10 fruits.

Two Piñón varieties were planted as a test during 2006. Both varieties, "India Salvadorian" and "Cabo Verde" blossomed after 3 months of transplanting. And 90 days later they were ready for harvest. The plant loses all its leaves during summer of the following years, and only blossoms when stimulated by moisture. The plantations without irrigation can be harvested only once a year. Apparently, the formation of flowers is related to the period of rain. It can blossom again after producing fruits, when conditions remain favorable for another 90 days; but after this 2nd. flowering, the plant does not blossom again, it only develops vegetatively (this happens if there is no irrigation).



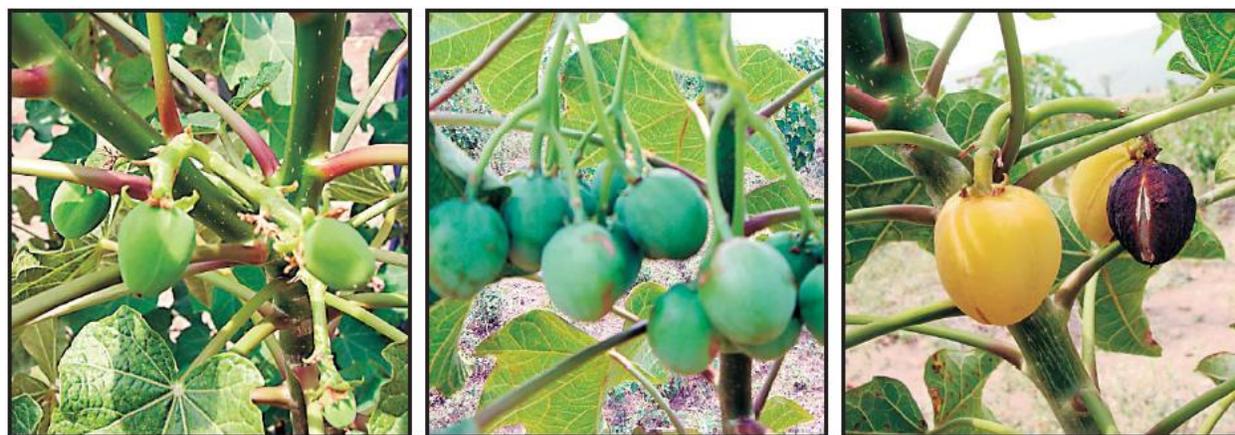
**Flowering of Piñón plant**

There may be up to five flowerings each year, but two of them are the most relevant: the first happens between May and June, and the second between August and September. In adequate conditions, the flowering period lasts from 3 to 5 days for female flowers, and from 12 to 14 days for male flowers. Normally, the number of female flowers is less than the male flowers.

#### **3.4.5. Fruit**

Fruits are drupaceous ovoid capsules, 1.5 to 3.0 cm. in diameter. They start fleshy, but become dehiscent when dry. The fruit development takes between 60 and 120 days (usually 90) from flowering to seed maturity depending on the variety. Similarly, breeding stops at the start of the rainy period. Fruits are often uneven, and the growth of late fruits start after the early ripening of fruits.

The fruit is trilocular (divided in three parts) with a seed in each cavity. It is formed by a pericarp or hard and woody skin, indehiscent (which doesn't open to release the seed) until maturity. It is initially green, changing to yellow, then brown, and finally black when it reaches maturity.



**Development of fruits in the Piñón**

### **3.4.6. Seed**

The seed is relatively big. When dry, it measures from 1.5 to 2.0 cm long and 1.0 to 1.3 cm in diameter. There is a white film below the seed's jacket (tegument) covering the almond: abundant albumin, white, oily, containing the embryo with two long and flat cotyledons. The Piñón seed weights between 0.551 to 0.797 grams. Depending on the variety and cultural treatments, it can have a proportion of 33.7 to 45% of skin and from 55 to 66% of almond. In those seeds, according to the literature, they concentrate: 7.2% of water, 37.5% of oil, 55.3% of sugar, starch, albuminoids, and mineral materials; being 4.8% ash and 4.2% nitrogen.

The seeds used in the dissemination should come from plants that have shown strength, health, and good productivity. The propagation system in nurseries is more rational and must be recommended. Being subject to better care in the first two years, the plant will certainly acquire greater resistance and better conformation. The germination of the seed lasts 15 days and can even start from the fifth day.

The seed storage should not exceed 10 to 15 months ensuring the quality of the seed the whole time and considering its oil content. Take into account the vigor of the seed.

The seed has an important content of protein (25-30%) and fat (55-60%).



Piñón seeds

**Table 1.** Seeds characteristics.

| <b>Content</b>          | <b>Mass 60%</b> | <b>Shell 40%</b> | <b>Flour</b> |
|-------------------------|-----------------|------------------|--------------|
| Raw protein             | 25.6            | 4.5              | 61.2         |
| Lipids (raw oil)        | 56.8            | 1.4              | 1.2          |
| Ash                     | 3.6             | 6.1              | 10.4         |
| Neutral detergent fiber | 3.5             | 85.8             | 8.1          |
| Acid detergent fiber    | 3.0             | 75.6             | 6.8          |
| Acid detergent lignin   | 0.1             | 47.5             | 0.3          |
| Brute energy (MJ/kg)    | 30.5            | 19.5             | 18.0         |

Source: J. de Jong. 15-03-2006, edited by W. Rijssenbeek.

### **3.5. Vegetative Cycle**

The seedlings develop in nursery for 3 months, and are transplanted to the field when they reach about 8 to 12 cm in height; or when they go from the Grassy phase to the woody phase, they can be taken to the nursery or directly to the cultivation field. Piñón is a perennial plant of rapid growth that starts producing (depending on the soil conditions) in between 6 months and a year, and its productive cycle extends from 45 to 50 years.

## **4. USES**

### **4.1. Agricultural reforestation.**

The Piñón is a type of potential use in deforested areas, constituting an excellent alternative for marginal, idle, and exhausted soils. It has a useful lifespan of 30 to 50 years. Piñón plants are cultivated as live fences in the tropics because the leaves, stems, and fruits are not eaten by livestock.

