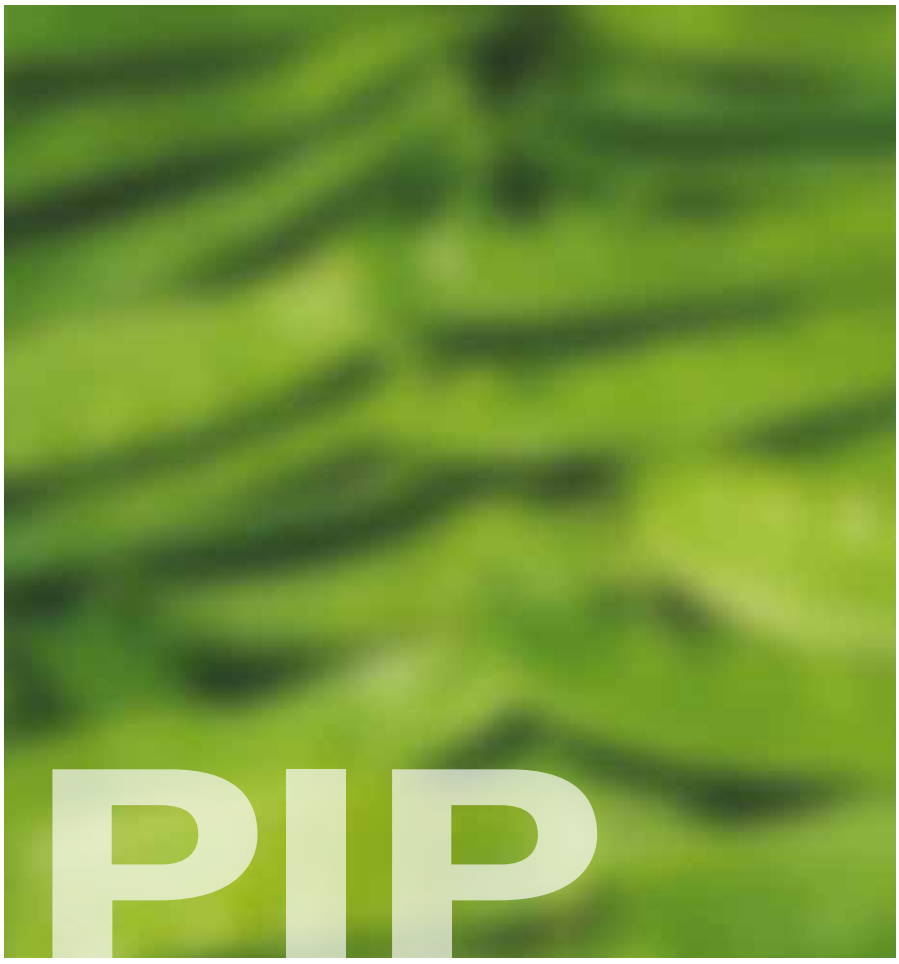

CROP PRODUCTION PROTOCOL

PINEAPPLE CAYENNE (*ANANAS COMOSUS*)

COLEACP is an international network promoting sustainable horticultural trade.

PIP is a European cooperation programme managed by COLEACP. It is financed by the European Development Fund and implemented at the request of the ACP (Africa, Caribbean and Pacific) Group of States.

In accordance with the Millennium Development Goals, the global objective is to: "Maintain and, if possible, increase the contribution made by export horticulture to the reduction of poverty in ACP countries".

www.coleacp.org/pip

PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Disclaimer

The document « Crop Production Protocol » (fruit or veg.) describes all the agricultural practices linked with the (fruit or veg.) and suggests control of pests and diseases based mainly on active substances supported by the pesticides manufacturers in the EU Regulation 1107/2009 review and due to comply with pesticides residues limits. Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The pests and diseases control suggested is dynamic and will be adapted continuously integrating all information gathered by the PIP (see the web site www.coleacp.org/pip). Nevertheless, each grower has the possibility to select among the products listed a set of active substances of no conce rn regarding residues.

It is obvious, that usage is allowed only for those formulations which have been legally registered in the country of application. It is each grower obligation to check with the local registration authorities whether the product he/she wishes to use is mentioned on the list of registered products.

The PIP's crop protocols and guides to good phytosanitary practices are regularly updated. For further information, see the PIP website www.coleacp.org/pip

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DISCLAIMER

Ongoing regulatory reviews and the implementation of stricter standards have led to many changes to authorisations of plant protection products (PPPs) and maximum residue limits (MRLs), both within the European Union (EU) and at international level. This has a direct impact on producers, who often must change their production practices (good agricultural practices, GAP) to comply with the new rules. Any non-compliances can lead to the interception and destruction of produce, causing significant financial losses as well as reputational damage.

Please note that this document has not been updated since 2011, and information it contains regarding the status of PPP authorisations and MRLs may not be up-to-date. This document is currently under revision.

Before applying any PPP, it is advisable to consult the latest regulatory changes. Producers may supply diverse markets that follow different regulations. EU approval of active substances and MRLs can be consulted in the **EU Pesticides database**[1]. For domestic and regional markets, a list of PPPs registered for use is usually provided by the national competent authorities. African, Caribbean and Pacific (ACP) countries generally apply the MRLs set by the **Codex Alimentarius**[2].

Keeping track of PPP authorisations and MRL changes is complex and time-consuming, but is essential to ensure regulatory compliance. COLEACP has responded to requests to provide a PPP information service that keeps members up-to-date with the changes that are most critical for the ACP fruit and vegetable sector. This includes a database (**e-GAP**) for COLEACP members and partners, which lists EU and Codex Alimentarius MRLs for key horticultural crops in ACP countries. It also provides the GAP (dose rate, intervals between treatments, pre-harvest intervals) that ensure compliance with these MRLs. Additional information is also offered – type of pesticide, registration status of active substance in the EU and in ACP countries, classification recommended by the World Health Organization, and resistance group (FRAC code for fungicides; IRAC classification for insecticides. The e-GAP database can be accessed via COLEACP's e-services website: eservices.coleacp.org.

1 https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN

2 http://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/pesticides/en/

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Foreword

Pesticides form one of the weapons that can be used to control pests of pineapple. They receive considerable coverage in this document. To guide the reader, we suggest substances that can be used in this control but nevertheless draw attention to the following points :

- the substances do not exclude other substances available on the pesticides market;
- the substances are often toxic for humans and the environment. Each user must respect the conditions of use specified by the manufacturer and also the safety rules for the protection of the user, his family, the environment and consumers.

Control of pests and diseases of pineapple also requires complementary actions described here. Applied properly, they will act in synergy with control by means of pesticides. The effectiveness of pesticides will be enhanced and the need to use them may possibly be lessened.

Note on the status of active substances in EU

Before a Plant Protection Product can be marketed in EU, its active substance must be approved by the European Commission. Regulation (EC) 1107/2009 (replacing former "Directive 91/414/EEC") came into force on 14th June 2011. By 25th May 2011 the Commission adopted the Implementing Regulation (EU) N° 540/2011 as regards the list of approved active substances. These Regulations and all other related Regulations can be accessed using the search facility on the following: http://ec.europa.eu/food/plant/protection/evaluation/index_en.htm

It should be noted that if an active substance is not registered in the EU it can still be used in the ACP countries in food items exported to Europe, provided the residue complies with the EU MRL.

Note on MRLs:

The quantities of pesticide residues found in food must be safe for consumers and remain as low as possible.

The maximum residue limit (MRL) is the maximum concentration of pesticide residue legally permitted in or on food or feed.

MRLs in the EU

Pursuant to Regulation (EC) No 396/2005 harmonized Community MRLs have been established.

The European Commission (EC) sets MRLs applying to foodstuffs marketed in the territories of the EU countries, either produced in the EU or in third countries.

Annex I to the Regulation contains the list of crops (Regulation (EC) 178/2006) on which MRLs are assigned, Annexes II and III contain the MRLs: temporary MRLs can be found in Annex III, final MRLs in Annex II. Substances for which an MRL is not required are listed in Annex IV (Regulation (EC) 149/2008). When there is no specific MRL for a substance / crop a default MRL, usually set at 0.01 mg/kg, is applied.

When establishing an MRL, the EU takes into account the Codex MRL if it is set for the same agricultural practices and it passes the dietary risk assessment. Where appropriate Codex MRLs exist, the import tolerance will be set at this level.

EU harmonized MRLs came into force on 1 September 2008 and are published in the MRL database on the website of the Commission http://ec.europa.eu/sanco_pesticides/public/index.cfm

See also the leaflet "New rules on pesticide residues in food" http://ec.europa.eu/food/plant/protection/pesticides/explanation_pesticide_residues.pdf

How are MRLs applied and monitored in EU?

- Operators, traders and importers are responsible for food safety, and therefore for compliance with MRLs.

- The Member State authorities are responsible for monitoring and enforcement of MRLs.

- To ensure the effective and uniform application of these limits, the Commission has established a multiannual Community monitoring program, defining for each Member State the main combinations of crops and pesticides to be monitored and the minimum number of samples to be taken. Member States must report results to the Commission, which published an annual report. At present the reports are published by the European Food Safety Authority (EFSA) http://www.efsa.europa.eu/en/scdocs.htm

- In case of detection of pesticide residue levels posing a risk to consumers, information is transmitted through the Rapid Alert System for Food and Feed (RASFF) and appropriate measures are taken to protect the consumer. The database is accessible on http://ec.europa.eu/food/food/rapidalert/rasff_portal_database_en.htm and RASFF publishes an annual report http://ec.europa.eu/food/food/rapidalert/index_en.htm.

- PIP monthly updates on its website a summary of RASFF notification for fruit and vegetable imports from ACP countries.

