



COLLECTION
PRO-AGRO

Improved
**plantain
production**

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General

information

Plantains are able to adapt to a variety of ecosystems and offer great potential in food production; however, despite this, plantain cultivation remains a marginal activity.

The cultivation of plantain is underexploited due to inadequate provision of good quality propagation material. The negative influence of parasites also leads to the use of poor quality suckers, resulting in a growth cycle of over two years. The return on the effort put in by farmers is therefore unsatisfactory, leading to further discouragement among plantain growers.

Fortunately, a number of intensive production techniques have been developed, including *in vitro* cultivation, typically used in research centres, and macropropagation using the plantlet from stem fragments (usually named the PIF technique) whereby the primary buds of entire suckers or fragments of corms are destroyed and axillary buds are exposed to high humidity to induce sprouts which are then harvested, hardened, and distributed. PIF has met with great success among small-scale farmers because it is relatively easy to produce large numbers of plantlets in a short time. One sucker can produce between 10 and 50 plantlets, depending on the variety of plantain and the experience of the farmer.

The procedure described in this manual may vary according to the needs and means of individual farmers, but it is important to follow the basic principles.

1

MAIN STAGES IN PIF PRODUCTION

1.1 Making a propagator

Propagators, or seedbeds, can be made from wood, plastic or cement, constructed at ground level or above ground. Their size can vary and depends on the production objectives.

The most important thing is that there is easy access to the explants. They can be built with planks of wood, cement blocks, etc.

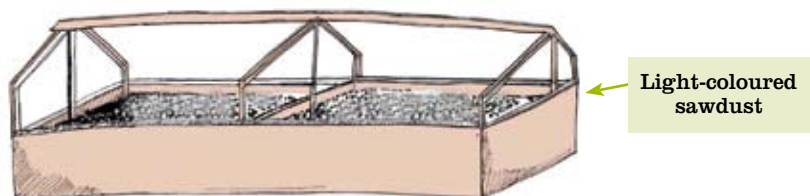
Recommended dimensions: One metre wide, with variable length. A propagator of 1 m x 10 m is a good size, allowing for easy handling of the explants.



Propagator dimensions

Depth is 25 to 50 cm. The base is sealed in order to prevent direct contact between the substrate and the ground below. A 10 cm layer of fine sand or gravel can be added to the bottom, or a sheet of polythene, perforated in order to allow drainage from watering.

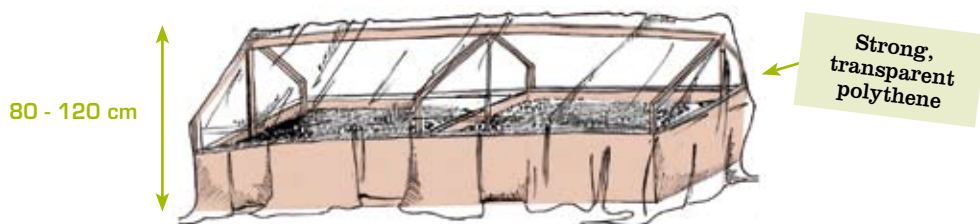
The seedbed is filled with a layer of light-coloured sawdust approximately 20 cm deep. Avoid using sawdust from coloured wood (dark, red or yellow) as this may contain substances that are potentially harmful to the development of plantlets.



⬆️ **Propagator or seedbed**

1.2 Greenhouse

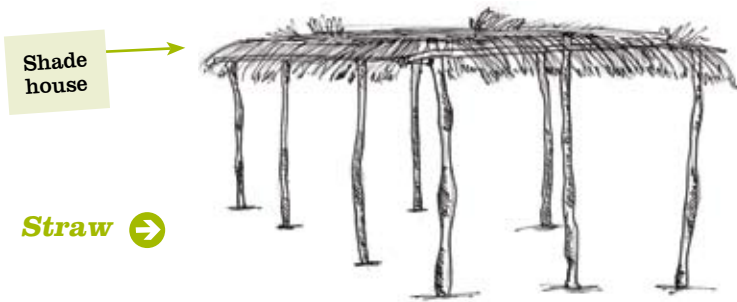
The greenhouse is built around the propagator. Build a framework 80 cm to 120 cm above the seed flat. It is best to make two slopes in order to facilitate runoff in case of rain. The propagator should be hermetically sealed with strong, transparent polythene.



