PRODUCTION GUIDE

CROP PRODUCTION PROTOCOL

SUGARLOAF PINEAPPLE

Ananas comosus

COLEACP

This publication has been prepared by the COLEACP as part of co-operation programmes funded by the European Union (European Development Fund – EDF), the Agence Française de Développement (AFD) and the Standards and Trade Development Facility (STDF).

This publication is an integral part of a COLEACP collection, which is made up of educational and technical tools and materials. All of them are suited to different types of learners and beneficiaries and levels of education found in agricultural supply chains, production and sales.

This collection is available online for COLEACP members and beneficiaries.

CONTENT

FOREWORD

This document describes a suggested crop production protocol for the cultivation of sugarloaf pineapple. A more definitive protocol will need to be based on new research on this variety, focusing on adapting techniques developed for other varieties, and on export-related practices such as harvesting methods, packaging, compliance with maximum residue levels (MRLs) and marketability.

The main principles governing pineapple cultivation are the same, regardless of the variety. Where specific data on sugarloaf are missing, we will mention information on other varieties. References to synthetic plant protection products are only briefly cited. Their use is not recommended for cultivation of sugarloaf, which is a very hardy variety and tolerant of many diseases and pests.

The technical innovations presented in this protocol aim to improve the yield and the percentage of fruit exported, as well as the image of the sugarloaf variety.

For further information, see the References on pineapple at the end of the text, in particular the documents published by COLEACP, which are widely distributed to producers, supervisors, support organizations and public authorities.

1. BACKGROUND

1.1. Botanical information and varieties

Cultivated pineapple (*Ananas comosus*) has botanical and physiological characteristics that affect production:

- the leaves form a "gutter" shape, allowing them to collect rainwater and fertilizer sprays;
- the roots at the base of the leaves can absorb these liquids;
- the root system is very fragile and strongly affected by any mechanical compaction of the soil, as well as by excess water;
- the plants have good resistance to unfavourable conditions, especially drought;
- the plants are responsive to artificial floral induction (using ethylene or acetylene).

There are several varieties, including the sugarloaf variety grown in Benin, and the Pérola variety, which is the most cultivated in Brazil. These are characterized by:

- a great rusticity;
- a remarkable tolerance to many diseases and pests;
- the presence of numerous shoots at the base of the fruit;
- a conical fruit that is highly valued, with skin that remains green when ripe, and white flesh that can quickly become fragile and translucent (a sign of over-ripeness): these characteristics are unfavourable for export by ship.

Due to the vegetative propagation of pineapple and the appearance of mutations, several clones can appear within a variety, forming relatively heterogeneous populations over time.

1.2. Climate impacts

Pineapple is a fairly drought-resistant plant, but drought greatly reduces its growth. Excess water is particularly harmful at the beginning of growth and at the end of fruit development.

Low temperatures and short days induce natural flowering of pineapple. This phenomenon is unfavourable to crop management, unlike artificially induced flowering.

Sunlight and temperature have a strong influence on the quality of the fruit. Augmenting them increases the sugar content and lowers the acidity. Skin colour stays green longer under high temperature conditions. This factor plays a key role in fruit development: the higher the temperature, the shorter the interval between floral induction and cutting. However, there is no mathematical modelling of this range for sugarloaf, unlike other varieties.

1.3. Soil requirements

Given the characteristics of the pineapple root system, the best soils for its cultivation are soft soils that are well aerated and have satisfactory and homogeneous drainage over 40–50 cm.

Following cultivation, the structural and organic characteristics of the soil may be quickly degraded. This phenomenon can be countered by systematically burying crop residues, which makes it possible to maintain organic matter levels and soil structural stability, while reducing the risk of erosion, which is often significant in pineapple crops.

The physical characteristics of the soil are also determining factors in the risk of attacks and infections by pests and parasites.

The optimal pH for growth is between 4.5 and 5.5.

Generally, poor soils are low in mineral elements. To compensate for this, it is necessary to supply almost all the plant's nutrient requirements, in particular by applying chemical or natural fertilizers, as well as by implementing crop rotations.

2. PRODUCTION SYSTEM

2.1. Rotation

Pineapple production must be integrated into a system of rotation and fallow land, making it possible to reduce the use of synthetic inputs. Restitution of crop and fallow residues is a key point of a good cropping system.