MRLs in ACP countries

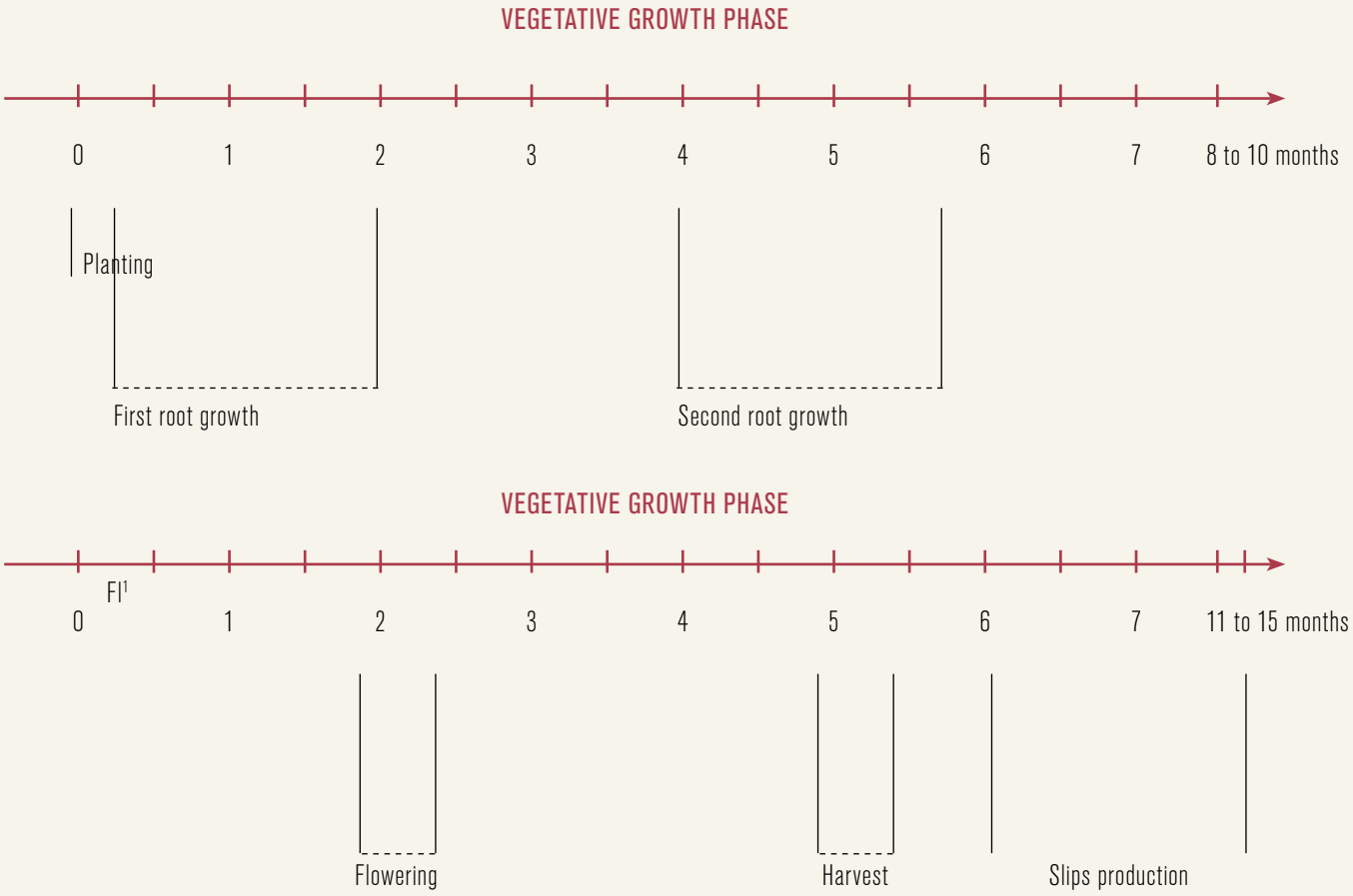
ACP countries don't have set their own MRLs therefore they usually admit Codex LMRs for foodstuffs marketed in their country.

The Codex Alimentarius Commission was established in 1961 by the Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) with the objective to develop an international food code and food standards. Membership of the Codex Alimentarius Commission is open to all Member Nations and Associate Members of FAO and WHO. More than 180 countries and the European Community are members of the Codex Alimentarius Commission.

The Joint FAO/WHO Meetings on Pesticide Residues (JMPR) is not officially part of the Codex Alimentarius Commission structure, but provide independent scientific expert advice to the Commission and its specialist Committee on Pesticide Residues for the establishment of Codex Maximum Residue Limits, Codex MRLs for pesticides which are recognized by most of the member countries and widely used, especially by countries that have no own system for evaluating and setting MRLs.

The Codex MRL database can be found on the web site: http://www.codexalimentarius.net/pestres/data/index.html?lang=en.

000 - Crop cycle : the example of smooth cayenne in an equatorial climate



Pineapple cultivation is unique because flowering is induced artificially by man. Floral induction (FI) enables planters to group flowering and therefore the harvest in a field. FI can be performed all the year round and so the production cycle can be scheduled.

As a result, the pineapple cropping cycle is divided into two stages. The first is the vegetative growth of the plant and is completed by floral induction (FI).

Most of the cultural operations are performed during this stage. The second stage is that of the production of fruits and then of the slips required for renewing plantations. Slip production must not be neglected during the cropping cycle.

The length of these cycles varies according to the climate in the production region and the plant material.

Cultivation periods:
As flowering is induced artificially, pineapple can be grown and harvested all the year round. However, fruits harvested during the rainy season display high levels of acidity.

[1] FI : floral induction

001 - Land preparation

Root fragility is a key element in understanding and making a success of pineapple growing. The root system is shallow, being mainly in the first 40 cm of the soil. The roots are extremely fragile and can only grow in loose, well aerated soil. Any obstacle to their growth adversely affects plant development. The roots are also very susceptible to asphyxia caused by excess water in the soil. These requirements must be taken into account in the choice of land and its preparation.

1.1. Soil characteristics

Suitable soil for pineapple is friable, well aerated with rounded solid particles, satisfactory drainage and homogeneous to a sufficient depth (40 to 50 cm).

Homogeneity is of prime importance as the roots are extremely sensitive to changes in soil density. The stopping of root growth is very often observed when there is plough pan[2], a more clayey zone or a layer of gravel and stones. Natural soil permeability is also an essential quality as too much water in the soil has catastrophic results. Roots may suffer from asphyxia after heavy rainfall. Any soil with traces of hydromorphism at a depth of less than 60 cm should not be used.

Light, porous fast-drainage soil should be chosen for pineapple. Soil with what can be considered to be the optimum texture has the following average features : 60 to 70% sand, 10 to 20% silt and 10 to 20% clay. Sandyclay to clayey-sandy soils are the best.

Silty soils ('capping' soils) and clayey soils (heavy) are not recommended at all. Soils that are too gravelly are not very favourable and hinder root growth. They enhance the development of symphylids, pests that cause serious damage to pineapple roots.

Pineapple can stand soil with low mineral content if the nutrient requirements are met by fertiliser application. Soil acidity should be a factor in choice more than richness. Optimum cultivation is at a pH of between 4.5 and 5.5 although pineapple tolerates pH values of 3 to 7.5. Risk of *Phytophthora* rot is high in soils with low acidity (pH > 6). In contrast, acid soils enhance the development of nematodes and pH < 4 should be avoided.

1.2. Evolution of soil fertility in land under pineapple

In pineapple monoculture, the structural and organic characteristics of the soil worsen fairly rapidly after the clearing of a forest fallow (the structural stability of aggregates decreases and humus contents fall) and a plateau is reached after several years. The systematic ploughing in of crop residues makes it possible to maintain the new balance of soil organic content and structural stability.

Soil erosion is a strong constraint to be taken into account. The rows of plants cover the soil poorly during the two or three months following planting and their root systems are little developed. The soil is therefore strongly exposed to erosion by runoff from rain between the rows. This is all the more marked when the slope is steep and the soil more sandy and less clayey. Gently sloping land should therefore be sought as runoff is limited during heavy rainfall.

It is recommended that contour planting with a very slight slope should be used on steep slopes and when the soil is sandy. The force of the runoff can also be weakened by planting three or four pineapple plants at regular intervals across the direction of water flow.

[2] Plough pan is the compaction of the soil at a depth following poor plough adjustment.

Decreased soil fertility can have as negative an effect on production as nematode attacks. Soil leaching and the loss of organic matter and decreased structural stability:

- significantly affect plant nutrition;
- enhance soil acidification;
- reduce resistance to water stress;
- adversely affect the biological activity of the soil, encouraging the development of nematode populations.

1.3. Soil management – Field preparation

Plant cover should be destroyed as thoroughly as possible to avoid the presence of unrotted plant residues in the soil that hinder root development and may harbour pineapple pests and diseases. It is recommended that organic matter be left to dry for at least two to three weeks after rotary slashing before ploughing it into the soil. Ploughing in is performed with a disc plough or a mouldboard plough, which turn the plant residues in deeper. When poorly handled, these classic ploughs often cause plough pan or soil compaction that are harmful for root growth.

Preparation of the soil surface is completed by one or two runs of machines with tines (scarifier, harrow, etc.) or a disc harrow. The latter, together with rotavators, are not very suitable as they tend to create compacted soil zones. Work on surface finishing of the land should be limited to avoid compaction and to reduce field preparation costs. Rotary spading machines are an interesting alternative to the two operations described above. Indeed, they avoid plough pan formation and compacted soil areas. If the plant cover has been destroyed properly, they provide very good soil preparation for pineapple by reducing the number of machine runs. Use of these machines must be well mastered.

Preparation is completed by ridging—even of a minimum kind. This creates a well-aerated immediate environment that enhances root development and limits standing water, especially in hollows. The advantages of ridging can only be called into question in naturally drained zones (sandy soil) or on steep slopes (runoff). Excellent mastery of land preparation is required in this case. Ridges are approximately 70 cm wide at the top, 90 to 100 cm wide at the base and 30 cm high for double row planting.

1.4. Polyethylene cover

Opinions of polyethylene film as soil cover vary. It creates large waste disposal problems but is justified in various situations with regard to moisture constraints. It can only be used on ridges. Laying polyethylene film serves the following purposes :

- preventing moisture stress during the early months of plant development, on condition that it is laid on moist soil;
- limiting the impact of heavy rainfall (reduction of excess water at the foot of the plant, considerable reduction of the leaching of fertiliser and pesticides applied in solid form);
- reducing invasion by weeds that are difficult to control on ridges although *Cyperus* and *Imperata* can pierce it;
- enhancing root growth by increasing soil temperature and reducing soil compaction caused by rainfall.

The main disadvantages of the technique are as follows :

- as it is difficult to re-moisten soil, the technique is not really advised if planting is performed in dry soil;
- it is expensive and the resulting increase in productivity must be strictly evaluated;
- spraying is less effective when the plants are little developed as 30 to 50% of the spray is 'lost' on the polyethylene or runs into the tracks;
- a microclimate at soil level that is more favourable for pests (mainly nematodes and symphylids);
- polyethylene waste accumulates and is difficult to dispose of.

Apart from this problem of residues after the harvest, the results of the use of polyethylene are often positive. Film 3/100 to 5/100 mm thick should be chosen, bearing in mind that effectiveness is proportional to thickness.

002 – Planting

2.1. Choice of variety

A few years ago, Smooth Cayenne was the main variety exported to the European Union. New hybrid 'sweet' varieties are now developing strongly.

The advantages of this new generation of hybrids are :

- the fruits naturally display better colour;
- low acidity in contrast with Smooth Cayenne;
- hardiness in transport and storage.

In addition to these two varieties suitable for shipment by sea, Queen fruits are also good for top of the market fruits (for example those shipped by air).

They colour naturally and are very fragrant. They are also fragile during transport and storage.