⬆️ **Greenhouse**

1.3 Shade house

The material used will depend on availability and resources (palm fronds, straw, netting, etc.). It should be 1.5 – 2 metres high, and should reduce sunlight on the seedlings by about 50 percent.



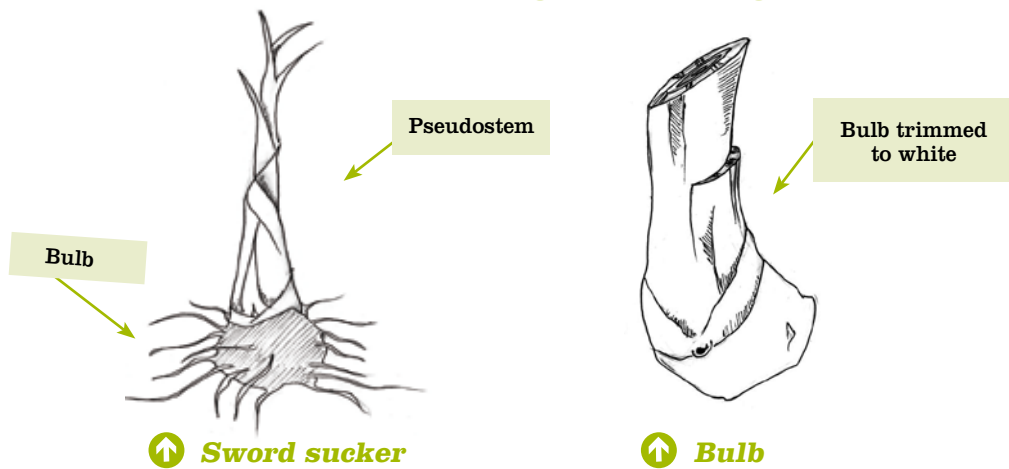
1.4 Selecting suckers

Selection is the key to the whole operation: remove a healthy sucker from the base of a fully grown cultivar. The sucker should have narrow, sword-shaped leaves, with a pseudostem of 5 to 40 cm in height (sword sucker), and the bulb should be free from traces of disease (no fringing or traces of nematodes).

1.5 Cleaning and trimming

This involves cleaning the bulb with a sharp knife or machete. The top of the bulb should be removed, as well as all the roots, up to 3 to 5 mm. Once trimming is completed, the bulb should be totally white.