The efficiency of fallow periods increases with their duration. Crops that favour nematode populations (such as maize and tomatoes) should be avoided. Planting leguminous crops (such as cowpeas and groundnuts) enriches the soil with nitrogen, while groundnuts and cotton have some effects against nematodes.

Fallow land works best when residues are deeply buried before the pineapples are planted. Burying residues improves soil structure and can enrich it with mineral elements, especially nitrogen. The addition of organic matter improves water retention capacity and availability, which is an important advantage in areas with a marked dry season. For effective burying, residues should be crushed as finely as possible and may be left to partially dry, then buried deeply (40 cm). These conditions are rarely met if mechanical means are not available; but it may be possible to bury residues with more modest means (e.g. a rototiller) or by using service providers.

2.2. Management and forecasting

Floral induction treatment (very rare in large-scale crops) has an important impact on plot management. As pineapple is a downstream-managed crop, it is up to the producer to acquire the necessary experience to define:

- the floral induction period in relation to the desired harvesting period;
- the desired plant size in relation to the desired fruit weight (there is a direct relationship between fruit size and weight).

Depending on the desired size of the plants, the grower will have to calculate:

- the weight of the planted shoots;
- the planting period;
- manuring (which conditions plant growth).

3. DISEASES AND PESTS: CONTROL METHODS

3.1. Fungi

3.1.1. Heart rot

Soft rot of the white, soft upper part of the stem and the base of young leaves is caused by a fungus present in the soil: *Phytophthora nicotianae* var. *parasitica*. Affected plants die in most cases. Following a colour change (yellow or light brown tint), the leaves soften and curl downwards. When their ends are pulled, they detach very easily, the base being completely covered by a soft, damp rot with a foul odour. Contamination occurs during rainy periods, mainly through rainsplash that transfers soil into the heart of the plant. Soil pH plays a very important role. On acidic soils (pH 4–5), the risks are relatively low. Heavy, clayey soils that remain moist for long periods of time are more favourable to the disease than sandy, fast-draining soils.

Control methods: Chemical control is essentially preventive and involves treatments with fosetyl-aluminium or mancozeb. However, the sugarloaf variety is little affected by this disease, and its impact can be limited by the choice of land and by planting on ridges. In this case, chemical control should not be considered.

3.1.2. Black rot

This disease is caused by the fungus *Ceratocystis paradoxa*. Besides the fruit, it also causes black rot on the stems of the shoots.

Symptoms of black rot may not be familiar to growers as it takes longer than the normal export time to develop and become visible. However, this disease can be very serious and can lead to the loss of more than 50% of certain consignments of fruit on arrival at the place of import.

Ceratocystis paradoxa is very common in plantations and develops in hot and humid weather on all pineapple debris (leaf fragments, bracts, etc.). Infection occurs at the time of harvest or packing, by spores spread by wind from rotting debris in the plantation or near the packing station. The fungus is a wound parasite for which the section of the peduncle or the slightest wound is a gateway.

Control methods: Control is mainly preventive. The fruit must be handled with the utmost care to avoid damage during harvesting, transport and packaging. Chemical treatments use triadimefon but should be avoided.

3.2. Mealybug Wilt of Pineapple (MBW)

Mealybug Wilt of Pineapple (MBW) is a viral disease transmitted by mealybugs, which are spread by ants.

It is seen as dieback of the plant, which results in reddening of the young leaves and a rolling towards the underside of the edge of the leaf blade. At a more advanced stage, the curling of the edge of the blade becomes more pronounced, the upper end of the leaves curves towards the ground, and the leaves lose their turgidity and take on a pinkish-yellowish colour. The course of the disease depends on climatic conditions: it is often very slow and incomplete in rainy and less sunny periods.

The symptoms are very similar (or even identical) to those caused by root system alteration or water deficiency. However, MBW withering symptoms are severe, rapid and rarely reversible (whereas drought-induced withering symptoms are reversible as plants may turn green again with the return of the rains). In addition, MBW appears on isolated plants or limited groups of neighbouring plants, whereas large areas are affected in cases of drought.

Mealybug Wilt of Pineapple rarely causes plant death, but in cases of severe infection the disease results in a severe reduction in yield and a considerable drop in the production of shoots.

Control methods: In most areas, control of MBW is based on the control of scale insects and ants. Chemical treatments are numerous and include insecticides with high toxicity, including chlorpyrifos-ethyl and dimethoate.