2.2. Plant material

We refer only to the use of slips, the most frequently available planting material in the fresh fruit export sector.

The quality of the slips (freshness, weight, homogenicity, etc.) is one of the key factors in the success of the crop. Good conditions must be ensured throughout slip production by good field maintenance (fertiliser application, weeding, pesticide application) and regular collection of the slips.

The slips used generally vary in weight from 300 to 600 grams. Lighter slips result in a longer cycle. The use of slips that are too large increases the risk of 'natural' uncontrolled flowering at certain times of the year. The optimum weight of a slip for planting is between 400 and 500 g.

Depending on size, slips do not grow at the same rate. It is therefore important to plant them in size groups to achieve homogeneous growth and then harvesting. Slips should be sorted by weight (100-g categories) or by diameter at the base.

Trimming consists of removing the old short leaves from the base of the slip before planting. This exposes the few roots present and speeds up root growth after planting in the dry season.

It is naturally essential to plant healthy plant material, that is to say material free of mealybug, and not infected by wilt or black rot at the base (blackheart of pineapple). Exposure of the base cut to the sun is usually sufficient to protect the slip from black rot. Regular treatment of slip production fields against mealybug means that the material harvested is healthy.

Once the slips have been cut and sorted and possibly assembled in bundles at the edge of the production field, they are taken to the field for planting as soon as possible. Properly prepared slips can be kept in the shade while awaiting planting but this nevertheless affects their quality.

2.3. Slip planting layout and planting

The plants are usually set out in twin rows or triple rows and planted with a quincunx layout. The plants should be spaced at 25 to 30 cm intervals along the row with 30 to 40 cm between the rows. The row must be 15 cm from the edge of the ridge.

Densities can be within the range of 50,000 to 70,000 plants per hectare. The lowest densities are the best in areas with low insolation such as lower Ivory Coast. The highest densities should be preferred in zones with ample sunshine north of the 6th parallel where, furthermore, the use of polyethylene cover and irrigation are recommended.

The higher the density the more the selection of slips must be rigorous. Indeed, as densities increase, competition phenomena increase as does the heterogeneity of the fields. The plants that develop least in the months following planting may then be completely smothered and bear only very small fruits.

It is preferable to stake before planting to ensure that the plants are set out regularly at the density chosen. Planting slips is an operation of prime importance for a good start to growth and the homogeneous development of plants. It must enable good slip/soil contact avoiding a smooth wall that would disturb root growth and favour the accumulation of water, bringing a risk of rot.

Planting depth should be no more than 8 to 10 cm (according to the size of the slip) to prevent rot and earth in the heart of the plants. The planting holes must not be prepared in advance. The plantlets should not be 'screwed' into the soil as this damages buds and smoothes soil with which they are in contact.

003 – Fertilisation

3.1. Plant requirements [3]

The average requirements of one pineapple plant for the production of fresh fruit are as follows :

- 4 g nitrogen, N;
- 1 to 2 g phosphorus, P_2O_5;
- 8 to 10 g potassium, K_2O;
- 2 to 3 g magnesium, MgO.

Calcium requirements are less precise but essential for growing highquality fruits.

All these substances must be applied when the soil is poor, and especially in pineapple monoculture in sandy-clayey soil. However, in other situations it is preferable to perform soil analysis to evaluate the right amounts of fertiliser to be applied. This is particularly necessary if pineapple is planted after a legume or forest fallow which modify the amount of nitrogen available in the soil.

It is essential to respect the balance between nitrogen and potassium in order to produce high-quality fruits. The K:N ratio should be an average of 2 to 2.5 throughout the vegetative cycle. If the plant requirements are not fully met, the decrease in applications of nitrogen and potassium should take this balance into account.

Leaf mineral analysis is a way of finding out the nutritional state of plants. Analysis is performed on the last leaf that has completed its growth and that is roughly the longest leaf. This leaf is removed, washed, dried and ground before analysis. Sampling should not be performed less than a week after fertiliser application. It is essential to perform a final application of nitrogen and potassium two (minimum) to three weeks before FI. Normally, no fertiliser application is required after FI.

Well-functioning plant roots are required for good fertiliser uptake. This means good land preparation and absence of root pests and diseases (wilt, nematodes, symphylids). There should be no competition from other plants and so weed management must be well handled.

3.2. Minerals : benefits and signs of deficiency

3.2.1 Nitrogen

Nitrogen determines speed of growth and hence plant volume and fruit weight. Minor deficiency at the beginning of the cycle can be compensated. In contrast, good nitrogen supply is essential at the approach to FI.

Plant nitrogen deficiency has a direct effect on yield. Too much nitrogen can have the following effects :

- reduction of plant response to floral induction treatments;
- excessive peduncle elongation;
- decreased sugar content at harvest;
- less fruit colour at harvesting (green fruits);- reduced fruit resistance to transport.

[3] These are for Smooth Cayenne.

Nitrogen must be applied regularly so that it is fully used and in order to avoid growth in fits and starts. A recovery of growth following nitrogen application after a period of deficiency at the end of the vegetative cycle risks reducing plant response to floral induction treatments.

The foliage of plants with satisfactory nitrogen nutrition is green to dark green. Nitrogen deficiency causes the yellowing of the foliage; this starts in the oldest leaves. It also causes a change in plant growth rate (on condition that climate is not a limiting factor–a period of drought, for example).

Excess nitrogen gives the plants a bluish colour and excessive vigour. Nitrogen contents of 1.3 to 1.5% of the dry matter in the last leaf are considered to be satisfactory [4].

3.2.2 Potassium

The level of potassium nutrition during the approach to floral induction has the most effect on fruit quality, affecting sugar content, acidity, color and flavour. It has an effect on fruit texture, colour and filling. It also affects yield but less so than nitrogen.

When nitrogen supply is normal, potassium deficiency is shown by the appearance of small yellowish linear and ellipsoid streaks at the edges of the leaves. They tend to merge if the deficiency worsens, causing withering from the tips of the leaves. The fruits have little acidity and no fragrance. In contrast, too much potassium gives coloured fruits that are acid with little colouring of the flesh.

It is considered that the potassium content of the last leaf should be more than 3.5% of dry weight at FI[5].

3.2.3 Phosphorus

This is essential for plants as it affects the movement of energy between organs. Phosphorus requirements are nevertheless small and pineapple displays good phosphorus uptake. The soil generally provides requirements and phosphorus deficiency is rare. Phosphorus moves little in the soil and mineral analysis of the latter is recommended for guiding application.

Phosphorus deficiency results in a slowing of growth, long, narrow and often bluish leaves if the nitrogen supply is plentiful and wilting of leaf tips, starting with the oldest leaves.

The phosphorus content of the youngest leaf should be more than 0.10-0.12% dry matter[6].-

3.2.4 Magnesium

This is essential for plants as a component of chlorophyll. It also contributes to fruit quality (fruit sugar content, flavour, resistance and shelf life).

Magnesium deficiency causes small more or less rounded, yellowish leaf spots generally in the central part of the lamina. They are first visible against the light and tend to become depressed and acquire a darker colour. The foliage is generally a paler colour than when there is no deficiency, mainly in very sunny zones ('sunscald' effect).

The magnesium content of the youngest leaf should be over 0.18-0.20% of dry matter [7].

[4] For Smooth Cayenne – adapation may be necessary for other varieties
[5] For Smooth Cayenne – adapation may be necessary for other varieties
[6] For Smooth Cayenne – adapation may be necessary for other varieties
[7] For Smooth Cayenne – adapation may be necessary for other varieties

3.2.5 Calcium

This contributes to the formation of cell membranes. It is an essential element by the calcium requirements of pineapple are poorly known.

Calcium has a twin effect. It acts on pH in the soil and this is the main reason for using it. It also contributes to plant development. Its effect on cell walls may mean that it affects susceptibility to black spot.

Calcium deficiency is very rarely observed. If it occurs, the plants have a very squat habit, the leaves become hard and brittle, the terminal bud dies and suckers proliferate.

3.2.6 Trace elements

Iron is the trace element most needed by pineapple. It is involved in photosynthesis. Deficiency causes chlorosis of the foliage, which display alternate pale and dark stripes like netting. The fruits are small, globular and red. This deficiency caused by blockage in the soil is very frequent on previous termite mounds places. Requirements in other trace elements are very small but their uptake can be slowed by an increase in soil pH.

Twin zinc and copper deficiency causes deformation of the plants. They become curved, with brittle leaves in the form of gutters and the foliage becomes pale green. Boron deficiency causes the formation of very typical 'corky' fruits.

3.3. Planned fertilisation

Fertilisation must be planned in the light of soil analyses (mineral contents and pH), local availability of formulations and forms of fertiliser (see Table 1), the degree of mechanisation of the farm and the planter's financial resources. It is important to draw up a fertilisation programme on the basis of several main principles.

TABLE 1. PRESENTATION OF CERTAIN FORMS OF FERTILISER USED ON PINEAPPLE

NAME	MINERALS	FORM	TYPE OF APPLICATION	ADVANTAGES
Phosphates (Phosphal)	P - Ca	Solid	Basal dressing	Meets phosphate requirements and modulates soil pH. Ideal for planning a fertilisation programme with urea, sulphate, and potassium chloride and nitrate.
Dolomite, magnesian lime	Mg - Ca	Solid	Basal dressing	Covers magnesium requirements and raises the soil pH. Makes it possible not to apply phosphate if soil analyses show that this is not necessary. Ideal for planning a fertilisation programme with urea, sulphate, and potassium chloride and nitrate.
Kieserite, magnesium sulphate	Mg	Solid	Basal dressing and vegetative cycle	Covers magnesium requirements as a complement to other basal dressings or not to apply phosphate or modify the pH.
Multinutrient fertiliser, 15-15-15	N – P - K	Solid	Vegetative cycle	A universal base to be completed by complementary applications (particularly K) of other formulations.
Special multinutrient fertiliser for pineapple, 11 – 5 – 27 – 5	N – P – K - Mg	Solid	Vegetative cycle	Specific for covering the requirements of pineapple. Ideal for planters with a low level of mechanisation or as the core of a fertilisation programme.
Urea	N	Solid and Liquid	Vegetative cycle	Classic nitrogen application in liquid or solid form. It makes it possible to adjust nitrogen application closely to requirements. Beware of the presence of phytotoxic biuret in poor quality formulations. Beware of leaf burn (concentration < 5% in liquid form).
Potassium chloride and potassium sulphate	K	Solid and Liquid	Vegetative cycle	The two formulations make it possible to provide plants with precise requirements in liquid or solid form. They are ideally combined with urea applications. Potassium chloride has considerable impact on the fruit acidity at harvesting. This will be favoured without excess (application during the second part of the vegetative cycle) for fruits harvested during the dry season (low acidity) but not applied for fruits harvested during the rainy season (high acidity).
Potassium nitrate	N -K	Liquid	Vegetative cycle	A liquid formulation providing complementary n nitrogen and potassium and rebalancing the fertilisation programme.
Magnesium sulphate	Mg	Liquid	Vegetative cycle	A liquid formulation providing complementary magnesium if this is necessary (drought, signs of deficiency or a desire to correct fruit quality).
Ammonium phosphate	P - N	Liquid	Vegetative cycle	A liquid formulation providing complementary phosphate if this is necessary (drought, signs of deficiency).