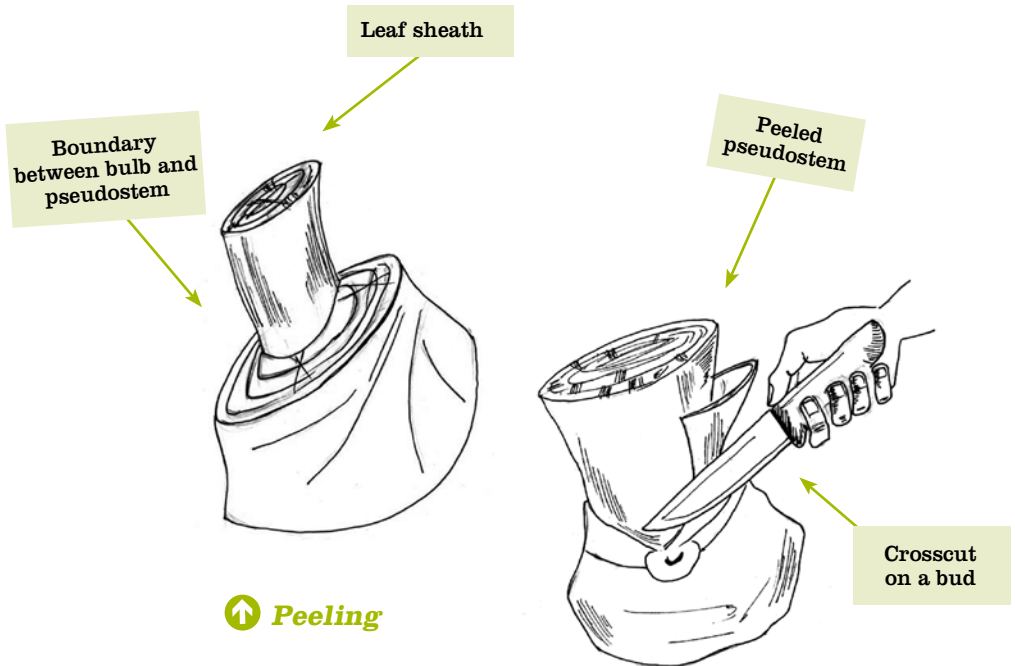
Before and after cleaning and trimming



1.6 Peeling

The success of the procedure depends on this stage. Note that the base of the plantain plant has a conical pseudostem formed by the leaf sheaths of its spirally arranged, long, thin leaves. Peeling involves removing these leaf sheaths one by one. At the level of the bulb, there is a light-coloured band (the colour depends on the variety) that attaches each leaf sheath to the bulb; this is called the knot.

Each leaf sheath has a knot. Peel up to 2 mm above the knot. Remove the sheaths one by one, generally 3 to 5 layers. The pseudostem should be cut back to 1 to 2 cm above the stem's last visible knot. Make a right-angled crosscut on the bud at the starting point of each leaf sheath.



1.7 Phytosanitary treatments before propagation

In order to eliminate fungus, insects and nematodes, the peeled stem is then soaked in a mix of fungicide and insecticide, then dried in the open air, in a dry, shady place for between 48 and 72 hours. There are a number of different products, with different instructions for use. The local agricultural service provider should be contacted for specific information. For example, the peeled bulbs can be soaked in a mix made up of 100 g of Callidium 50EC and Ridomil Plus in 40 litres of water. The precise amounts of pesticides should be added to the water while stirring.

By way of example, the following table shows some commercial pesticides:

<i>Trade name</i>	<i>Active ingredient</i>	<i>Remarks</i>
CALLIDIUM- RIDOMIL PLUS	Dimethoate-copper oxide	Refer to instructions for use
SARPAGRUM	Cypermethrine 1,5% + Iadocarbamate 3,0%	Refer to instructions for use
CAIMAN ROUGE	Endosulfan 250g/kg + Thiram 2250g/kg	Refer to instructions for use

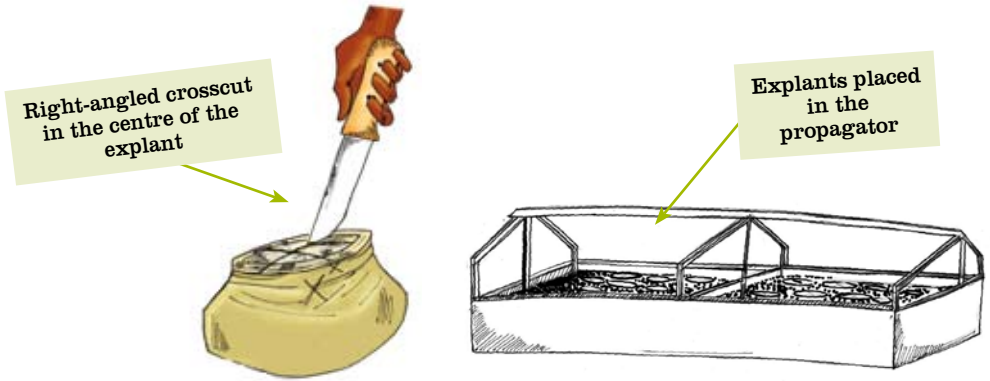
Besides commercial products, it is recommended to use organic fungicides-insecticides. There are several easily accessible means of organic treatment. Natural substances, for example, can be used as insecticides and fungicides.