The sugarloaf variety is very tolerant of MBW, and treatments with synthetic insecticides are not recommended. Affected plants should be eliminated as quickly as possible and the area treated with insecticides that are authorized in organic farming (e.g. neem oil). The eradication of plants must be complete to prevent ants (whose activity is not easily visible) from spreading scales. It is also advisable to burn the plants.

3.3. Pests

3.3.1. Nematodes

Soil nematodes are very small roundworms (about a millimetre long). In West Africa, *Pratylenchus brachyurus* is the most widespread and harmful species for pineapple. This nematode feeds on the roots and thus disturbs growth of the plant (sometimes very strongly).

Among other species encountered on pineapple, nematodes belonging to the genus *Meloidogyne* cause characteristic nodules on the roots. Although very harmful, this type is less virulent.

The presence of nematodes cannot be detected by the naked eye. It can only be suspected through the observation of external symptoms (dead roots, nodules). The presence of nematodes must be confirmed by analyses carried out in a specialized laboratory.

The evolution of populations of these parasites depends mainly on soil humidity (periods of drought or heavy rains are unfavourable to their development).

Control methods: Nematode control is essential in most pineapple-growing areas to make the crop economically attractive. Synthetic treatments are expensive and use substances with high toxicity, including carbosulfan, ethoprophos and fenamiphos.

For sugarloaf pineapple, which is relatively tolerant to these pests, the use of these products should be avoided. As an alternative, it is possible to practise fallows (minimum 12 months) or to include in rotations crops that have some nematicidal action (e.g. groundnuts and cotton). Note that it is absolutely necessary to avoid crops that promote their development, especially maize, cassava and tomato.

The use of natural products (such as neem cakes incorporated into the soil) may also be considered.

3.3.2. Symphylids

These are small, fragile, white millipedes that move very quickly through the soil. They occur naturally in most soils, in forest humus, between dead leaves and in old decaying stumps, where humidity is generally quite high.

The damage caused by symphylids is characterized by the section of the apical end of the root, which takes on a crater-like appearance. The root swells at its tip and then forms many long, thin branches. Blind and very fragile, symphylids use the open spaces in the soil to move around, so their presence is strongly linked to the soil's structure and texture. Most favourable to symphylids are light soils rich in decomposing organic matter, as well as heavy (clay-sand) soils with cracks or microcracks, or gravelly soils. Moist soils are also particularly favourable to symphylids, but free-flowing water is harmful to them.

To observe the presence of symphylids it is necessary to pull up the plant and remove old, dead leaves from its base. The observation must be rapid since symphylids move and hide very quickly. They are easier to observe early in the morning, before warming of the soil's surface layers causes them to move deeper.

Control methods: Conventional agricultural treatments use highly toxic insecticides, including chlorpyrifos-ethyl and ethoprophos. The usefulness of these treatments needs to be confirmed according to the context and the extent of the damage caused by this pest.


Qdibra
Succombez au
Pain de Sucre
BIO du Bénin !

4. CULTIVATION TECHNIQUES

4.1. Soil preparation

4.1.1. Burying residues and tillage

Burying crop residues is an essential part of soil preparation. It is advisable to let residues dry for at least 15 days (up to 3 weeks) before incorporating them into the soil. Decomposition must be as complete as possible in order to avoid pest outbreaks.

Most of the time, tillage and burying residues are carried out simultaneously by working the soil for approximately 40 cm. This operation is ideally achieved by mechanical means. If such means are not available, the volume of organic matter to be buried can be reduced by increasing its drying time.

Studies carried out in Benin have shown that burying residues is more efficient than leaving them on the surface as mulch; however, mulching does considerably reduce the amount of weeds.

4.1.2. Surface preparation

After tillage and burying residues, the soil surface should be prepared by flattening it and breaking up the largest clods. This operation requires mechanical means.

In most large pineapple-growing areas, preparation of the plot ends with ridging, which has many advantages including:

- a very airy environment favourable to root development;
- limitation of water stagnation;
- concentration of fertilizer inputs in the root area.

Unfortunately, ridging cannot be achieved without mechanization.

The impact of ridging increases if it is combined with a polyethylene cover.

4.2. Polyethylene covers

Using polyethylene to cover the ground generates a lot of waste, but can be justified depending on water constraints and weeding requirements.