It grows without the need for protection and can be used as a hedge to protect crops. It is widely used as shade and ornament in parks and gardens. It has been used for a long time in Mexico and Guatemala to host an insect that produces a highly prized lacquer, which is used as coating to polish guitars and other wooden items.

In Madagascar, the plant is used as a tutor to support vanilla. In Cabo Verde and Bolivia, it has been planted at high densities in arid areas to control soil erosion.

## **4.2. Edible**

The seeds are laxative, but they partially lose that property when toasted, and are often eaten in some regions of Mexico. This plant has been considered toxic because alkaloids has been found in the seed, known as phorbol esters, which cause the laxative effect and some other symptoms. Only in Mexico, there have been found varieties with very low content of toxins, which are eaten roasted and prepared in traditional dishes by the people of the Papantla region in Veracruz, Othon P. Blanco in Queretaro (Makkar et al., 1998), Pueblillo in Veracruz, and Huitzilan in Puebla (Martinez et al., 2004). The cake resulting from the extraction of oil, which comes from toxic varieties, can only be used to produce fertilizers; after extracting the alkaloids, or if the cake comes from edible seeds, it can be used in animal feed.

## **4.3. Medicinal**

It is applied locally to treat algodoncillo, lip-fire, and bad-mouth; it has been attributed abortive properties. The leaves macerated in castor oil are used in home medicine to accelerate the discharge of infected pimples. Because of its property to coagulate blood immediately, the juice flowing from the trunk (the sap) is used as a hemostatic to contain bleeding from small wounds. Apart from its coagulant effects, the latex has antibiotic properties against some bacteria; it is applied directly to wounds and cuts as antiseptic, as well as on rashes, burns, and skin infections.

## **4.4. Industrial**

It is also used to prepare varnish after being burned with iron oxides, or as an excellent substitute for industrial oils. In Europe, it is used in the threading of wool and textile manufacturing. It is used together with ashes of burned bananas to make a hard homemade soap. The juice of the leaf dye fabrics with an indelible black color. The crust has 37% tannins that give a dark blue dye. Its latex also has 10% tannin and can be used as ink.

## **4.5. Fuel**

Te seed's oil is a renewable energy source, not conventional, affordable, and environmentally friendly; it is also a substitute for diesel, kerosene, and other fuels. The oil was used in engines in Africa during the Second World War. It burns without producing smoke and has been used for lighting some streets near Rio de Janeiro, Brazil. The shell of the fruit and its seeds can be used as fuel. Dry seeds covered with palm oil are used as torches, which stay lit even with strong wind.

**Table 2.** Biodiesel Properties

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|                             |                  |
|-----------------------------|------------------|
| Specific weight             | 0.870 to 0.890   |
| Viscosity 40 °C             | 3.70 to 5.80     |
| Ignition point              | 130 °C           |
| High caloric value (btu/lb) | 16,978 to 17,996 |
| Low caloric value (btu/lb)  | 15,700 to 16,735 |
| Sulfur (% of weight)        | 0.00 to 0.0024   |

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Bio-diesel has similar properties than conventional diesel.

### **Pure Plants Oil (PPO)**

The pure Piñón oil is an excellent fuel (engine must be modified) for its outstanding characteristics including: cetane number, and lower viscosity than other oils.

### **Biogas production with huskes of fruits**

O. Lopez, G. Foidl, N. Foidl, National University of Engineering, Department of Biomass, Managua, Nicaragua. Sucher & Holzer, Austria.

An anaerobic digestion was conducted in the laboratory using husks of Piñón fruits: the experiment was performed in an anaerobic filter with vertical flow of 23.8 liters. The reactor operating at room temperature. Retaining its mass 3 days and adding NAOH only at the beginning of the reaction to stabilize its pH.

2.5 liters of biogas were collected per day (70% methane). Material degradation was between 70% and 80%. To avoid an obstruction in the reactor, the fruits' husks were subjected to a pre-treatment to separate its fibers.

### **Biogas with paste resulting from oil extraction**

R. Staubmann, G. Foidl, N. Foidl, G.M. Gübitz, R.M. Lafferty, V.M. Valencia Arbizu, W. Steiner, Institute of Biotechnology, Technical University Graz, Austria, Biomass Project, National University of Engineering, Managua, Nicaragua.

Between 50% and 60% of the Piñón seeds' weight remains as paste resulting from the oil extraction. It contains protein, carbohydrates, and toxic compounds. Further treatment is required to feed animals with this past, which is a good substrate to produce biogas. Biodigestors with vertical flow have been used to obtain biogas, with filters in each reactor to obtain methane.

## **4.6. Domestic**

The seeds' oil is used for lighting, as a lubricant, and to produce soaps and paints.

## **4.7. Carbon Capture**

The capture of carbon from Piñón, as well as from other types of plantations, occurs only during the development of the plants until they reach maturity. Carbon is stored in trunks and branches. The amount of carbon dioxide (CO<sub>2</sub>) captured by the tree is just the small annual increment occurring in the wood of the tree, multiplied by the biomass of the tree that contains carbon. Between 40% and 50% of the biomass of a tree (wood: dry matter) is carbon. It is necessary to preserve the trees to prevent the carbon dioxide (CO<sub>2</sub>) they contain from being emitted into the atmosphere.

## **5. DEMANDS OF CLIMATE AND SOIL**

### **5.1. Climate**

The Piñón is found in tropical and subtropical climates, entirely planted below the sun, normally resisting the heat (35 °C). It bears little time under low temperatures (18 °C) and light frosts. Its water requirement is extremely low and can endure long periods of drought.

Ecologically, it adapts from very dry tropics with rainfall of 250 mm to humid subtropics with precipitations of more than 1500 mm. Piñón plants can be found between 5 and 1500 meters above sea level (msnm). Its development is best achieved on land located between 600 to 800 msnm. Relative humidity at night should be preferably low.

### **5.2. Soil**

Like any fruit crop, it grows better on deep soil, well-structured and prepared (sandy loam to clay loam) so its root system can develop and explore greater volume of soil, satisfying the need of plant nutrients. The most recommended pH range is between 6.0 and 8.0.

Avoid very clayey soils (+ 40% clay), superficial (-20 cm), with constant humidity, poorly ventilated, and difficult to drain (Peixoto, 1973; Brazil, 1985). It usually develops on arid and semi-arid soils, it is susceptible to flooding, and resistant to drought (Makkar et al. 1997).