Some natural substances used as insecticide and fungicide

<i>Natural substance</i>	<i>Part used</i>	<i>Active ingredient</i>	<i>Utilization</i>
NEEM (Melia azadirachta L.)	Seed, leaf, bark	Azadirachtin	Dilute 2 cl of neem oil as droplets in one litre of water. One litre of oil produces 50 litres of product for spraying. Put the mixture in a vaporiser and spray.
GARLIC (Allium Sativum)	Bulbs	Allicin	Pour 10 litres of boiling water over 80 to 100 g of crushed bulbs. Cover the container and leave for 1 hour. Filter, without diluting, and spray once it is cold.
HOT PEPPERS (Capsicum annum)	Fruit	Capsaicin	Mix 300 g of finely ground peppers with two litres of water. Then shake the mixture in a sealed container in order to get a good mix. Filter the mixture and add soapy water. Spray the mixture.
Insecticidal plants such as the Mahogany (Khaya senegalensis), mango tree, acacia, etc.	Ashes		Spray a suspension of the ashes in soapy water, urine or milk.

Another possibility is Bordeaux mixture, which is a fungicide made up of 20 percent copper sulfate and 80 percent hydrated lime.

1.8 Propagation



This stage involves placing the explants in the propagator. Once the drying period is completed, use a sharp knife to trim the surface of the explant until only 2-3 mm of the pseudostem remains. Make a right-angled crosscut in the centre of the explant. Leave it to stand for 30 to 60 minutes.

Place the explants side by side in the propagator with the crosscut facing up. The number of explants per square metre will depend on the size of the explants used. Cover with a 2 to 3 cm layer of light-coloured sawdust. It is recommended not to water the explants on the day they are placed in the propagator, but to water thoroughly 24 to 30 hours later.

1.9 Reactivation

Two weeks later, the explants will have multiple shoots. In some cases, plantlets stemming from side buds develop more quickly and have greater strength. When the shoots reach thumb size, reactivation can begin. Remove the plantlets from the explant 2 mm above the node, and make a new right-angled crosscut in the pseudostem of the plantlet. Reactivation is not necessary and will depend on production objectives. It is not recommended for beginners as it requires a lot of experience, but is a means of increasing the number of plantlets per explant.

1.10 Taking cuttings

Taking cuttings occurs 30 to 40 days after propagation. Young plants with 3 to 5 leaves are carefully removed with a scalpel, razor blade or very sharp knife. Depending on the variety (Horn or French), in three months 20 to 100 plants can be produced per explant.



1.11 Replanting in bags and acclimatisation in shade houses

The plantlet is replanted, with all its roots, in a black, perforated polyethylene bag, whose size will vary according to the production schedule. In contrast, separated plantlets without roots should be replanted in the propagator sawdust for ten days before being transferred to bags. Bags of 17 cm x 24 cm are highly recommended.

Make sure that the bags are filled with rich compost and that water can easily drain through. In certain conditions, the compost can be mixed with sand or coffee husks. The quantities used will depend on the local

Young plants with 3 to 5 leaves are carefully removed with a scalpel, razor blade or very sharp knife.



Bagging plantlets



soil types and the material available. In coastal regions in Cameroon, for example, equal measures of soil and coffee husks are often used. Once filled, the bags are placed on a plank and watered the evening before replanting. It is recommended that the bags be thoroughly soaked when beginning the replanting. To replant, make a hole in the centre of the bag, deep enough so that the roots will not be bent.

Place the plantlet in the hole and gently fill it with soil, without pressing down. Only the bulb should be in the soil; if the plantlet is pushed too far in, it may take longer to begin growing.