3.3.1 Basal dressing, fertilisation during vegetative growth

Basal dressing provides the plants with the elements with little mobility in the soil (phosphorus, calcium, magnesium and trace elements) for the entire vegetative cycle. It is worked into the soil before ridging that then concentrates the fertilisers applied in the ridge. It may include nitrogen and potassium if polyethylene is used, but in small quantities as these elements are little needed by the plant in the first month of growth.

Fertilisation during vegetative growth provides the plants with the minerals that do no remain available for long for pineapple roots. This mainly concerns nitrogen and potassium. They are soluble and easily leached by water. They may also evaporate in hot weather or be used by other organisms in competition with pineapple (weeds, soil bacterial fauna). It is sometimes useful to apply complementary phosphorus, magnesium or trace elements during the vegetative cycle. Splitting nitrogen and potassium applications means that plant requirements can be more closely matched during growth. The amounts applied should increase with plant development either by increasing the dose at each application or by making more frequent applications.

3.3.2 Liquid and solid fertiliser

In basal dressing, solid fertiliser is turned into the soil. During vegetative growth, it is advised that solid fertiliser should be used in the rainy season, although the period of the heaviest rain (beginning of the season) should be avoided as this causes losses by runoff. The application of solid fertiliser during the dry season is strongly discouraged. Indeed, without rain this cannot be taken up by the plant and the heat causes nitrogen to volatilise rapidly (in two or three weeks). Solid fertiliser is placed at the base of the old leaves of the plants.

Liquid fertilisers should be preferred during the dry season. Application of liquid fertiliser during the rainy season is not advised as it is soon leached by rain. Splitting differs according to whether solid or liquid formulations are used and must allow for the duration of the vegetative cycle. A 7 to 8-month vegetative cycle requires 4 applications of solid fertiliser or 7 applications of liquid fertiliser. A 9 to 10-month vegetative cycle requires at least 5

applications of solid fertiliser or 9 of liquid. One application of solid fertiliser can be replaced by two applications of liquid fertiliser and vice versa.

3.3.3 Suggestion of a procedure for drawing up a fertilisation programme

A compound fertiliser designed for pineapple is a very satisfactory way of fertilising well. Special attention should be paid to splitting applications according to plant requirements and to avoiding fertilising at the peak of the rainy season (loss by leaching) or the peak of the dry season (loss by the volatilisation of fertiliser and especially of nitrogen). It is interesting to design a more complex fertilisation programme when other forms of fertiliser are available.

1. Planning P, Ca and Mg

Depending on the types of fertiliser available and in the light of soil analyses and the pH in particular, plan P, Mg and Ca applications on the basis of basal dressing completed by one or two applications of compound fertiliser during the first half of the vegetative cycle.

2. Complete the programme with N and K

Position nitrogen and potassium applications by using the different formulations and forms of application in order to allow for the following aspects:

- cycle length (the number, frequency and size of applications);
- the stage of growth of the plants (first or second half of the cycle); begin applications in the third week after planting;
- the climate at harvesting (choose potassium sulphate or chloride in the second part of the vegetative cycle in order to play on fruit acidity);
- the climate during application (solid in the rainy season and liquid in the dry season);
- whether polyethylene is used (part of the solid requirements is applied under the polyethylene at planting);
- a K/N ratio of 2 to 2.5;
- the need for a last application of nitrogen and potassium 2 to 3 weeks before FI;
- no fertiliser application after FI.

3. Complete the programme with trace elements

Possibly complete with applications of iron sulphate, zinc sulphate or more complex formulations during the vegetative cycle if this is necessary.

The programme can be adjusted during the cycle according to weather conditions (solid or liquid fertiliser), plant growth (possible complement of P, Mg and trace elements), cycle length (supplementary application of N and K with respect of the ratio of 2 to 2.5 if FI is delayed by two weeks).

3.3.4 Examples of possible fertiliser programmes

Special fertiliser for pineapple

If a special solid fertiliser for pineapple is available (11-5-27-5 type formulation), 5 applications of 7.25 g per plant per run is satisfactory. It is then essential to stagger the applications allowing for the increasing requirements of the plants. It is also essential to allow for the climate and to delay application during peak rainy and drought periods. For example, the following programme can be planned for a cropping cycle with FI in the second week of the 8th month :

Fertiliser g per plant	Week	N	P_2O_5	K_2O	Mg	K_2O/N
7.25 g	4 to 5	0.8	0.36	1.96	0.36	2.45
7.25 g	9 to11	0.8	0.36	1.96	0.36	2.45
7.25 g	15 to 17	0.8	0.36	1.96	0.36	2.45
7.25 g	20 to 22	0.8	0.36	1.96	0.36	2.45
7.25 g	26 to 27	0.8	0.36	1.96	0.36	2.45
Floral Induction (FI)	30	i.e. 4 g N	i.e. 1.8 g P_2O_5	i.e. 9.8 g K_2O	i.e. 1.8 g Mg	

Classic agricultural fertiliser

Very simple fertilisation can be performed by using phosphate and dolomite as basal dressing and then applications of urea and potassium sulphate (in solid or liquid form) during the vegetative cycle.

Basal dressing in solid form :

- 3 to 6 g per plant of Phospal (34% P2O5, 11% CaO);
- 10 to 14 g per plant dolomite (the composition varies from 30 to 36% CaO and 16 to 22% MgO).

Fertiliser during the vegetative cycle :

- 8.7 g per plant urea (46% N) divided between planting and FI;
- 17.6 g per plant potassium sulphate (50% K2O) divided between planting and FI.

The mix is applied in solid or liquid form according to the climate and allowing for the increasing requirements of the plants. For example, 8 applications of liquid fertiliser can be planned as follows for a crop cycle with FI planned in the second week of the 9th month :

Fertilizer g per plant	Week	N	P_2O_5	K_2O	Mg	K_2O/N
3 to 6 g Phospal 10 to 14 g dolomite	Before planting		1 to 2 g		2 to 3 g	
1.09 g urea 2.2 g potassium sulphate	4	0.5		1.1		2.2
1.09 g urea per plan 2.2 g potassium sulphate	10	0.5		1.1		2.2
1.09 g urea 2.2 g potassium sulphate	15	0.5		1.1		2.2
1.09 g urea 2.2 g potassium sulphate	20	0.5		1.1		2.2
1.09 g urea 2.2 g potassium sulphate	24	0.5		1.1		2.2
1.09 g urea 2.2 g potassium sulphate	27	0.5		1.1		2.2
1.09 g urea 2.2 g potassium sulphate	30	0.5		1.1		2.2
1.09 g urea 2.2 g potassium sulphate	32	0.5		1.1		2.2
FI	34	i.e. 4 g N	i.e. 1 to 2 g P_2O_5	i.e. 8.8 g K_2O		2.2

If necessary, two consecutive applications of liquid fertiliser can be replaced by a single application of solid fertiliser, i.e. 2.18 g urea and 4.4 g potassium sulphate applied in the old leaf axils.

Fruit acidity can be increased by replacing potassium sulphate by potassium chloride in the last two or three applications.

If necessary, two consecutive applications of liquid fertiliser can be replaced by a single application of solid fertiliser, i.e. 2.18 g urea and 4.4 g potassium sulphate applied in the old leaf axils. Fruit acidity can be increased by replacing potassium sulphate by potassium chloride in the last two or three applications.

Use of polyethylene film

The laying of polyethylene film means that the nitrogen and potassium required for the starting of growth can be applied before planting and applications are delayed during the vegetative cycle. Basal dressing and first application of nitrogen and potassium in solid form :

- 6 g NPK 15-15-15 per plant,
- 14 g dolomite per plant (composition varying from 30 to 36% CaO and 16 to 22% MgO).

Fertilisation during the vegetative cycle :

- complete phosphate application in the middle of the cycle by a second application of NPK compound fertiliser at 6 g per plant applied to the axils of the old leaves.

Complete fertilisation by applying 6 times the following doses of fertilisers :
1.33 g urea per plant and 3.33 g potassium sulphate per plant equivalent to 0.6 g N and 1.66 g K_2O per application.

For example, the following applications can be planned for a crop cycle with FI planned in the second week of the 9th month :

Fertilizer g per plant	Week	N	P_2O_5	K_2O	Mg	K_2O/N
6 g NPK 15/15/15 14 g dolomite	Before planting	0.9	0.9	0.9	3	1
1.33 g urea 3.33 g potassium sulphate	9	0.6		1.66		2.7
1.33 g urea 3.33 g potassium sulphate	15	0.6		1.66		2.7
1.33 g urea 3.33 g potassium sulphate	21	0.6		1.66		2.7
1.33 g urea 3.33 g potassium sulphate	26	0.6		1.66		2.7
1.33 g urea 3.33 g potassium sulphate	29	0.6		1.66		2.7
1.09 g urea 2.2 g potassium sulphate	31	0.6		1.66		2.7
Total		i.e. 4.5 N	i.e. 0.9 P2O5	i.e. 10.9 K2O	i.e. 3 Mg	2

We have played on the K_2O/N ratio in this programme in order to provide richer nitrogen nutrition at the beginning of the cycle and then more potassium at the end of the cycle.

004 – Weed management

4.1. The issues

Pineapple grows slowly, especially in the first three or four months after the slips have been planted. Growth can be greatly slowed by competition from weeds. Yield losses can exceed 50% in extreme cases.

Weeds compete in three ways :

- for water;
- for minerals;
- for light.

Weeds may also serve as 'reservoirs' and reproduction sites for certain pests such as mealybugs, symphylids, nematodes, etc.

Weed control is therefore essential and must be performed preventively to prevent their spread and growth.

4.2. Control before planting

At this stage, all the weeds that are subsequently difficult to remove should be dealt with and in particular ligneous plants (*Leucena*, *Centrosema*, *Eupatorium*), *Cyperaceae* and *Imperata*. The former can be eliminated mechanically when the preceding crop is destroyed.

Cyperaceae and *Imperata* require repeated cultivation operations to force the corms to germinate, expose them to the sun and possibly collect them. Destruction by a contact herbicide for *Cyperaceae* at the flowering stage and of young active *Imperata* plants is also recommended. It is preferable to act early to prevent these weeds from spreading. If registered in the countries of use and with respect of the standards in force in consumer countries, examples of substances that can be used are glyphosate or paraquat (paragraph 4.5).