Its has many advantages:

- water savings during the first 4–5 months by eliminating direct evaporation from the soil. When placed on a moist soil, it maintains a humidity level favourable to the resumption of growth;
- reduction of excess water in the rainy season when the cover is laid on the ridges;
- significant reduction in leaching of fertilizers incorporated into the ridge before the cover is applied. It allows to bring ¼ nitrogen and potassium manure into the furrow before planting, as well as various pesticides, with limited risk of deep entrainment;

- reduction of soil compaction. The ridges remain loose and therefore more favourable to root growth;
- reduction of weeds, which are usually very difficult to control on the furrow when polyethylene is not used;
- increase in soil temperature, which promotes root growth and therefore improves foliar emission;
- improvement of plot homogeneity, which reduces sorting differences at harvest.

However, there are some significant drawbacks:

- the cost;
- the accumulation of hard-to-remove residues in each crop cycle.

4.3. Planting

4.3.1. Planting pattern and plant density

Two planting patterns can be used: in single lines (with about 90 cm between lines and 25 cm spacing on the line); or in double lines (space between two double lines of 90 cm, space between 2 lines of 40 cm and 33 cm between 2 plants). The same density, about 45,000 plants/ha, is obtained with both patterns. The first pattern is recommended to facilitate weeding and improve homogeneity.

4.3.2. Planting material

The availability of planting material is not a problem because of the presence of many shoots (slips and suckers) that develop on the stalk after the fruit is harvested. The quality of the shoots (freshness, weight, homogeneity, etc.) is an essential factor for the success of the crop.

In general, the weight of shoots ranges from 300 to 600 g; the weight class 400–500 g is considered the best. Sorting is based on a visual estimate of weight and freshness. Shoots should be planted separately according to their freshness, as old shoots (stored or harvested for some time) have a different recovery capacity than fresh ones.

Planting homogeneous material is essential to obtain homogeneous plots and harvests.

In some production areas, it is advisable to prepare the shoots for dry-season planting, which involves removing the old shorter leaves at the base of the shoots to expose the few roots present. This operation accelerates the root growth after planting. However, it is increasingly being abandoned because of the cost.

The base of the shoots must dry slightly before planting to avoid rot caused by *Ceratocystis* fungi in the rainy season. The usual delay due to the harvesting, transport and distribution of shoots is usually sufficient.

4.3.3. Planting method

Shoots should be distributed along the planting rows. The planting hole should not be prepared in advance. The planter (ranging from a simple wooden stake to a lanceolate metal blade) is driven obliquely into the ground and lifted forward, creating a lighter cone of earth into which the shoot is introduced. The planter is held in one hand and the shoot in the other. Breaking up the soil in this way prevents the formation of smooth, impermeable barriers that can disrupt root growth and encourage the accumulation of water, thus increasing the risk of rot. After planting, it is advisable to lightly compact the soil by treading to ensure good contact between the stem and the soil. This will improve the penetration of the first roots.

A well-planted shoot should resist when a leaf is pulled lightly, holding it between the thumb and forefinger.

The planting depth should not exceed 8–10 cm. It is not advisable to twist the shoot into the soil to avoid damaging the plant bud.

It is easy to make a double-bladed planter: the larger blade is used to make the planting hole, while the smaller blade (which should be the same distance from the larger one as the desired distance between two plants) marks the location of the next plant when the tool is planted in the ground.

It is advisable to count the number of seedlings planted precisely so that all treatments can be applied at the correct dose.

4.4. Water requirements

In some areas, the dry season may be long enough to significantly disrupt plant growth. In this case, the use of irrigation may be considered, depending on the socioeconomic context (mainly cost) and water availability. As already mentioned, the use of a polyethylene cover can be an alternative to limit evaporation and maintain a humidity level favourable to growth at the beginning of the cycle.

4.5. Weed control

Weed control is essential in pineapple, as its relatively slow growth (especially during the first 3–4 months) can be greatly hindered by weed competition.

Weeding is one of the most demanding jobs. It is preferable to carry out manual weeding as often as possible. The tool used must not penetrate the soil, to avoid injuring the very pineapple superficial roots. The use of a hoe is therefore not optimal. Here, too, it is very easy to make specific tools: a flat blade in the approximate shape of a crescent moon, with two sharp edges, at the end of a long handle, can be used to cut weeds at ground level by making forward/backward movements.

As already mentioned, the use of a polyethylene cover reduces weeds and thus reduces labour requirements.

The use of chemical treatments should be avoided as far as possible, and considered only:

- in the event of a shortage of labour;
- before or just after planting.