Once replanting is completed, water the plantlets thoroughly. Place them in the shade, in a temperature of 25-27°C, in order to facilitate acclimatization. The plantlets should be watered four times a week.

1.12 Plant care

Weed the nursery regularly. The plantlets will suffer from competition with weeds. In addition to treating the plantlets, insecticide can also be applied directly in the bags or in the propagator in order to control parasites. In case of need, apply foliar fertilization. Between six to ten weeks after taking cuttings, the young plants are ready to be planted and can be transferred to the field.

2

PLANTAIN PRODUCTION AND SALES

2.1 Production costs and sales price

On average, 100 suckers are needed to produce 1000 plantain plants. The production cost per plant is determined by the initial investments to construct the propagator and shade house.

In general, it costs around 100,000 FCFA, or 150 euros, to produce 1000 plantain plants: 10% to purchase the first plants; 30% for the materials, the bags and the plant care products; and 60% for labour costs. Each plant produced can be sold for between 150 and 230 FCFA (0.23 - 0.35 euros).

Production costs: 1000 plantain plants

<i>Description</i>	<i>Unit price (FCFA)</i>	<i>Total</i>
Purchasing 100 suckers	100	10 000
Purchasing 100 bags	300	30 000
Labour		60 000
Total		100 000

Income: 1000 plantain plants

<i>Description</i>	<i>Unit price (FCFA)</i>	<i>Total</i>
Sale of 1000 plants	150	150 000
Gross margin		50 000

2.2 Agronomic requirements

>>> **Temperature:** The optimal temperature for growing plantain is 28°C. From 28 to 20°C, growth will gradually slow down, and will become negligible around 16-18°C.

>>> **Light:** Shade accelerates height growth, and it is advisable to determine the density depending on the cultivar selected, in order to provide the best light conditions for the plantation.

>>> **Water:** Plantain needs a lot of water. It should get around 200 mm per month throughout its life cycle.

>>> **Wind:** Plantain is very sensitive to strong wind, which can cause physical damage to the plant (torn leaves, toppling).

>>> **Soil:** Plantain grows best in deep soil that is well drained and rich in organic matter. Fallow land can also be used, but the yield will depend on what was previously grown and the duration of the fallow.

2.3 Cultivation

>>> Choosing a site

The site should be easily accessible, have good exposure to sunlight and offer shelter from the wind. Flat or slightly sloping land with good drainage should be chosen rather than land with steep slopes that could lead to problems of erosion and loss of fertile soil, and that have greater risk of wind damage. It is best to use virgin land due to its high levels of organic matter, but previously cultivated, fallow land can also be used, depending on the amount of plant matter. At all costs, avoid former banana or plantain plantations due to the likelihood of poor soil fertility and phytosanitary conditions.

>>> Land preparation

Preparation will depend on the type of land and the type of farm, and should be adapted according to available resources. Some months before planting, the land should be systematically cleared, followed by selective felling. In forest zones, after clearing, the dry undergrowth is burned. In savanna zones that have only sparse plant biomass, burning is not recommended; systematic clearing is enough to prepare the land.

**Systematic
clearing of
undergrowth**

>>> Choosing a system of cultivation

Plantain can be grown together with other types of compatible crops (cocoa, cocoyam) or as a single crop. In the latter case, each plot should comprise only one cultivar. Plots should be as homogenous as possible, by selecting the same type of plant material (plantlet or sucker) within one plot.