## **6. RECOMMENDED AREAS**

According to the requirements of the crop (based on the criteria of the climate and soil in Honduras) the areas with greater potential to develop this crop are

found in the Departments of Yoro, Comayagua, La Paz, Choluteca, Valle, Intibuca, Ocotepeque, Santa Barbara, and El Paraiso.

## **7. VARIETIES**

The most famous variety is the "Cabo Verde" [green cape] developed in the western Africa Island of Cabo Verde. Among the characteristics of this variety are: small to medium size plant, produces many stems, it can be harvested from the first year, and it is resistant to adverse climate and soil conditions. There are other varieties developed locally in India, Brazil, and so on; but it is necessary to evaluate them commercially to have better arguments to distribute them to other areas.

When the biofuels project started in 2006, the only variety with available seed was one brought from India in 2005. It was sown in El Salvador, and since those seeds were provided to us, it was named "India Salvadorean" for handling purposes. Its characteristics (still under evaluation) are: average growth, with some plants with many stems on loam soils and with one or two stems in heavier soils, with harvest from the first year in loam soils and from the second year in heavier soils.

Being located in the center of origin of this plant, it is possible to find other varieties with similar or better performance than the Cabo Verde. That is why our work in identifying highly productive plants should go in the selection of grounds in different areas of the country. The following are desirable characteristics:

1. Low to medium high altitude grounds
2. A greater number of primary branches, counted from the base.
3. A greater number of fruits per cluster.

## **8. PROPAGATION**

The Piñón can be spread sexually by seed and asexually by vegetative parts (cuttings). It can also spread through grafts (experimentally). The results to date are more inclined to use the seeds, because the plants propagated from seed show faster development and a stronger root system. The plants propagated vegetatively produce earlier but, in the absence of the main root, their root system is weaker; causing the tipping of the plant by its own weight and the loss of harvest in the absence of a suitable anchor. Vegetative sowing is very common in live hedges and on the delineation of boundaries; wire and pruning maintain the plant in a manageable size as a hedge pole, but with little production.

## **8.1. Propagation by seed**

The seeds have to be selected before sowing. The choice should be by size, preferring the larger seeds (> 17 mm). Preferably, the seeds must be recently harvested or previously stored under proper temperature and humidity for up to 3 months, free of mechanical damages, insects, etc. The seeds can be spread by using two alternatives depending on the percentage of germination. When the seed has less than 80% germination, it is better to use sowing to place only germinated seedlings in the bag. When the seed has more than 80% of germination, there is no need of sowing and can be planted directly in the bag or in the field. In the case of the Piñón seed intended for planting, the storage time should be reduced after being cut, because it is a seed with high oil content and quickly loses its germination power.

## **8.2. Propagation by stem cuttings**

The first Piñón plantings were established with stem cuttings. There is evidence in live hedges in several places in Honduras.

In the absence of a pivotal root system, the wire fence keeps the plant upright. Commercially, planting large areas by stem cutting is not suitable because although its preliminary development is greater and seeds production is sooner, long term sustainability is threatened by the weight of the harvest tipping the plants lacking the main root. However, all the boundaries and fences in many farms can be used for stationary production during the rainy season.

### **8.2.1. Preparation of the stem cuts**

After pruning of the Piñón, the vegetative material larger than one meter long can be used, removing all the foliage and young parts, placing it vertically inverted in the shade to heal and prevent dehydration for about 3 days (similar method to that used with cassava stems).

The best time for this activity is during summer, because during winter the soil moisture can promote the entry of fungi and cause spoilage. Once healed, the stem is planted burying between 10 to 15 cm in its place and leaving free the rest above the ground. In our conditions, planting is done in April so the root is formed before the rainy season; that is when it needs to absorb nutrients for the formation of its foliage structure.



Live hedge of Piñón

## **9. SOWING AND NURSERY**

### **9.1. Sowing**

As cited in the paragraph related to seedlings, it is important to emphasize that sowing is a technique used only when the seed has little germination rate. The aim of this activity is to provide a place with suitable temperature and moisture to sprout embryos, and plant in nurseries only those seedlings that emerged.

#### **9.1.1. Steps to establish the sowing**

##### **a. Site selection**

Select a location protected from flooding, near to the nursery, and with access to a permanent source of water.

##### **b. Cleaning and leveling**

The selected grounds for sowing should be preferably flat. The first task will be weed control, removal of rocks and logs, and leveling of lower areas.

##### **c. Fencing**

To avoid negative situations with pets, it is preferable to enclose the seedlings, placing around them a 1.5 m high wire mesh.

##### **d. Materials for sowing**

4" cement blocks or flaps of wood can be used as borders for the seedlings perimeter. Pine sawdust is used as stuffing inside, preferably of thick fiber.



**Sawdust substrate used in the sowing (left) and germinated seedlings (right)**

**e. Sowing field dimensions**

The size of the sowing field will depend on the area to plant. Our suggestion is 1.2 m wide and as long as needed. For one hectare of land, 1.2 m wide and 2.0 m long is enough sowing field to plant 1 to 2 kilograms of seed.

Within the perimeter we place a layer of pine sawdust, 4 inches thick, to generate heat and accelerate the germination of seeds.



**Preparation of the perimeter wall**

**9.1.2. Steps for sowing**

**a. Level the sawdust bed before proceeding to mark the furrows.**

**b. Mark Trenches on the sawdust**, 15 cm from each other, perpendicular to the length of the bed. Then the seeds are planted horizontally inside the trench, 1 inch deep, one after the other.



Leveling of the sawdust bed.



Sowing in furrows.

c. Cover the seed with a layer of sawdust, whose thickness should have at most twice the thickness of the Piñón seed.



Cover the seeds with sawdust



d. **Germination.** Piñón seeds start germinating after 7 days and continue until 15 to 20 days (a reasonable time to achieve proper development of roots, stems, and first leaves), allowing the seedlings to be moved to a bag without stress problems.



Piñón germination.



Seedlings ready for bagging.

After the seedlings have germinated (since the sowing field is only a steril environment to germinate without nutrients) it is preferable to keep them there the shortest time possible to ensure a smooth development in the next stage of nursery. The most suitable time for transplant is when the emerging of true leaves starts.