Substances that may be considered for use are: bromacil, diuron, glyphosate, haloxyfop, paraquat and propaquizafop.

4.6. Nutrition/fertilizer application

As with most plants, applying mineral fertilizer is one of the most important operations. Pineapple's needs are relatively high, and it is sometimes necessary to provide almost all the nutrient requirements when soils are poor.

Less work has been done on sugarloaf than on other varieties, but studies carried out in Brazil and Benin suggest that the basic principles are the same:

- the most effective contributions are those made before floral induction;
- the needs of the plant increase with its development;
- the more you divide up the applications, the more effective they are;
- the morphology of the plant allows the absorption of fertilizers applied at the base of the old leaves;
- solid applications are of no use in the dry season – during this period, liquid applications are preferred;
- the yield is very strongly linked to nitrogen;
- potassium influences the quality of the fruit.

Nitrogen and potassium have antagonistic effects on pineapple fruit quality. Excess nitrogen reduces the acidity of the fruit and increases the fragility and translucence of the flesh, two characteristics already marked in sugarloaf pineapple. Increased potassium leads to greater acidity, improved fragrance, better skin colour and firmer flesh (but poorer colour). For example, the K_2O/N ratio of 2.5 should not be exceed for the Cayenne variety.

There is no reference system for sugarloaf pineapple, for example relating the weight of the fruit to the average needs of a plant. For Cayenne pineapple, however, the production of a fruit of:

- 1.1 kg is obtained with 4 g N
- 1.5 kg with 6 g N
- 2 kg with 8 g N

The quantity of potassium is then determined by observing a K_2O/N ratio of 2.5, i.e. a respective input of 10, 15 and 18 g of K_2O.

Phosphorus and magnesium requirements are much lower and, again for Cayenne pineapple, are estimated at 2 and 3 g per plant, respectively.

This kind of reference system has yet to be established for the sugarloaf variety. The recommendations below are provisional and should be considered cautiously, as producers seem to obtain satisfactory yields with very low doses of fertilizer (2 g N and 5 g K_2O per plant).

4.6.1. Programme with simple fertilizers

Based on one of the current common practices (total doses of 3 g N and 7 g K_2O per plant over the whole cycle, applying 6.5 g of urea and 14 g of potassium sulphate, respectively), several steps can be considered (see below).

	Nitrogen		Potassium		Phosphorus	
	Element	Urea	Element	Potassium sulphate	Element	Triple super-phosphate
Current practice: Three applications. Flower induction at 36 weeks (9 months); solid intake at 4, 20 and 30 weeks.						
Total dose (g/plant)	3	6.6	7	14		
Application (g/plant)	1	2.2	2.3	4.5		
Application (kg/ha)		100		202		
First level of improvement: Five applications. Flower induction at 36 weeks; solid intake at 4, 11, 18, 25 and 30 weeks.						
Application (g/plant)	0.6	1.3	1.4	2.8		
Application (kg/ha)		60		125		
Second level of improvement: Increased doses; five applications. Flower induction at 36 weeks, same calendar						
Total dose (g/plant)	5	11	12	24		
Application (g/plant)	1	2.2	2.4	4.8		
Application (kg/ha)		100		215		
Third level of improvement: Phosphorus applications. Burying of residues (10 t/ha). Five applications, same schedule						
Total dose (g/plant)	5	11	12	24	1.7	3.7
Application (g/plant)	1	2.2	2.4	4.8		

Before planting or within 15 days Application (kg/ha)		100		215		165
Fourth level of improvement: Five to six applications. Introduction of one or two liquid spray(s) in the dry season						
Application (g/plant): liquid	0.6	1.3	1.4	2.8		
Application (kg/ha)		60		125		

Notes:

- Fertilizer mixtures must be carefully mixed using a succession of shovels.
- The final application should be made no later than 1 month before floral induction treatment.
- Application dates are indicative. It is essential to take the climate into account and to delay applications in periods of heavy rain or drought.
- One teaspoon corresponds to 8 to 9 g of fertilizer.
- Fertilizer quality is important. Excessive levels of biuret in the urea can lead to burns. Potassium sulphate may be replaced by chloride for the last application (risk of negative effects on fruit quality).
- In the case of a liquid application, the concentration of urea must not exceed 5%, and that of total fertilizers 8%, to avoid foliage burns. These conditions can be met by diluting 1.3 g urea and 2.8 g sulphate in 60 ml water for one plant (or 1.3 and 2.8 kg in 60 l for 1000 plants; or 58 kg and 125 kg in 2700 l/ha).