4.3. Control at planting

Herbicides with residual action are recommended at planting to block the germination of weed seeds for as long as possible. Application is in two runs. The solution is first applied to the ridge before the slips are planted and then between the ridges after planting. It is recommended that the operator should walk backwards to avoid breaking the film of herbicide left on the soil. It is also better not to work on the ridge during the month following application. If no cyperaceous are present, only the application between ridges is performed if polyethylene is used. Such weed control provides protection for two to three months under favourable climatic conditions.

If registed in the countries of use and with respect of the standards in force in consumer countries, examples of substances that can be used are bromacil or diuron (paragraph 4.5). Caution : bromacil is toxic for pineapple if the recommended dosages are exceeded.

4.4. Control during growth

Manual weeding is certainly the best solution but it must be rationalised according to its cost. It is the only way of weeding between the pineapple plants on the ridge. Chemical weed control can also be performed between ridges. In both cases it is essential to act quickly before weeds go beyond a certain stage of growth.

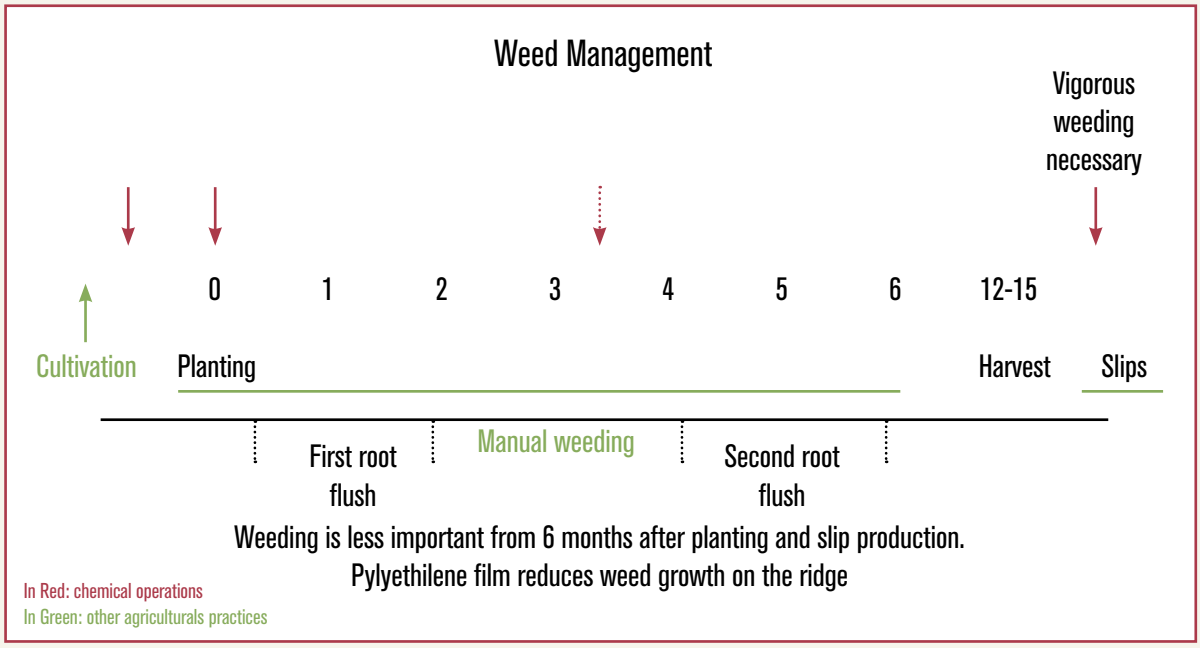
In the case of widespread weed growth, control can be performed between the ridges using the herbicides recommended above on condition that the pineapple plants are not touched. It is preferable to avoid bromacil as this can slow growth without the appearance of visible signs. If residual action herbicide has been applied at planting, a period of three to four months should be left if possible before the second application.

Cyperaceae generally grow in patches. It is then preferable to perform local applications in the zones concerned as early as possible. The areas to be treated are smaller and specific herbicides for *Graminaceae* can be used (these are more expensive but more effective and can be used in general applications on pineapple). After the first 6 months of the plant cycle, pineapple has often grown sufficiently to make a further herbicide application unnecessary before the harvest.

It is reminded (see Chapter 8) that it is essential to weed slips production fields.

TABLE 2. SYNTHESIS OF FAVOURABLE AND UNFAVOURABLE FACTORS IN WEED CONTROL

	FAVOURABLE FOR CONTROL	UNFAVOURABLE FOR CONTROL
Cultivation	++ germination of weeds before planting – exposure of roots to air	
Polyethylene film	++ Prevents weed growth on the ridge	
Total destruction of vegetation in the field after harvesting	+ Control of weed populations	
Cultivated fallow and crop rotation	+ Control of weed populations	++ In case of poor mastery of the fallow species grown
Climat		Rainfall are favorable to weeds development and perturb herbicides applications



4.5. Herbicides : dose recommended in certain countries

The doses of active substance per ha recommended in certain countries are listed below for the substances suggested here.

We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country and in respect of export standards.

	Dosage active substance per ha	Mix volume per ha
Glyphosate	1.5 to 3 Kg/ha	800 to 1,000 l/ha
Paraquat	0.6 to 1 Kg/ha	800 to 1,000 l/ha
Bromacil	1.6 to 2.4 kg/ha	400 to 1,000 l/ha
Diuron	1.7 to 2.2 Kg/ha	400 to 1,000 l/ha

Caution : these are toxic substances and safety conditions for their use must be respected.

005 – Pest and disease management during the pineapple vegetative cycle

We have limited coverage in this document to the 8 pineapple pests and diseases that we consider to be a priority in the ACP zones. They are : nematodes, symphylids, mealybugs and wilt, *Phytophthora*, pre-harvest insect attacks, black spot and *Thielaviopsis*. The first four affect the plants during the vegetative cycle and are discussed in this chapter. The last three affect fruits approaching maturity. They are addressed in Chapter 7 concerning harvesting.

5.1. Nematodes

5.1.1 The problem

Pineapple nematodes are very small worms (about a millimetre long) that live in the soil and parasitise the roots of the plants. They damage the roots and affect plant growth. Yield losses of 30 to 40% are frequent.

Several species parasitise pineapple and are found to varying degrees in production regions. Four of them are of definite economic importance :

- *Rotylenchulus reniformis* is reported above all in the Caribbean and Hawaii;
- *Pratylenchus brachyurus* is reported in different countries. It causes serious damage in West Africa and especially in Ivory Coast;
- *Meloidogyne javanica* and *Meloidogyne incognita* are found in all pineapple producing countries.

A degree of competition between these species has been observed. The environment is generally more favourable for one species and this develops more than the others.

The presence of nematodes rarely causes specific symptoms. The field acquires a heterogeneous appearance and infested plants look poorly nourished and seem to lack moisture : small, narrow, erect leaves, reddening. Only *Meloidogyne* attacks can be identified by the formation of root knots (galls). The lesions caused by the other nematodes are not visible; roots only seem to be little or not functional. At the most advanced stages of *Pratylenchus* attacks the root sheath becomes detached from the central core. However, these symptoms are not specific to nematodes; they simply indicate root senescence.

Nematodes can be observed in root samples under a binocular microscope. Root sampling and counting techniques make it possible to evaluate the degree of infestation and to monitor the evolution of the nematode population in a field. They are of valuable help in the control of these pests.

Rotylenchulus and *Meloidogyne* prefer sandy soils but may be present in all types of land. *Pratylenchus* is less dependent on soil texture but studies have shown its susceptibility to soil pH. It develops more in pineapple roots when the pH is low. A pH of more than 6 is unfavourable while a low pH (< 4) is very favourable. Low soil organic matter content is more favourable or the development of nematodes.

The evolution of the populations of these parasites depends on soil moisture in relation to the development of pineapple roots. Drought periods negatively affect both plant growth and the development of nematodes. The same applies to excess water in extreme cases (very heavy rainfall, areas where water collects). In contrast, mid-season periods are very favourable for these pests.

A very small nematode population at planting is enough to infest the field. The population in the roots first grows very slowly, staggered after root development. It then accelerates suddenly, generally three or four months after planting, unless this feature is delayed by unfavourable moisture conditions. The nematodes live and reproduce in the pineapple plants throughout the lifetime of the latter.

5.1.2 Nematode control

Nematodes have strong survival capacity in the soil :

- in resistant forms in the soil while awaiting the return of favourable conditions for growth;
- by parasitising suitable host plants other than pineapple;
- by parasitising still living roots of poorly destroyed pineapple stumps.

Absence of nematode control is only possible when the land meets the two conditions of being planted with pineapple for the first time or after a long fallow and never previously having had pineapple nematode host plants. It is generally necessary to perform control.

Effective control requires the reduction of the population at planting (inoculum) and the maintaining of the sanitary condition of the plantation during the vegetative cycle. Nematode problems increase with the length of the pineapple cycle as it is difficult to keep pest populations down to low levels.

Nematode control should be seen as a race between vegetative and root growth of pineapple and the growth of nematode populations. The creation of favourable conditions for strong growth of pineapple from planting onwards (good soil fertility and vigorous, sufficiently developed slips) makes it possible to outrun pest populations by taking the plants to a stage suitable for floral induction at 6 months.

Although chemical control often seems essential, the use of non-chemical control methods and especially fallows and crop rotations have advantages that are too often neglected :

- they improve soil quality and thence have a synergic effect with chemical control in yield build-up;

- it allows a decrease in the use of expensive chemicals that are dangerous for the environment and human health, whose use is increasingly restricted and that are sometimes phytotoxic.

Nematode control requires total cleaning of the fields after the harvesting of slips. Not a single pineapple plant that might grow suckers and roots may be left.

It is possible to burn off the field and then grub up and crush the remaining stumps. This technique destroys a good proportion of animal pests but results in loss of organic matter at the expense of soil renewal. Mechanical elimination should be preferred. This allows the formation of mulch that limits soil drying and erosion. Ploughing in the organic matter improves the soil structure and returns a proportion of the minerals taken up during the growth of the pineapple plants. The difficulty is that of completely destroying the plants—especially the stumps. Mechanisation is often essential for cutting and lacerating all the vegetation in the field (using a rotary slasher or cultivator).

These techniques are made easier by preliminary withering after the application of desiccating or contact herbicide (see paragraph 4.2).

Polyethylene film must be removed before the field is cleared. At planting, it is essential to carefully remove any roots from slips to avoid planting material that is already infested. It is also recommended that soil preparation tools should be cleaned to avoid taking contaminated soil in to a clean field.

In the case of an attack by *Pratylenchus*, growth of the nematode population can be slowed during plant growth by adjusting the soil pH (by applying calcium) to close to 5.5. Care should nevertheless be taken not to enhance *Phytophthora* growth by going beyond pH 6.