### **9.1.3. Sowing field care**

#### **a. Irrigation**

Moisture is essential for the germination of seeds. It is recommended to apply deep daily irrigation before sprouting (1st to 5th day) and alternating every 3rd day after germination.



Applying irrigation to Piñón sowing field

#### **b. Weed control**

In the seedbed, sawdust serves as a mechanical medium to accelerate the germination of plants. This medium does not nourish them, and if additionally we allow weeds to grow, weeds will compete for space, light and nutrients, delaying the growth of our newly sprouted seedlings. The best way to control weeds is through manual cleaning, removing the roots of the weeds without harming the Piñón seedlings.

#### **c. Fertilization**

Since the time of the seedlings in the sowing field is very short, fertilizers are not recommended, leaving this activity for the nursery stage.

#### **d. Monitoring of pests and diseases**

The time that the seedlings will remain in the sowing field is short, and the presence of cuts should be monitored to avoid the loss of seedlings by worms, crickets, lizards, etc. The most critical period is during the first 10 days, while the stems are tender and juicy.

Seeds take 5 to 10 days to sprout and will be ready for transplant to bags in 10 to 15 more days when they are about 15 cm in height and have 2 to 3 true leaves.

## **9.2. Nurseries**

The nurseries aim to complete the preparation of the seedlings that come from the sowing field, so they get ready for their final destination: the farm.

### **9.2.1. Steps to establish the nursery**

#### **a. Preparing the soil mixture**

Generally, loam soil should be chosen. Husk can be added as a source of organic matter in 2:1 ratio (double measure of soil). It can also be mixed with organic matter like dry manure in the same proportion. This mixture allows better aeration, good root development, and adequate moisture content.



**Soil preparation for nursery**

#### **b. Bag size**

The size of the bag used in the nursery will depend on the time that the plant is going to stay in it before replanting. The small bag of 6" x 7" is designed for plants that are going to stay in the nursery for only 25 to 30 days. The plants that will stay more time in the nursery need larger size bags, like 7" x 8". This also applies if the nursery is far from the replanting field. The plant established in a larger bag resists more moving conditions.

#### **c. Filling bags with mixture**

Fill up 3/4 of the plastic bags used for this operation with soil mixture. The size of the plastic bags used in the nursery depend on the time that the seedlings will stay in the nursery. For a stay of 2 months in the nursery, a bag of 7 x 8 inches (18 x 21 cm) is recommended; this prevents the roots of the plant from being distorted while reaching its definitive site. For less time, a smaller bag could be used; for example: 4 x 5 inches (10 x 13 cm).



**Filling the bag with soil mixture**

**d. Establishing the nursery**

Similar to the sowing field, the first task is the removal of weeds and rocks, to then proceed to level the ground, before placing the bags.

**e. Moving and forming terraces**

The bags filled with soil mixture should be moved to the nursery where they are lined up in terraces, placing 8 bags at the head and as long as convenient, according to the measurements of the nursery. In works carried out by the FHIA in Ayapa, Yoro, 12 terraces were established with an average of 1250 bags/terrace; and 7 terraces in Sulaco, with an average of 1100 bags/terrace.



**Terrace with bags**

**f. Size of the nursery**

The size of the nursery depends on the area for planting. For one hectare, 1666 plants are needed in rectangular plantings of 3.0 m x 2.0 m (1166 plants/set),

and these plants can be placed in 4 terraces of 5.0 m x 0.80 m in an area of 16 m<sup>2</sup> with two separations of 0.90 m between terraces.



**Terraces under shading**

**g. Shading**

To succeed in the propagation of Piñón plants, shading must be provided during the first weeks to reduce solar incidence, stress, and irrigation cycles. Shading can be artificial using saran shade cloth with 60% light reduction, or the natural shade of trees (eg Guanacaste).



**Artificial shading**



**Natural shading**

**9.2.2. Transplanting with bare root**

The following tasks should be performed before transplanting:

**a. In the sowing field**

1. Moisten the seedbed to facilitate the extraction of the seedlings.
2. Choose the seedlings by size to establish more uniform sections.
3. Eliminate defective plants (twisted roots, etc.).

**b. In the nursery**

1. The hole in the ground, inside the bag, must be the size of the root of the seedling. If the root is bigger, you can prune part of it; in this case it will be necessary to apply a protective fungicide solution in the dose recommended by the manufacturer (eg: Captan).

2. Spread the roots inside the hole, ensuring that they are distributed (not tied) and cover with soil to mark the neck of the plant. Water it generously every day during the first week, alternating the following weeks.



Planting a bare root (left), which is planted in the bag (right).

**9.2.3. Taking care of the nursery**

The plants will stay in the nursery between 1 and 2 months. For their normal growth, it is necessary to give them the following care:

- **Fertilization**

Foliar application of a nitrogen solution every 15 days (1 ounce of 46% Urea in 1 gallon of water). Apply a glass of this solution to the feet of the seedlings.

- **Pests**

Especially during summer, search every two days for the presence of pests, observing the damage to leaves and stems caused by worms, crickets or ants, selecting the type of control to be used. Two pests caused damages to some plants in the nursery in Ayapa, Yoro. Beginning with zompopos ants (*Atta* sp.) devouring the foilage, which were controlled with applications of Mirex to the pockets. The other pest found in some plants during the month of May was the blind chicken scarab beetle (*Phyllophaga* sp.), whose larvae damage the root system, causing the death of the seedlings.



*Zompopos (Atta sp.)*

- **Illness**  
During the period of nurseries in 2006 using the Indian Salvadorean variety of Piñón, no illness problems were reported. In nurseries established in 2007 with the variety Cabo Verde (green cape), damage to the foliage was caused by rust and canker (*Colletotrichum* sp.); that was controlled by reducing the cycles of watering, and applying a fungicide solution (Manzate) in doses of 1.0 liter/ha.
- **Irrigation**  
When the nurseries are established during dry season, the seedling should be irrigated twice a week.
- **Weed control**  
Should be done by hand inside the bag, and between the rows of the terraces.

## 10. FINAL TRANSPLANT TO THE FIELD

### 10.1. Main activities

#### 10.1.1. Selecting the plants

After the plants are ready in the nursery, it is necessary to make a selection to ship them to the field by size; choosing only those seen as healthy, strong, and with thick stems.