>>> Plant density

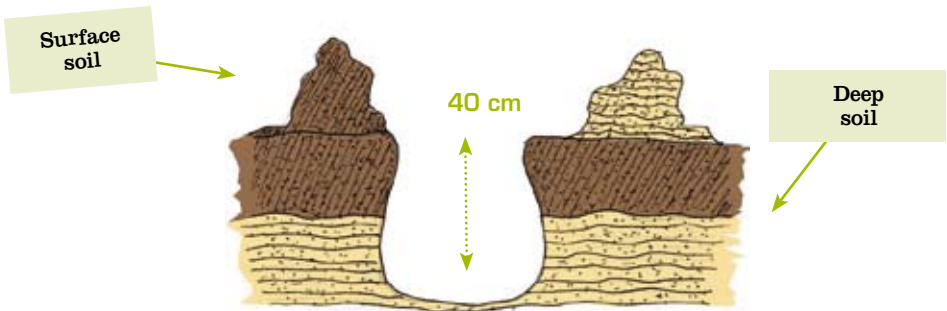
Density will depend on the climate, the soil quality, the planned lifespan of the plantation and the cultivars selected. The higher the density, the longer the lifecycle and the lighter the bunches produced. In a monoculture, distances of 3 m x 2 m or 2 m x 2 m will give 1 666 to 2 500 plants/Ha. In mixed cultivation, distances of 4 m x 4 m or 4 m x 2 m will allow the farmer to use the spaces between the plantain plants for other food crops. There will be a low yield as of the third year because of an increase in parasite pressure and reduced soil fertility. After harvesting, only one plant should be left to replace the mother plant.

>>> Marking out

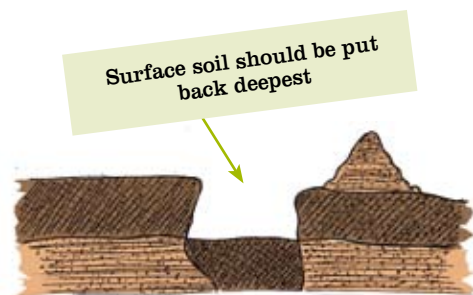
The field should be laid out according to the planting distances described above and marked with stakes/poles of about two metres high.

>>> Digging planting pits

In non-mechanized farming, plantains do not require any particular soil preparation. Planting pits of 40 cm x 40 cm x 40 cm produce the best results. During this step, make sure to separate the surface soil (10 – 15 cm) that is rich in humus from the deep soil. The pits will also be filled with about 2 kg of well composted manure per pit.



⬆ **Planting pit**



➔ *Planting*



>>> **Calibrating the plants**

Calibrating involves grouping plants together according to size and weight. Only plants with similar characteristics should be planted together.

>>> **Planting**

While planting, make sure the bottom of the pit does not fill with water. If necessary, mix black earth with 10 to 15 kg of compost. Before planting, add 15 to 20 cm black earth to the bottom of the pit. The plants should be placed in the pit with their scars facing the same direction in order to facilitate their care and propping. Planting PIF plants is very delicate. Make sure each one is planted so that the collar is visible. Pile up a little soil around each plant and avoid planting them too deep.

Good growth in the first 3 to 4 months guarantees good productivity

>>> Choosing planting dates

In intensive farming, using the most homogenous material possible, it is possible to forecast the exact time of flowering and harvesting in the first cycle, depending on climatic conditions. In the second cycle, there will be greater heterogeneity within the plantation and it will be much harder to determine the flowering period, which could be spread over several months.

2.4 Plant care

>>> Physical and sanitary care

Good growth in the first 3 to 4 months guarantees good productivity, as long as other measures are not neglected. Tilling or hoeing is not necessary. Annual crops or crops with shallow roots or that require hoeing or earthing up should be avoided.

<i>Trade name</i>	<i>Active ingredient</i>	<i>Quantity per application</i>	<i>Remarks</i>
ROUND UP	Glyphosate	6 litres per ha for perennial weeds; 4.5 litres per ha for annual weeds	<ul style="list-style-type: none">• Long-lasting effect• Useful in dry season and in between (4 hours without rain after application)
GRAMOXONE	Paraquat	2 to 3 litres per ha	<ul style="list-style-type: none">• Useful in the wet season (1 hour without rain after application)
BASTA	Ammonium glufosinate	3 to 5 litres per ha	<ul style="list-style-type: none">• Long-lasting effect (4 hours without rain after application)
GRAMURON	Paraquat	3 to 4 litres per ha	<ul style="list-style-type: none">• Not useful in the dry season

Herbicides currently used for chemical weeding in banana and plantain plantations

>>> Weeding

Weed the plantation regularly during the first six months, using a machete or herbicide. Herbicide can be used on weeds up to 10 to 15 cm in height; if they are higher, then they should be cut with a machete. Herbicide should then be applied when they begin to grow back, but should never touch the plantain plants.