5.1.3 Several features for planning rotations

Crop rotation makes it possible to reduce the initial nematode population of a field and hence delay the infestation of pineapple roots for several precious months. Different types of rotation can be used. The avoiding of bare fallow is strongly advised.

Cultivated fallow is recommended. This means growing a plant that improves the soil if possible, that is not parasitised by nematodes and that covers the soil. The beneficial effects on soils are as follows :

- decompaction as a result of root growth;
- improvement of nitrogen content (legume plants);
- improved structure enriched mineral content and better moisture retention capacity following the ploughing in of the plant cover;
- the nematicide effect of certain plants (this is rare).

The choice of plant should allow for both the nematode species to be controlled, the ease of growth of this plant (emergence rate, soil covering capacity) and the possibility of subsequent mastery so that it does not compete with pineapple. We suggest the following species among plants to be tried:

FAMILY	NAME	FAMILY NAME TARGET SPECIES
Legume	*Mucuna pruriens*	*Rotylenchulus* *Pratylenchus* *Meloïdogyne*
Legume	*Macroptylium atropurpureum* (Siratro)	*Rotylenchulus*
Legume	*Crotalaria usaramoensis, Flemingia congesta*	*Pratylenchus* *Meloïdogyne*
Legume	*Cajanus indicus*	*Meloïdogyne*
Graminaceae	*Panicum maximum* (Caution: risk of spread by seeding)	*Rotylenchulus* *Pratylenchus* Possible effect on *Meloïdogyne*
Graminaceae	*Brachiaria decumbens*	*Rotylenchulus*
Graminaceae	*Digitaria umfolozi*	*Pratylenchus*
Graminaceae	*Digitaria decumbens*	*Meloïdogyne*
Compositae	*Eupatorium odoratum*	*Pratylenchus* - Possible nematicide effect of large quantities – action on other species possible
Compositae	*Tagetes patula*	*Meloïdogyne* - Nematicide effect– action on other species possible

A successful cultivated fallow requires a degree of care (cultivation, fertilisation, initial weed control, irrigation in dry zones if possible). It thus has a cost that must be studied and compared to the benefit expected.

The incorporation of pineapple in a true crop rotation is the best way of reducing the nematode population while conserving the economic interest of the farm. The rotation can consist of food crops, industrial crops or forage production. A few examples of the crops to be used in rotations are as follows :

- some of the species suggested in the table above are useful forage plants for livestock farming;
- a food crop appropriate for the nematode species concerned will be planted before pineapple. Groundnut and yam are minor *Pratylenchus* hosts. Tomato and gumbo are minor *Pratylenchus* hosts but favourable for *Meloidogyne*. Maize and sorghum are minor *Meloidogyne* hosts but maize, cassava, rice and pimento to a lesser extent are *Pratylenchus* host plants.

Sugarcane can be effective in the elimination of certain *Rotylenchulus reniformis* and *Pratylenchus brachyurus* populations. Banana is also a good crop in rotation with pineapple as it is not infested by the same nematode species. However, the destruction of banana plants can be difficult.

TABLE 3. SYNTHESIS OF THE FAVOURABLE AND UNFAVOURABLE FACTORS FOR THE GROWTH OF NEMATODE POPULATIONS

FACTORS	FAVOURABLE FOR CONTROL	UNFAVOURABLE FOR CONTROL
Excessive soil acidity		++ *Pratylenchus* develops best when the soil pH is low
Decreased soil fertility		++ Decreased biological activity enhances nematode development
Sandy soil		++ Favourable for the development of *Rotylenchulus* and *Meloidogyne*
Climate – drought or excess water	++ Extreme soil moisture conditions are unfavourable for both nematodes and root growth	
Climate – mid-season		++ Medium soil moisture conditions are favourable for nematodes
Polyethylene film		+ Plastic film contributes to making a favourable environment for nematodes
Clean, sound slips	+ No roots on slips	
Vigorous slips	++ Vigorous slips ensure rapid plant growth ahead of nematode development	
Excessively long vegetative cycle		++ Nematode development becomes difficult to control
Total destruction of plants after the harvest	+++ Destruction of food for nematodes, which then decrease	
Cultivated fallow and crop rotation	+++ Absence of food for nematodes they disappear	

5.1.4 Current control techniques using pesticides[8]

Control must be planned according to the length of the vegetative cycle and the virulence of nematode attacks. The planning of pesticde control can be schematised in two typical situations :

- with well-managed fallow, good soil fertility and good plant growth, FI is possible after 6 to 7 months and a single spraying 2 months after planting should be sufficient;
- in other situations, and especially with strong nematode virulence, pesticide control consists basically of one treatment close to planting before the parasites have penetrated the roots and, in general, one or more complementary treatments just before the periods favourable for a sharp increase in nematode populations.

Treatment of the plantation

This can be performed with solid formulations (preferable in the rainy season) or liquid formulations (preferable in the dry season). The timing of treatment should be set at the peak of the rainy season and that of the dry season to avoid the leaching or evaporation of pesticide and because of the slow start to plant growth.

[8] For Smooth Cayenne – adapation may be necessary for other varieties

Application of nematicides in solid form is performed on the ridge before planting with the product turned into the soil to a depth of about 5 to 10 cm. It is best applied with a Vicon apparatus fixed on the front of the ridger. Manual spreading on the ridge and raking in gives good results. Spray products should be mixed with a minimum of 2,500 to 3,000 litres of water per hectare and spraying preferably directed at the plants. Systemic products (transit via the plant) should be used and only applied when the plantlets begin to grow roots, that is to say 2 to 4 weeks after planting according to weather conditions or whether irrigation is used.

Only treatment with solid nematicide formulation is used when polyethylene film is used. In case they are registered in the countries of use and with respect of standards in force in consumer countries, the following substances can be used, for example (see paragraph 5.1.5) :

- **solid form :** cadusafos, ethoprophos[9], carbosulfan, phenamiphos;
- **liquid form :** carbosulfan, phenamiphos.

The effectiveness of certain substances may differ according to the region of use or the nematode species present in the zone. Thus oxamyl is used in South Africa, Kenya and Hawaii whereas previous studies revealed insufficient efficacy under the conditions of Ivory Coast. Other substances such as fosthiazate are now proposed for pineapple and are to be tested.

Treatment/s during the vegetative cycle

These are performed with liquid, systemic products only. When they follow treatment at planting they are usually performed 3 to 4 months after planting during the second root flush. This treatment can be performed one month earlier if there has been no treatment at planting.

It is important to take weather conditions and irrigation (if used) into account. These applications should not be performed during the vegetative season in the peak dry season (unless irrigation is used) and during the peak of the rainy season. Treatment can be combined with fertiliser application.

In practice, the timing of the treatment is adjusted to the return of rains at the end of the main dry season, at the end of the main rainy season or during the minor rainy season. The use of polyethylene prolongs the action of treatment at plantation (pellets) and a second treatment can be performed after 5 months if the cycle is long.

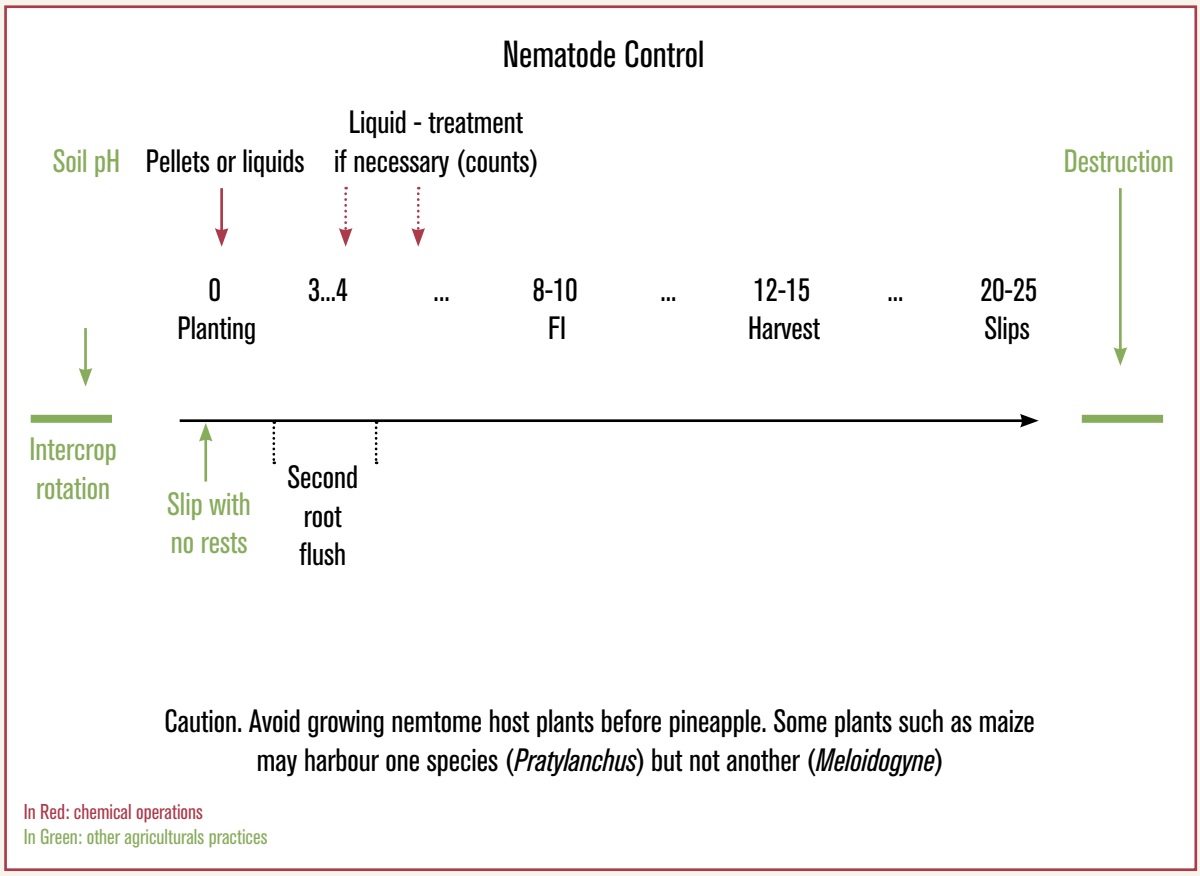
The follow-up treatments do not achieve complete cleansing but slow the development of nematode populations. A second follow-up treatment may sometimes be required in intensive monoculture. This is only performed during serious nematode outbreaks detected by counts during the growth cycle.