#### 10.1.2. Selecting the ground

Although Piñón crops can survive and accept different soil conditions, only loam soil with good drainage, flat or slightly inclined, can be considered for long-term commercial production

### **10.1.3. Soil sampling**

Whether the planting will be by transplants or direct seeding, soil sampling serves to ensure that plantations receive proper nutrition at every step of their growth. It is necessary to obtain soil samples one month before transplanting, then send them to a laboratory to be analyzed; and based on the results of the analysis, prepare a fertilization program according to the nutritional needs of the crop.



**Soil sample**

### **10.1.4. Preparing the field**

Piñón is a perennial plant that will remain for many years in the same place. Proper soil preparation is needed to ensure the development and production of this crop, using machinery or oxen to break a layer of at least 20 cm deep. The soil can be prepared dry or at the point of friability, depending on its texture and structure. The definite area where the field will be, should be subsoiled, crawled; and if the soil analysis in a laboratory indicates imbalance, make the correction of the acidity of the soil.

Instead of making 30 cm holes, it is advisable to use a subsoiler with one iron only, making the clearing in the line of sowing. After subsoiling, make the hole with a hoe to the proper depth, according to the size of the Piñón roots.



**Plowing with a tractor.**



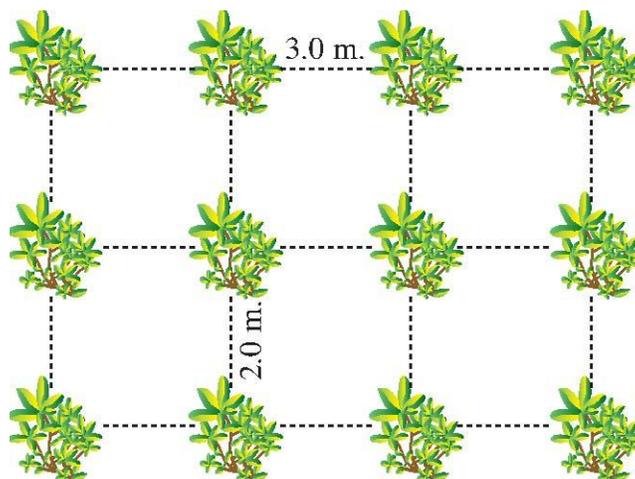
**Plowing with oxen.**

### 10.1.5. Whitewashing

Piñón roots do not develop in acid soils with pH below 4.5, being necessary to apply calcium oxide. The amount needed to apply will depend on the results of chemical analysis of the soil, which will indicate the amount of calcim, gypsum, and macro and micro nutrients needed to meet the requirements of the crop. Whitewashing must be done 3 months before sowing, with calcium oxide at a depth of 20 cm in two applications, the first before plowing and the second when the plough passes to correct the soil (Peixoto, 1973)

### 10.1.6. Planting density

| System     | Distances (m)  | Plants/ha       | Plants/mz       |
|------------|----------------|-----------------|-----------------|
| Square     | 2.0 x 2.0      | 2,500           | 1,750           |
|            | 2.5 x 2.5      | 1,600           | 1,120           |
| Rectangle  | 3.0 x 2.0      | 1,666           | 1,166           |
|            | 4.0 x 2.0      | 1,250           | 875             |
|            | 4.0 x 1.0      | 2,500           | 1,750           |
| Live hedge | 1.0 continuous | 1,000/km linear | 1,000/km linear |



Tracing a sowing in a 3 m x 2 m rectangle with 1666 plants per hectare.

Piñón plants planted in high densities (2500 plants/ha) produce less individually than those planted in lower density (1666 plants/ha), but collectively their production is similar.

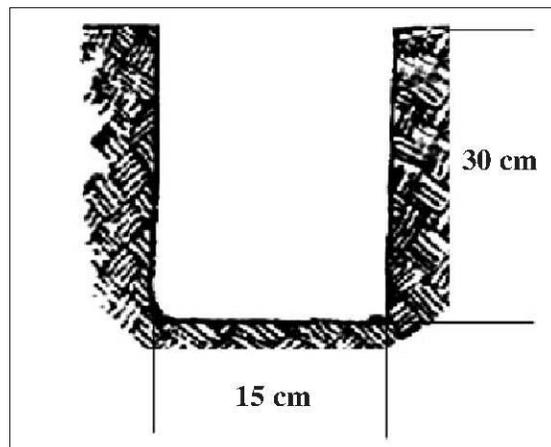
### 10.1.7. Plants distribution

To facilitate transplant, plants must be transported in groups, placing them near the hole.

## 10.2. Transplant

### 10.2.1. Holing

The first step in the ground already prepared and traced is to make holes; according to the size of the block of soil in the bag, and the size of the plant. A suggested average size would be 30 cm deep and 15 cm in diameter, as shown below.



Size of the hole.

### 10.2.2. Eliminating the plastic bag

The second step is the elimination of the plastic bag. To do this, a cut is made at each side of the bag, sliding it outward while placing the plant in the bottom of the hole.

### 10.2.3. Sowing

The plant is leveled as the third step, leaving its neck at ground level. It is straightened and its roots are covered with soil. At the end, some pressure must be exerted downward on the soil to remove any air pockets.



Transplanting.

#### **10.2.4. Sowing time**

The planting should be established under the right humidity and temperature conditions, coinciding with the rainy season, starting in May and ending in November. Plantings outside this period are only possible if there is an irrigation system.

### **11. DIRECT SOWING**

This modality is only possible during the winter or when there is an irrigation system, but especially with good seed germination (+ 90%).

#### **11.1. Soil preparation**

It is very important to prepare the soil because Piñón germinates at the same time as weeds, sharing nutrients, space and light. If the land selected is loam soil and it has been previously used with annual crops, its preparation should consist of one pass of plow and two passes of plough (first North to South, and second East to West) to incorporate the crop residues or weeds. Also, the ground can be prepared with the help of oxen.



**Soil prepared for Piñón sowing.**

#### **11.2. Supplies applied**

After preparing the soil, it is important to prepare the supplies to be used in planting:

- Seeds selected: big (+ 17 mm) and of good germination.
- Insecticide - nematicide: Curato 10 GR (Terfubos), Counter, Furadan (Carbofuran), Diazion (granulated)
- Fertilizer: a few grams of formula type 12-24-12.