4.6.2. Use of complete fertilizers

This type of fertilizer is mainly used in a 15/15/15 formula, which is not very favourable for pineapple unless it is enriched by a third of its weight in potassium sulphate. With such a mixture, a formulation of the type 11/11/23 is obtained. If to 100 g of 15/15/15 we add 100/3 g, i.e. 33 g of potassium sulphate, the equivalent of 16 g of soluble potassium (K_2O) is added to the 133 g mixture, which is now composed of 15 g of N, 15 g of P_2O_5 and 31 g of K_2O, i.e. a mixture at 11/11/23 per 100 g. In the current configuration, the total amount of mixture to be applied to each plant would then be 27 g since the current application rates correspond to approximately 4 g of N, i.e. 9 g per application for a 3-application split and 5.4 g for a 5-application split. If the applications are increased to 5 g of N and 12 g of K_2O, these figures become 45, 15 and 9 respectively.

However, it is best to have a complete fertilizer adapted to the needs of pineapple (type 11-5-27-5/N-P-K-Mg). While such a formulation can be developed specifically for the needs of pineapple growers, making five applications of 6–7 g per plant/application would ideally cover the nutrient requirements of one plant.

For a flowering treatment at about 9 months (36 weeks), these applications could, for example, be made in weeks 4, 11, 18, 25 and 30 after planting.

In the dry season, solid applications can be replaced by liquid sprays of a urea/potassium sulphate mixture, as described above.

If a polyethylene cover is used, the manuring plan could be as follows: bury 7 g of complete fertilizer per plant (fertilizer distributed on the ground, then "concentrated" and mixed with the soil when making the ridge). In this case, the first application at 4 weeks would be removed, as proposed in the above schedule.

4.6.3. Use of certified organic fertilizers

The use of a fertilizer such as 'Bioferti' (supplied by Biophyto) could be considered. Its formula 4.8-3.5-4/N-P-K requires an enrichment in potassium sulphate at the ratio 15 K_2SO_4/100 Bioferti. Total requirements would then be 70–80 g per plant. The methods of application are as described above for complete fertilizers.

This formulation has the advantage of containing various natural compounds with insecticidal and nematicidal properties.

4.7. Floral induction treatment (FIT)

4.7.1. Principles

This treatment is one of the most remarkable features of pineapple cultivation and allows downstream management of the crop. Depending on the floral induction treatment, the grower can:

- direct production towards the most interesting periods in terms of price and/or fruit quality;
- act on the average weight of the harvested fruits, which is proportional to the stage of development of the plant at the time of FIT.

FIT is an essential operation, on which the profitability of the farm depends. Beyond its punctual efficiency, its most important feature is reliability: at least 98% success at any time of the year should be targeted.

Although other processes exist, such as ethephon or ethylene (gas) treatment, calcium carbide treatments are recommended. They induce a better response in sugarloaf compared to the Cayenne variety.

There are, however, a few principles that must be respected:

- maximum effectiveness is achieved when treatments are carried out at night (an early-night application is preferable to a late-night application);
- daytime treatments are possible in cool and not very sunny periods, but in daytime the success of the operation is less certain;
- repeating the treatment 3–4 days after the first one is of much less interest for sugarloaf, which is more sensitive to artificial induction than other varieties;
- rain occurring within 3 hours after treatment will cancel its effect;
- the water used must be fresh to optimize gas dissolution, so it is preferable to bring the water to the edge of the plot at the last moment, or to keep it in the shade.

In addition, important precautions must be taken:

- Acetylene produced by the reaction of water with calcium carbide is dangerous – it is flammable and explosive. Therefore, smoking must be avoided during the treatment. In contact with copper, acetylene gives a very unstable compound that can explode. Any contact between this gas and this metal is therefore to be avoided.
- If the equipment used for floral induction treatments is also used for other treatments (fertilizer, pesticide and herbicide applications), it must be washed carefully to avoid accidental blooms.

4.7.2. Treatment practice

In a 200-litre metal drum (e.g. a motor oil drum) filled with water (150 litres), 500 g of calcium carbide is added in small pieces. Calcium carbide should always be stored in a very dry place, away from water. Shortly before use, it should be broken into small pieces with a hammer.