The first count is performed before the first follow-up treatment in order to appraise the effectiveness of the treatment at planting. A second count is performed about 2 months later, that is to say towards the 5th month, to decide whether to apply a second treatment. As a guide, treatment thresholds are 5,000 nematodes per 100 g of roots for *Pratylenchus* in heavy soil with a high pH and 10,000 per 100 g of roots in other cases. The figures should be adjusted according to the counting method and the local context of the plantation. Counting FI allows a posteriori evaluation of the effectiveness of the treatment. The same substances as those suggested in liquid formulation for treatment at planting can be used (see paragraph 5.1.5).

Considerations concerning the use of nematicides

Liquid formulations (especially fenamiphos) can cause serious burns, mainly in young leaves. The risk is greater in hot, sunny weather. It is strongly recommended that treatment should be performed in cool, cloudy weather. Ethoprofos should not be used in liquid form for the same reasons. It has been shown that certain nematicides have a depressive effect on leaf growth and on response to FI[10]. This effect on vegetation may continue after FI. The multiplication of treatments or failure to respect the recommended doses may thus result in poor production in spite of all the efforts made.
Nematicide treatments should be halted two months before FI. Repeated use of the same substance may lead to a decrease in its efficacy. This is the case of phenamiphos, for example. It is therefore recommended that the substances used in a field should be alternated.

[9] Avoid all use of the liquid formulation of this substance that causes serious burns in plants.



5.1.5 Nematicides : dose recommended in certain countries

Doses of active substance are proposed below per 10.000 plants or per ha for substances recommended in certain countries.

We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country. Please also see the following paragraph for information about European legislation if you wish to export your pineapples to Europe.

Active Substance	Active substance per 10,000 plants or per ha	Mix
Cadusaphos	1 kg/10,000 plants	Solid
Ethoprophos	2 kg/10,000 plants	Solid
Carbosulfan solid	0.75 kg/10,000 plants	Solid
Carbosulfan liquid	0.75 kg/10,000 plants	400 to 1,000 l/ha
Fenamiphos solid	4.5 to 5 kg/ha	Solid
Fenamiphos liquid	4.5 to 5 kg/ha	3,000 l/ha
Oxamyl	9.6 kg/ha	
1,3-Dichloropropene		

Caution : these are toxic substances and the safety conditions for their use must be respected.

5.2. Mealybug wilt disease

5.2.1 The problem

Pineapple wilt causes reddening, inward rolling of the edges of laminae and downward curving of the leaves. The symptoms first affect young leaves and then spread to the entire plant. The leaves lose turgor, turn yellowish pink and twist. The root system has been completely destroyed at this stage. Wilt causes serious decrease in yields and slip production.

The symptoms are very similar to those caused by too much or too little water. However, wilt is different in three basic ways :

- the first symptoms appear on isolated or neighbouring plants. The disease then spreads in patches. Water stress affects all the plants in a field;
- wilt is sudden, quick and irreversible, whereas wilting caused by lack of moisture is gradual and reversible;
- wilt causes rolling of the laminae along the whole length of the leaf whereas shortage of water causes the rolling of only the upper third of the leaf.

Wilt is a disease caused by a viral complex, at least partly, inoculated by the grey pineapple mealybug (*Dysmicoccus brevipes* and *neobrevipes*. The adult mealybug has little mobility and generally lives fixed to the plant. Shifting from one plant to another is usually performed by ants. The latter love the honeydew excreted and maintain and move colonies of mealybugs.

The mealybug is some 3 mm long and 2 mm wide at the adult stage. It is then covered and protected by a waxy white coating, whence the name mealybug. They are generally found in the axils of old leaves at the base of the plant, on roots and also at the bases of fruits and suckers.

Wilt is introduced in a field by :

- the use of slips taken from infected mother-plants;
- the arrival of mealybugs in the field (via ants or poorly cleaned slips).

It is essential to monitor this disease attentively since it can insidiously infect all the plants in a plantation in a few crop cycles. It is then impossible to eliminate it except by replacing the plant population by healthy slips.

5.2.2 Control of the disease

Wilt is controlled by means of several complementary strategies :

- the use of healthy slips from plants apparently free of wilt;
- the strict elimination of infected plants and the plants closest to them (carriers of the disease but not displaying symptoms). These plants must be burned or brought out of the pineapple fields far away and buried;
- the systematic removal of mealybugs from slips and fields;
- the complete destruction as possible of pineapple plants after the collection of slips to eliminate any mealybugs and outbreaks of disease present. Burning is effective for this.

TABLE 4. SYNTHESIS OF FACTORS FAVOURABLE OR UNFAVOURABLE FOR WILT

	FAVOURABLE FOR CONTROL	UNFAVOURABLE FOR CONTROL
Polyethylene film		+ Plastic film protects and contributes to forming an environment favourable for ants and mealybugs
Clean, healthy slips	+++ Makes it possible to start a field with plants not infected by wilt and subsequently	
Strict weeding during the production cycle	++ Makes it possible to limit development of the disease and to keep the plant material free of wilt	
Maintenance of slip production fields	+++ To obtain wilt-free slips	
Total destruction of plants after the harvest	+++ Destroys mealybug populations	

5.2.3 Current pesticide control practices

The elimination of mealybugs is based on the use of insecticides sprayed at the following moments :

- at planting if mealybugs are observed on slips;
- during vegetative growth;
- during slip production.

Sprayings at intervals of 6 weeks to 3 months depending on the situation at each farm are stopped 1 month before floral induction. Spraying must be resumed in slip production fields when the fruits have been harvested. These sprayings can be combined with fungicide application at planting to control *Phytophthora* and the application of liquid fertiliser during plant growth.

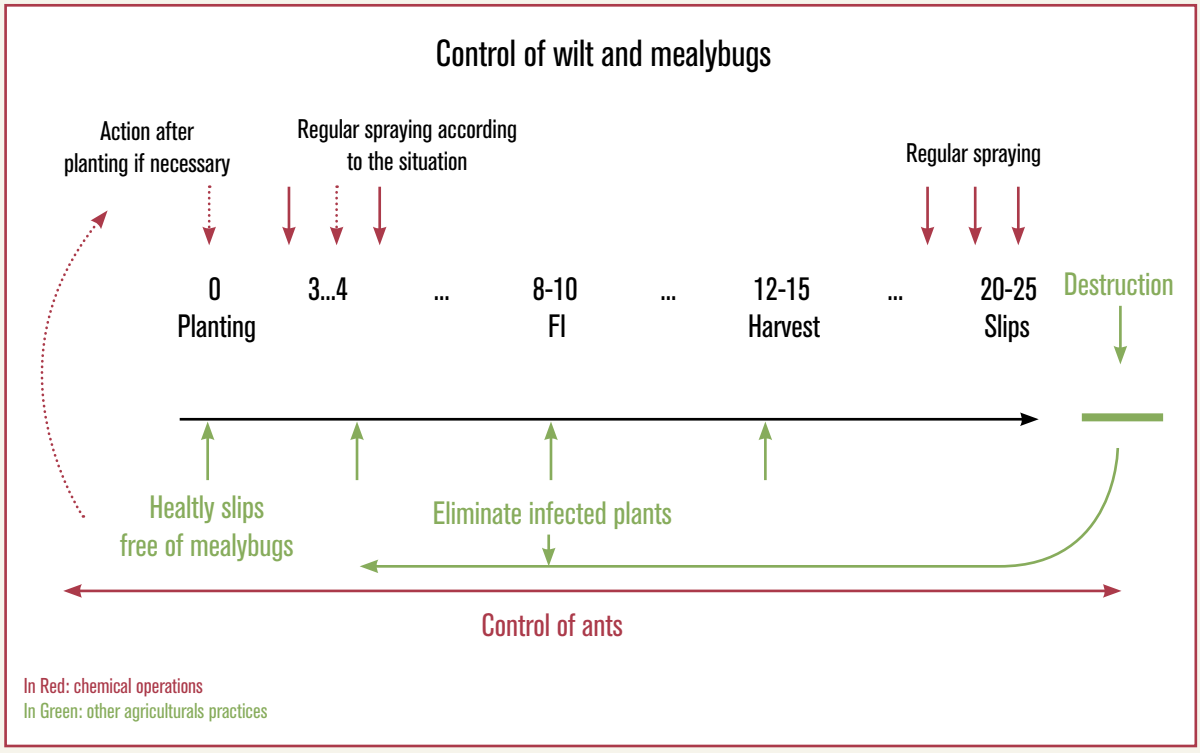
Two sprayings are performed with an interval of one month in case of severe infestation.

Given the location of mealybugs, a large volume of liquid must be applied (2,500 to 3,000 litres per ha) to ensure good contact between the pests and the solution. The mix should fill part of the rosette to infiltrate the base of the plant. It is preferable to alternate different pesticides to prevent the development of resistance.

If registered in the countries of use and with respect of standards in force in consumer countries, the following substances can be used, for example (see also paragraph 5.2.4) :

- contact insecticide : chlorpyrifos-ethyl, diazinon;
- systemic insecticide : dimethoate.

Note : Spirotetramat, a new active substance, is not mentionned in the tables below but is of high interest for mealybugs control.The dosage should be 150 g/ha applied with 1000 to 1200 liter of water. Maximun number of applications should be 3. Registration should be soon obtained in Kenya and West Africa.



5.2.4 Mealybugs : dose recommended in certain countries

Doses in active substance per ha are proposed below for substances recommended in certain countries.

We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country. Please also see the following paragraph for information about European legislation.

Active Substance	Dose of active substance	Mix
Chlorpyrifos-ethyl	1 to 1.5 kg/ha	3,000 l/ha
Dimethoate	1 kg/ha	3,000 l/ha
Diazinon	0.8 to 1 kg/ha	3,000 l/ha

Caution : these are toxic substances and the safety conditions for their use must be respected.

5.2.5 Control strategy to be used

Destroying ants considerably limits the spread of mealybug colonies and therefore the spread of wilt. In some producer countries (in South America), this is the main operation taken to control wilt. Direct mechanical and chemical operations are performed on ants and their nests.

Although all-purpose formicides can be used, the search for trapping techniques should be developed. This first requires the identification of the species involved in the spread of mealybugs. This work should be carried out in most ACP countries.

5.3. Symphylids

5.3.1 The problem

Symphylids (*Hanseniella* spp.) are small white soil-dwelling millipedes that feed on the roots of pineapple plants. These attacks seriously affect the nutrition and hence the development of the plant. The decrease in production can be very large.

They prefer well aerated soils with a relatively high organic content. They are abundant in gravelly and clayey-sandy soils and in certain kinds of limestone tuff on volcanic islands. In contrast, sandy and sandy-clayey soils do not suit them.

Symphylids are particularly fond of moist soils but do not like excess water and cannot survive drought. Attacks are therefore to be feared particularly at the start of the rainy season, during the small dry season and the small rainy season. They can survive for up to four months without eating if there is sufficient soil moisture. Symphylids are also present during the dry season in irrigated farming.

Young pineapple roots are a favourite food. Pineapple is therefore very susceptible during root flush periods, that is to say during the first two months after planting and then two or three months later during the second root flush (when the plants are four to five months old).