#### **11.3. Sowing distance**

The distance of sowing varies according to the purpose of our plantation. If the plantation will be associated with another annual crop, the rows of sowing will be handled in the form of hedges; and the seeds are planted 1.0 m inside the row, leaving enough space between the rows for the associated crop. 1.0 m x 4.0 m or 1.0 m x 5.0 m are the most appropriate combinations because they allow the planting of several lines of annual crops without disrupting the development of the Piñón.

#### **11.4. Sowing depth**

At the distance agreed, a 3 cm deep hole is made where the seed is sowed.

#### **11.5. Herbicides application**

While the Piñón develops its toxins, it can be easy prey to insects and rodents that use weeds as cover. Therefore, it is necessary to apply a preemergent herbicide over the soil surface to control weeds and allow a good development of the emergent Piñón plants. A glyphosate in doses of 1.5 liters/ha can be used as herbicide, applied on the soil surface immediately after sowing.

### **12. PLANTATIONS HANDLING**

#### **12.1. Fertilization**

The nutrition of the Piñón crop guarantees success in production. It will be according to the soil analysis results, which should include the necessary doses of nitrogen (N), phosphorus (P), and potassium (K), in addition to micronutrients.

A preliminary recommendation for a Piñón plantation sowed at a distance of 2.0 m x 3.0 m (1666 plants/ha) would be:

- From its first year: apply 20-40-20 kg/ha of nitrogen (N), phosphorus ( $P_2O_5$ ), and potassium ( $K_2O$ ).
- From its second year: apply 40-20-40 kg/ha of nitrogen, phosphorus, and potassium.

Tests conducted so far have shown that the Piñón responds to the application of nutrients, both organic and inorganic. Therefore, it is advisable to apply chemical fertilizers right after transplanting and during the first year. From the second year proceed to apply a chemical-organic mix, distributing the crop residues at the base of the plants.

#### **12.2. Pruning**

The purpose of pruning is to cause the growth of several main stems, to increase the number of clusters per plant. Depending on several factors like

variety, soil conditions, and so on, the Piñón crop is pruned in 2 ways: training and maintenance. Training pruning is done 2 months after transplant or direct sowing (done with scissors, knife, or machete), removing the apical part of the plant; especially in the variety Cabo Verde, at a height of 35 to 45 cm. This practice is done at the beginning of the rainy season, leading to the development of lateral branches. Training pruning aims to keep the plant at a height that makes the different field works efficient. In this case the plantation should be kept at a height not higher than 2.0 m. Training pruning of adult trees must be done between March and May to maintain the height of the trees and facilitate harvesting fruits.

### **12.3. Irrigation**

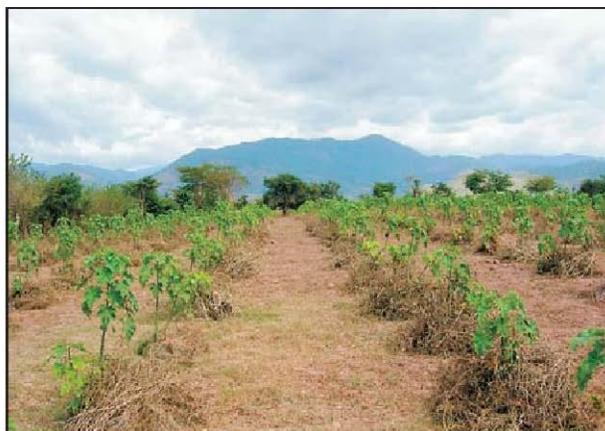
The Piñón plant can survive with a yearly rainfall of only 250 mm. However, to ensure production throughout the year, the plant needs between 600 and 1000 mm of continuous and evenly distributed water. Long drought with low temperatures could stop the growth of new flowers, which may adversely affect the crop yield.

Continuous irrigation can increase the harvest from 6 t/ha/yr to 10 t/ha/yr, harvested during all 12 months.

The type of irrigation will depend on the source and flow of water. Modern commercial plantations use preferably two types: drip irrigation or micro irrigation.

### **12.4. Weeds control**

Cleanliness is essential to allow the development of Piñón plants and their production. When the plant is small, weeds (grasses and broadleaf) grow in the interlining space, especially during the rainy season, competing for nutrients, water, space, and can host pests and diseases. During the plantation's first year, cleaning is done by hand using machete, motorized bush cutter (weedwhacker), and so on. Cleaning work is carried out every 3 months and it is nearly the most expensive component. One way to lower this cost is planting annual crops in association, which provide extra income for the producer while s/he begins to harvest the Piñón. It is also needed to clean during summer time, placing cutting waste (as mulch) at the foot of the Piñón plants. When the plant is older than a year, the cleanup can be done as integrated control by lowering the size of the weeds with a low-cut and applying a herbicide to eliminate weeds from their roots. This activity must be done in times with no wind, applying the product with care on the weeds and not on the Piñón. There are several products that can be used for chemical control, like the glyphosate in doses of 1.0 liters per ha.



A proper weed control will allow a better crop growth.

## 12.5. Pests and diseases

### 12.5.1. Pests

The main pests found in Piñón plants in Yoro, Honduras, are the red dot bedbug (*Pachycoris klugii* Burmeister) and the leaf-footed bug (*Leptoglossus zonatus* Dallas). Occasionally, other pests are present such as the green bug (*Nezara viridula*), the fluory cochineal (*Pseudococcus* sp.) and Zompopos (*Atta* sp.).

#### a. Red dot bedbug (*Pachycoris klugii* Burmeister)

This pest belongs to the Heteroptera order and the Scutelleridae family. Its natural host plant is called Chichicaste (*Cnidoscolus multilobus* Pax).

**Distribution:** it is a common species in Mexico and Central America.

**Damage:** it cause damage sucking the Piñón fruits in various stages of development; other microorganisms penetrate through the wounds, that cause decomposition and abortions. Deformed fruits may or may not contain seeds.

**Control:** apply insecticides such as Monarch, Karate 2.5 EC in doses of 360-500 ml/ha.



Red dot bedbug

**b. Leaf-footed bug (*Leptoglossus zonatus*)**

The second most frequent pest in this crop is the leaf-footed bug of the Heteroptera order and the Coreidae family.