To ensure complete gas release and good dissolution of the calcium carbide, it is preferable to cap the drum before shaking. The resulting white spray mixture should be used as soon as possible. It should be transferred to a knapsack sprayer without a pre-pressure system, or to a small canister modified to be carried as a backpack, with a hose that can be plugged with a gloved finger to control the flow of the liquid by gravity.

Between 25 and 50 ml of spray are poured into the heart of the plants. The water requirement is therefore 25 to 50 litres per 1000 plants or 1125–2250 litres per hectare.

4.8. Fruit care

4.8.1. Fruit protection

At present, there is no intervention between floral induction treatment and ethephon degreening.

Due to the weight of the fruit and shoots, lodging phenomena are very frequent and have some harmful effects, such as:

- sunburn on the upper side of the fruit making it unsuitable for export;
- risk of increased translucency of the flesh and therefore greater fragility;
- curved crowns, a defect regularly pointed out by importers.

These drawbacks can be largely mitigated by carrying out an operation to reduce lodging 4–6 weeks before harvest. The procedure described below can only be carried out in double-row planting.

The operation consists of stretching strings on each side of double rows of pineapple and over their entire length to bring all the leaves towards the centre of the row. The two parallel strings are connected every 1.5 m by 60 cm transverse strings, which hold them in place. In addition to the stakes placed at the end of the rows, stakes should be planted along the row to stabilize the string network. This operation is costly as it requires several days of work per hectare. The strings (nylon strings are stronger and cheaper than sisal strings) can be retrieved and used at least a second time. This technique uses 20–22000 m of string per hectare.

The strings should be removed just before ethephon treatment (which takes place close to harvest), in order to limit the risks of lodging.

This operation has advantages (increase in the percentage of fruit exported), but also a certain cost. It is up to producers to conduct their own experiments to assess its economic feasibility.

4.8.2. Ethephon degreening treatment

This treatment aims to remove chlorophyll from the skin of the fruit. The green colour fades and gives way to the yellow/orange pigments present in the fruit skin (the ethephon does not affect the intensity of these). The intensity of yellow/orange pigments is determined long before in the crop cycle (for example by use of adapted potassium manure, and with temperatures not too high). The stage of maturity at the time of application only determines the different reactivity of the fruit to the degradation of chlorophyll.

For optimal effectiveness, and in compliance with European regulations on maximum residue levels (MRLs), the methods of treatment with ethephon depend on several factors:

- stage of fruit development (generally estimated as degrees Brix);
- size of the fruit;
- climatic conditions;
- method of application;
- interval between application and harvest.

Currently it is impossible to recommend an exact procedure for sugarloaf due to a lack of data. If we take as an example the knowledge acquired on the smooth Cayenne variety in Ivory Coast, and aiming to comply with an MRL of 2 mg/kg for medium-sized fruit (1300 g), the following should be taken into account :

- apply when the degrees Brix value is higher than 12;
- spray each fruit with 15 ml of a solution providing 27 mg of active ingredient – this corresponds to 55 ml of commercial product at 480 g a.i./l in a 15 litre knapsack sprayer to treat 1000 plants, or about 3 litres of commercial product per hectare (at a density of 55,000 plants);
- apply a smaller volume to the smaller fruit;
- rainfall, even of low intensity, occurring within 8 hours after application will cancel the effect of the treatment; rainfall occurring 24 hours later has no impact on its effectiveness and considerably reduces residues, mainly on the skin;
- washing/brushing the fruit before packing reduces residues by up to 60%.

Depending on the time of year, the desired Brix value for applying ethephon is reached 135 to 140 days after FIT. It would be useful to carry out a more detailed study on this topic, which could lead to a mathematical forecasting model based on the sum of the temperatures experienced by the fruit. Such models exist for other varieties.

In addition to compliance with standards, it should be remembered that an inaccurate use of ethephon, particularly if it is applied too early, can have negative consequences on the quality of pineapples.

Moreover, consumers are increasingly suspicious of synthetic plant protection products and the residues they cause. Selling pineapples with green skin deserves to be considered, but only if good communication is put in place.

4.9. Harvesting and packaging

Due to the persistence of its green colour, it is necessary to gain some experience to correctly determine the optimal cutting point for sugarloaf pineapple. It is becoming more and more common to harvest a plot in one go, thanks to the homogenization of external coloration obtained by applying ethephon. This practice facilitates organization of the harvest, reduces costs and simplifies freight booking. However, it unfortunately results in a decrease in the average quality of the fruit, as not all of them are at their optimal stage of ripeness. For this reason, it is preferable harvest over 2 days. In this case, the large fruits, which are the most fragile, must be harvested first. This practice is unfortunately limited by its cost.