>>> Propping

This involves supporting the plantain plant by using some form of support or a cord, called a prop, and use mainly for tall varieties (French) or in areas that are subject to strong winds. Props should be used when bunches begin to appear.

>>> Trimming

Remove any old, dry leaves that hang down on the pseudostem (they can hide insects and larvae). Do not cut the green leaves as they are essential for ripening the bunches. Approximately 2 to 3 months after harvesting the bunches, remove all remaining shoots apart from two bayonet-shaped shoots, one large and one small. Avoid weeds, dead leaves, pieces of pseudostem and other plant debris piling up at the base of the plantain plants, where they could provide shelter for the banana root weevil or other insects and larvae.

>>> Pruning of suckers

This involves removing all the shoots that appear around the base of the parent plant in order to reduce competition during the initial growth phase. After flowering, keep the strongest sucker that is best placed in line with the plantation rows. Remove the others by cutting or pulling them out; this should be done at regular intervals. The removed suckers can be used as replanting material.



⬆ **Propping**



⬆ **Removing male buds**

>>> **Caring for the bunch**

Break the male bud 7 to 10 days after the appearance of the last hand around 20 cm long.

>>> **Fertilization**

It is strongly recommended to provide the plants with waste plant material from weeding or other crop sources. Animal manure should only be applied during the wet season. Be careful not to spread the manure too close to the plant because the heat produced during decomposition could cause the plantain to wilt. Additional mineral fertilizer can be used depending on the soil type and the use of organic waste. It is necessary to put back in the soil the elements that the plant has withdrawn in order to maintain high yields.

- Apply around 10 to 15 tonnes (100 to 150 sacks of 100 kg) of compost or chicken droppings per hectare per year. This means that before planting, each planting pit should get 10 to 15 kg of chicken droppings or compost mixed with black earth.
- At the beginning and end of each wet season, apply 1 to 2 kg of a complete fertilizer high in nitrogen and potash to each plantain plant each year. Divide the fertilizer into two or three measures. Apply the fertilizer in a drip line placement around the plantain plant.

2.5 Control of pests and diseases

The plantain is prone to several parasites and diseases. Here is a list of the most common ones:

>>> **Banana weevil (*Cosmopolites sordidus*)**

The larva of this weevil bores into the root of the plantain in order to provide food for itself, thereby destroying the root system. As a result, the plant cannot draw up nutrients effectively and its anchorage to the soil is undermined, which means it can be toppled even by a light breeze. Both chemical and organic measures can be used. Neem powder, mixed with soil, can be effective against banana weevils. Chemical products should be applied to the soil at the edge of the plant in a drip line placement of 10-15 cm wide (make sure to first remove any organic waste material).

There are not many authorized and effective products, and those that exist tend to be relatively expensive (500 FCFA per litre).

- Dursban (active ingredient: Chlorpyrifos): liquid pesticide sprayed around the plantain plant.

- Furadan (active ingredient: Carbofuran): a systemic pesticide in granular form, spread around the plantain plant.

Apply Dursban or Furadan 2 to 4 times per year, depending on the degree of infestation. Use these pesticides only during the wet season.

>>> **Black sigatoka**

Black sigatoka is a leaf spot disease caused by a fungus that grows on the plantain leaves, causing them to wilt. The fruits are badly filled and maturation is abnormal resulting in poor taste quality and lower fruit yields. When black sigatoka is found,

- Remove the damaged leaves (burning them, if possible);
- Make sure plantations are not too damp: reduce the density of plants in order to facilitate good air circulation; avoid using plots that are too damp; and weed regularly.