**Distribution:** it is in almost all America; from USA, Mexico, Central and South America.

**Damage:** the damage is present in both the flower and fruit; drying the flowers, deforming the seed, and dropping the fruit.

**Control:** the same control used for the red dot bedbug.



Leaf-footed bug

**c. Green bedbug (*Nezara viridula* L.)**

**Description:** This green color bedbug, called stinky bedbug, belongs to the Heteroptera order and the Pentatomidae family.

**Distribution:** Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Colombia, Venezuela, French Guiana, Brazil, Uruguay, Paraguay, Argentina, and Chile.

**Control:** the same control used for the red dot bedbug.

**d. Floury cochineal (*Pseudococcus* sp.)**

**Description:** it belongs to the Homoptera order and the Pseudococcidae family.

**Distribution:** it is located in citrus crops and occasionally in Piñón crops.

**Damages:** it damages the first flowers of Piñón, aborting the flowers (present in Yoro and Honduras during the first quarter of 2008).

**Control:** application of insecticides type Karate 2,5 CS in doses of 360-500 ml/ha or MTD 60 in doses of 1.0 to 1.5 liters/ha.

**Mutualism between ants and Pseudococcus.** Many ants take care of Coccoidea species to collect honey dew. It is an important food for the ants because it is rich in sugars, amino acids and waxes (Gonzalez-Hernandez, Gull and Kosztarab, 1997). In some ant-Coccoidea associations, Coccoidea species are preyed by the ants; perhaps as a source of proteins and lipids, or as a means of regulating their food resources. The ants look after the Coccoidea, arresting predators and parasitoids, and additionally removing honey dew. Honey dew affects the Coccoidea communities, and serves as a substrate for fumaginas and other fungi.

**e. Whitefly (*Bemisia tabaci*) (*Ennadius*) (*Bemisia argentifolii*) (Ellows & Erring)**

**Description:** there are 7 biotypes known of this species worldwide, making it difficult to produce a taxonomy of this highly variable species.

**Distribution:** Europe, Africa, Asia, Hawaii, USA, Mexico, Barbados, Cuba, Dominica, Jamaica, Puerto Rico, Guatemala, Honduras, El Salvador, and Nicaragua.

**Damage:** they are recognized as sucking insects, virus transmitters.

**Control:** products application such as Actara (Tiametosam) 250-400 grams/ha.

**f. Zompopos (*Atta* sp.)**

**Description:** this small insect belongs to the Hymenoptera order and the Formicidae family.

**Distribution:** Central America.

**Damage:** colonies are very active, especially during the night, causing defoliation in different types of plants.

**Control:** placing poisoned bait or Mirex in the drop pockets. 1.5-2.0 kg/ha or Blitz (Fipronil) 0.003 GR, in doses of 10 grams/square meter.

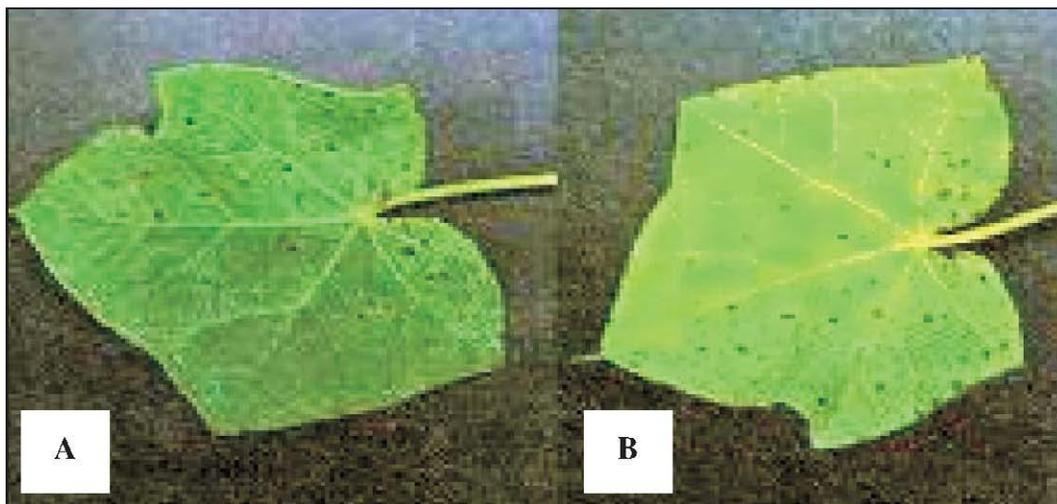
### 12.5.2. Diseases

There are several diseases that cause problems for the Piñón crop, such as:

**1. Angular stain on the Piñón**

- a. Causative agent: *Xanthomonas axonopodis* pv. *malvacearum* (bacteria).
- b. Symptoms/signs: the disease manifests itself as a dark brown stain delimited by veins, which cause the angular shape. A yellow halo exudes

around the stain. With aging, the stain becomes necrotic and takes a whitish coloration in the center.



**Angular stain on Piñón: A. Top & B. Underside**

## **2. Little pigment or circular stain**

- a. Causative agent: *Dothiorella* sp. (Fungus).
- b. Symptoms/signs: circular and small yellow stains. It is possible to observe fungal structures on the underside of the leaf. When the attack is severe, all the leaf lamina is covered with stains.