For harvesting, the fruit must be detached from the plant by simple breaking. The shoots must remain on the peduncle.

The transport, sorting and packing conditions must be optimal in order to:

- reduce the time interval between harvest and export as much as possible;
- avoid injury to fruit during harvesting, transport and packaging, as far as possible;
- be able to sort and allocate fruit easily and correctly.

The creation of correctly arranged mini-packing centres close to plots can make it possible to:

- reduce transport time and the risk of damage;
- work even during rain without the cartons becoming wet;
- provide sorting tables with sufficient surface area to spread out the fruit well and to be able to allocate it into homogeneous cartons.

Ideally, packaging centres must have a basin for plunging the fruit. This makes it possible to :

- remove over-ripe fruit (which are runny);
- wash fruits – in combination with brushing, this strongly reduces ethephon residues.

The water in this basin must be regularly changed and chlorinated to be disinfected.

4.9.1. Post-harvest work

This can be limited to the elimination of a few shoots on plants that have a large number of them: work in Brazil has shown that this operation accelerates and improves the growth of the remaining shoots.

BIBLIOGRAPHY

General documents on pineapple

Agro Eco and FAO (2008) Improve your sugarloaf pineapple production: illustrated manual for organic farmers in Ghana.
http://www.fao.org/fileadmin/templates/organicexports/docs/Organic_sugarloaf_pineapple_manual.pdf

d'Eeckenbrugge, G.C. and Leal, F. (2001) Pineapple.
http://ciatweb.ciat.cgiar.org/ipgri/fruits_from_americas/frutales/more%20about%20pineapple.htm

PIP (2015) Guide to good crop protection practices for pineapple (Ananas comosus) in organic farming in ACP countries. https://eservices.coleacp.org/en

PIP (2015) Crop production protocol: Pineapple Cayenne.
https://eservices.coleacp.org/en

PIP (2015) Crop production protocol: Pineapple MD2. https://eservices.coleacp.org/en

Py, C., Lacoeuilhe, J.J. and Teisson, C. (1984) L'ananas : sa culture, ses produits. G.P. Maisonneuve et Larose et A.C.C.T, Paris, France.

More specific documents on sugarloaf

Agbangba, C.E. (2016) Réponses agronomiques de l'ananas (Ananas comosus) à la fertilisation minérale au Bénin: croissance, rendement et qualité du fruit. Thèse de Doctorat - Université Cheikh Anta Diop Dakar

Agbangba, C.E. *et al.* (2016) Modélisation de la réponse de l'ananas Cayenne Lisse à l'azote, au phosphore et au potassium sur sols ferralitiques au Bénin. Revue Cames, vol. 4, n°2, 12-24

Cayrol, J.C. *et al.* (1984) La lutte biologique contre les nématodes phyto-parasites. Courrier de la Cellule environnement de l'Inra, n°17, 31-44

Reinhardt, D.H. *et al.* (2001) Slip thinning – a new cultural practice for 'Pérola' pineapple. Newsletter of the Pineapple Working Group, International Society for Horticultural Science, n°8, 10-13

Reinhardt, D.H. *et al.* (2002) Pérola and Smooth Cayenne pineapple cultivars in the state of Bahia, Brazil: growth, flowering, pests, diseases, yield and fruit quality aspects. Fruits, vol. 57, n°1, 43-53

Rodrigues, A.A. *et al.* (2013) Nutrição mineral e produção de abacaxizeiro 'Pérola', em função das relações K/N na adubação. Revista Brasileira de Fruticultura, vol. 35, n°2, 625-633

dos Santos, N.M. and Filho, P.E.M. (2011) Evaluation of pineapple genotypes for resistance to the pineapple mealybug wilt-associated virus. Newsletter of the Pineapple Working Group, International Society for Horticultural Science, n°18, 12-15

Sossa, E. (2016) Influence des pratiques culturales sur le statut nutritionnel, le bilan hydrique, le rendement et la qualité de l'ananas cultivé sur sols ferralitiques du plateau d'Allada au Sud Bénin. Thèse de Doctorat - Université Abomey Calavi

GROWING PEOPLE

JANVIER 2020 - Réf. : 00406-03

coleacp.org