>>> **Nematodes**

Nematodes are microscopic “worms” that penetrate and reproduce in the roots of the plantain, thereby destroying them. Infested roots die off, and the plantain can no longer extract nutrients from the soil and can topple easily. To combat nematodes, apply a mix of water, clay and nematicide to the base of the infested plant. However, the most effective solution is to use healthy source material and to rotate crops to include nematicidal plants such as marigolds or neem.

>>> **Viral diseases**

A serious viral disease that affects plantain – the so-called “bunchy top”, caused by BBTV, banana bunchy top virus – is becoming increasingly widespread in certain regions of production. Initial symptoms consist of yellow leaf margins and dark green streaks in the veins of lower portions of the leaf midrib and the leaf stem. In badly affected plants, the leaves are narrower than normal and appear to be “bunched” at the top of the plant. On the appearance of these symptoms, uproot and bury the infested plants and their offshoots.

2.6 Preventive methods

Whatever the system of cultivation being practised, the most effective way to prevent and combat parasites is to use healthy source material such as in vitro micropropagation and PIF macropropagation. Use of chemicals is only cost effective in very large-scale, intensive farming.

2.7 Income generated from sales

The cost of producing a bunch of plantain is about 597 FCFA (0.91 €) in the first year, and will rarely go above 197 FCFA (0.30 €) as of year two. The sales price for a bunch will vary according to the variety, but can be estimated to be around 795 FCFA (1.21 €). Even taking into account losses in production, the plantain grower can end up making a considerable profit.

3

OTHER

INFORMATION

3.1 Uses and nutritional value

Plantain is never eaten raw because of its high levels of starch. The green or ripe fruits can be eaten boiled, as chips or as flour. Plantain is rich in starch, tannin, potassium and vitamins. In 100 g, plantain contains 116 kcal calories, 31 g carbohydrates, 0.2 g fat and 0.8 g proteins.

3.2 Suggested recipes



Boiled plantain

- *Cut off the ends and make a lengthwise slit along the plantain (avoid cutting the insides).*
- *Boil the plantain in salted water for several minutes, then remove the skin.*
- *Continue boiling without the skin. Check the plantain is cooked through. It is ready when a knife point goes in easily.*
- *Remove and drain. The plantain can now be mashed or fried in butter or oil.*



Baked plantain

- *Preheat the oven to 180°C.*
- *Wash the plantain with the skin on.*
- *Place in the oven for 45 to 60 minutes.*
- *Remove from the oven, remove the skin and serve with a knob of butter and a sprinkling of brown sugar.*



3.3 Useful addresses

■ **International Institute of Tropical Agriculture (IITA)**

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■ **African Centre for Banana and Plantain Research (CARBAP)**

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Cultivation and processing of maize

Maybelline Escalante-Ten Hoopen

Improved plantain production

Pro-Agro is a collection of practical, illustrated guides that are jointly published by CTA and ISF Cameroon. They are an ideal source of information for farmers, rural communities and extension workers in tropical and subtropical regions.

The present text describes the technique of producing plantain from stem fragments (PIF), and the recommended steps for growing plantain. The reader will also find useful information regarding some economic and practical aspects of this agricultural production.

- **The Technical Centre for Agricultural and Rural Cooperation (CTA)** is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). Its mission is to advance food and nutritional security, increase prosperity and encourage sound natural resource management in ACP countries. It provides access to information and knowledge, facilitates policy dialogue and strengthens the capacity of agricultural and rural development institutions and communities. CTA operates under the framework of the Cotonou Agreement and is funded by the EU.

- **Engineers without Borders (ISF)** is a network of professionals in more than 52 countries to promote human development through improved access to scientific and technical knowledge. In Cameroon, ISF works together with local people to improve their livelihoods and strengthen their technical capacity by sharing and diffusing information adapted to their needs.