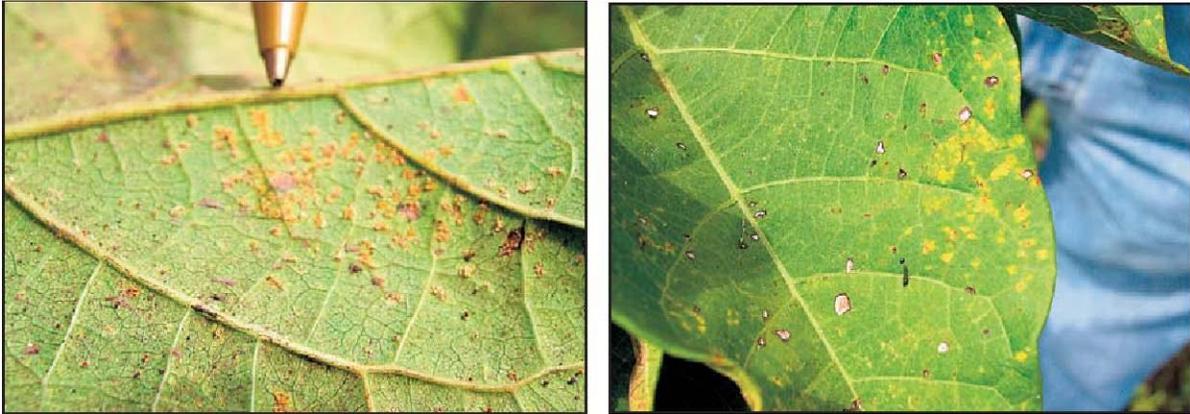
**Circular stain on Piñón.**

## **3. Anthracnose**

- a. Causative agent: *Colletotrichum gloeosporioides* (Fungus).
- b. Symptoms/signs: large and irregularly shaped necrotic stains. Symptoms usually start at the edges moving toward the center of the leaf. Fungal structures can be observed on the underside of the leaf, in the form of dark brown or black spots known as acervulus.

## **4. Rust**

- a. Causative agent: *Phakopsora* sp., *Aecidium* sp., and *Uromyces* sp. (Fungi, required parasites).
- b. Symptoms/signs: orange to light brown pustules are observed on the underside of the leaves. Yellow stains can be seen in the area of the visible pustules on the underside. These pustules contain large number of spores which can be spread by wind, water, or insects



**Pustules (A) and chlorotic stains (B) typical of the physic nut rust**

### **5. Yellow mosaic**

- a. Causative agent: Virus from the Begomovirus group (virus transmitted by whitefly).
- b. Symptoms: yellow stains pronounced in the nervs. Similar to some nutritional deficiencies. Sick plants have reduced growth.



**Yellow mosaic on Piñón**

### **Disease management of the Piñón**

In Honduras, there is lack of experience in disease management of this plant. The general recommendations shown below will help minimize the damage caused by diseases.

1. Establish the planting at sites with good drainage. The majority of soil diseases are favored by high humidity.
2. Use healthy sowing material, coming from disease free areas.
3. Proper weeds control. Weeds serve as hosts for pests and crop diseases.
4. Proper pests control. In addition to cause direct damage to the crop, pests can serve as vectors of pathogens. In the case of the Piñón, whitefly control can minimize the risk of those viral diseases transmitted by this insect.
5. Balanced fertilization, based on soil analysis and crop requirements.
6. Suitable distance between plants. High densities of plants should be avoided.
7. Pruning, to remove old or poorly formed tissue that can serve as inoculum source of pathogens.
8. Clean work tools before and after performing tasks in the crop.

### **12.6. Harvest**

The harvest of Piñón is done manually by collecting mature fruits. The first harvest is reaped from the 1st year, three months after flowering. Initially small, grows after successive harvests until stabilized between the 5th and 6th year. The fruits are ready for harvest 90 days after flowering, when the fruits are yellow and the seeds have reached their maximum development. Being a manual process, collecting the Piñón seeds is a source of rural employment. A person can reap up to 30 kg of Piñón fruits per hour. After harvesting, the fruits are taken to a terrace (as the one used to dry coffee) to lose moisture, dry, and remove the seeds before being stored.

#### **12.6.1. Seed yielding**

From the 5th year, adult plants can produce an average of 4 to 6 tons of seeds per hectare, after several cuts. The results of recorded production vary, depending primarily on the soil characteristics, rainfall or permanent irrigation, plantations structure, sowing period, and the plants' age.

**Table 3.** Average productivity projection, estimated per plant under very favorable crop conditions.

| Product<br>(kg)       | Years |       |       |       |       |       | Average<br>1-30 |
|-----------------------|-------|-------|-------|-------|-------|-------|-----------------|
|                       | 1-2   | 3-4   | 5-6   | 7-8   | 9-10  | 11-30 |                 |
| Seed                  | 0.10  | 2.00  | 4.50  | 6.00  | 7.50  | 9.00  | 5.40            |
|                       | 0.80  | 4.00  | 5.50  | 7.00  | 8.50  | 10.00 |                 |
| Oil 35%               | 0.035 | 0.70  | 1.60  | 2.10  | 2.60  | 3.15  | 1.90            |
|                       | 0.280 | 1.40  | 1.90  | 2.45  | 3.00  | 3.50  |                 |
| Bio diesel            | 0.034 | 0.67  | 1.55  | 2.03  | 2.52  | 3.06  | 1.84            |
|                       | 0.270 | 1.36  | 1.85  | 2.38  | 2.90  | 3.40  |                 |
| Glycerin              | 0.003 | 0.060 | 0.150 | 0.180 | 0.250 | 0.300 | 0.18            |
|                       | 0.025 | 0.130 | 0.170 | 0.230 | 0.290 | 0.340 |                 |
| Co <sub>2</sub> catch | 1.60  | 4.80  | 8.00  | 8.00  | 8.00  | 8.00  | 6.00            |
|                       | 3.20  | 6.40  |       |       |       |       |                 |
| Paste                 | 0.05  | 1.5   | 2.5   | 3.5   | 4.5   | 5.5   | 3.17            |
|                       | 0.45  | 2.0   | 3.0   | 4.0   | 5.0   | 6.0   |                 |

Bio-diesel has similar properties compared to conventional diesel

### 12.6.2. Oil yielding

The seeds have between 35 and 38% of oil, producing from 1,500 kg to 2,000 kg of oil per hectare from the 4th to the 5th year.

## 13. SEEDING IN ASOCIATION

Associating the Piñón with annual crops is another farming practice that allows an additional income from the crop, providing higher returns on the intensive use of land. Taking the soil and climate into account, in the areas with greater ability to grow Piñón, it is suggested the use of plantations interlaced with peanuts, sesame, or soy; which in addition to increasing the supply of vegetable oils per unit area, presents other legumes, as well as the advantage of promoting the fertilization of soils. Additionally, as a way to keep the interlineal area clean and get other income, Piñón crops can be combined with annual crops such as corn and beans or crawling legume during the first year. It is not good to associate Piñón with Higuierilla or yucca plants, because they are of the same family and susceptible to the same pests and diseases.

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