It is sometimes possible to see symphylids by stripping off the base of old leaves. These small millipedes (about 6 mm long) with fairly long antennae run away quickly when exposed to the light. However, their presence can be detected by observation of roots.

The first symptom is a main root whose tip has been gnawed and that displays a characteristic tiny 'crater' at the point. Numerous secondary roots may display the same symptom.

The young roots are gnawed and almost completely destroyed when attacks are intense and early (during or immediately after the root flush). All that remains around the steam is a collar of very short, little functional roots.

When the attacks stop, the root swells at the extremity and then grows numerous long, fine ramifications. The root has a 'witch's broom' appearance. This is the case after effective treatment with insecticide or a weather period that is unfavourable for the pest.

However, if a fresh attack occurs during the formation of the ramifications, the latter are entirely destroyed in turn, resulting in a club-shaped root. As the distribution of symphylids is irregular, infested pineapple fields display patches with poor growth in the middle of zones of green, welldeveloped plants. This heterogeneous appearance is characteristic, with strong differences in growth being possible between two neighbouring plants. If there is no rainfall, the patches infested display symptoms that are identical to those of water stress (reddening leaves).

5.3.2 Current practices

Control of symphylids should not be performed systematically but where and when required. Treatments are performed according to the degree of risk resulting from the season and the age of the plants:

ON HIGH-RISK SOILS (GRAVELLY, CLAYEY-SANDY, TUFF)		
Age of plants :	Start of rainy season and small rainy season Small dry season and dry season under irrigation	Rainy season and dry season with no irrigation
0 – 2 months	High risk – preventive control essential	Low risk – treat in case of attack
2 – 4 months	Medium risk - control if symphylids are observed. Vigilance required	No risk
4 – 5 months	High risk – control essential as soon as the first symptoms are observed	Low risk- treat in case of attack
5 – 6 months	Medium risk - control if symphylids are observed	No risk
> 6 months	Treatment is no longer necessary	Treatment is no longer necessary

TABLE 5. SYNTHESIS OF FAVOURABLE AND UNFAVOURABLE FACTORS FOR THE DEVELOPMENT OF SYMPHYLIDS

	Favourable for control	Favourable to the pest
Gravelly and clayey-sandy soils, limestone tuff		+++ Symphylids are found in these soils; they can move around in cracks
Sandy and sandy-clayey soils	+++ No symphylids in these soils as they cannot move in them	
Soils with high organic matter content		+ Organic matter is a source of food
Polyethylene film		+ Plastic film contributes to making an environment suitable for symphylids
Climate – periods of drought or excess moisture	++ Extreme soil moisture conditions are unfavourable for symphylids	
Climate – intermediate season		++ Average moisture conditions are favourable for symphylids
Root flush period		+++ Young roots are a favourite food for symphylids
Total destruction of plants after the harvest	++ Destruction of food for symphylids, which decline	

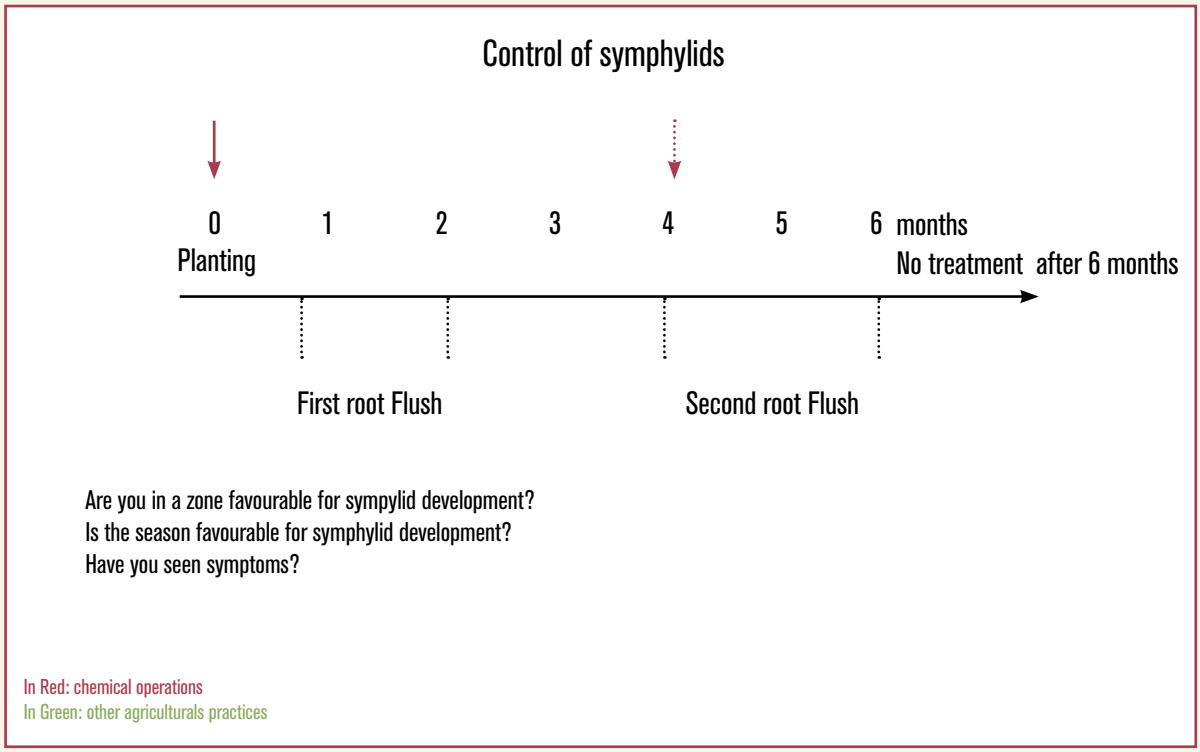
Control methods are based on the use of insecticides.

Treatment at planting. Solid formulations are recommended. They are applied to the ridge before planting and turned into the soil to a depth of about 5 to 10 cm. When a ridger is used, application is performed before the passage of the latter. The product is thus incorporated evenly into the ridge.

Treatment during the growth period. It is preferable to use products in liquid form that are easier to apply. The spray must be aimed at the plant with sufficient water for the solution to penetrate the soil.

If registered in the countries of use and with respect of standards in force in consumer countries, the following substances can be used, for example (see also paragraph 5.3.3):

- solid: ethoprophos;
- liquid: chlorpyrifos-ethyl, carbosulfan.



5.3.3 Symphylicide: dose recommended in certain countries

Doses of active substance per ha are proposed below for substances recommended in certain countries.

We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country.

Please also see the following paragraph for information about European legislation.

Active Substance	Dose of active substance	Mix
Chlopyrifos-ethyl	2.4 kg/ha	2,500 to 3,000 l/ha
Cadusaphos	1 kg/10,000 plants	2,500 to 3,000 l/ha
Ethoprophos	2 kg/10,000 plants	Solid

Caution: these are toxic substances and the safety conditions for their use must be respected.

5.4. *Phytophthora* heart rot

5.4.1 The problem

This disease is soft rot of the white, tender upper part of the stem and the base of the young leaves. Infected plants die. The first symptom is a change in the colour of the young leaves, which turn yellow or pale brown. These leaves become soft, droop and can easily be removed by pulling the tip, revealing a base entirely covered with moist soft rot with a nauseous smell.

The healthy zone is separated from the rotten zone by a dark brown line. The change in the colour of the leaves is observed only about a month after contamination of the plants and it is then much too late to take direct action on infected plants. The neighbouring plants should be treated when such symptoms appear.

Heart rot is caused by the fungus *Phytophthora nicotiane var. parasitica*. This is present in the soil and forms spores in soil water or in the heart of the rosette. The spores are spread by surface water, accounting for the spread of the disease in patches and along runoff pathways.

The greatest number of cases are usually observed shortly after planting. However, *Phytophthora* attacks on older plants are not rare, especially after floral induction with carbide.

Contamination occurs during rainy periods mainly by the splashing of soil into the hearts of the plants. Stored suckers and crowns are more susceptible than fresh ones. The disease is also favoured by sprinkler irrigation.

The nature of the soil (pH) plays a very important role. The risks are comparatively low in acid soils (pH 4 to 5). In contrast, the risks become very great when the pH is higher than 5.5 or 6. The role of the pH explains the much greater susceptibility of the plants after FI with carbide in comparison with ethylene. Carbide reacts with water to increase the pH in the leaf rosette to 11-12.

Heavy, clayey soils that remain moist for a long time are more favourable for the disease than sandy soils. Vegetable debris mulch leads to greater pressure from the disease.

5.4.2 Control of the disease

This requires good mastery of the following aspects:

- soil pH, which should be < 5.5 if possible. At > 6, the amount of calcium in the basal dressing must be reduced to a minimum;
- optimum soil drainage in particular on clayey soils (high ridges, drains, subsoiling with the slope in extreme situations);
- the ploughing in of crop residues after destruction and drying to prevent sources of infection. They can also be burned;
- the sanitary quality of slips. Stored slips should not be planted in rainy weather;
- use of gaseous ethylene or ethephon (according to the region) rather than carbide for FI, especially during the rainy season.

Even when all these precautions are taken, plant mortality may be significant and it is preferable to envisage fungicide application to protect the plants.

TABLE 6. SYNTHESIS OF FAVOURABLE AND UNFAVOURABLE FACTORS FOR THE DEVELOPMENT OF PHYTOPHTHORA

	Favourable for control	Favourable to the pest
Soil pH > 6		+++ pH > 6 is favourable for *Phytophthora* ++ pH raising following burning after deforestation is favourable to the disease
Clayey soils		+++ Clayey soils remain moist for longer and are thus favourable for *Phytophthora*
Storage of slips		++ Storage of slips enhances the appearance of *Phytophthora* during the rainy season
Climate – rainy season		++ Moisture favours *Phytophthora*
Irrigation		++ Moisture favours *Phytophthora*
Young plants		++ Young plants are susceptible to *Phytophthora* after planting
FI – calcium carbide		+++ The pH at the heart of the plants becomes very high and favours *Phytophthora*
Crop residues		+ Plant debris is a reservoir for *Phytophthora*
Variety		+ Some varieties such as the new hybrid MD2 (sweet pineapple) are more susceptible

5.4.3 Present pesticide control practices

Chemical control is used at three stages—at planting, during vegetative growth and at FI. Fungicide-fertiliser compatibility is often poor and combined spraying of the two is not recommended.

Treatment after planting

This cleanses the slips after planting and must be done when conditions are favourable for *Phytophthora*—very often the case (high soil pH, rainy season, known precedents of *Phytophthora* attacks, storage of slips, etc.). The treatment consists of spraying a fungicide suspension on or in the hearts of the plants as early as possible (two days after planting at the latest).

Treatment during vegetative growth

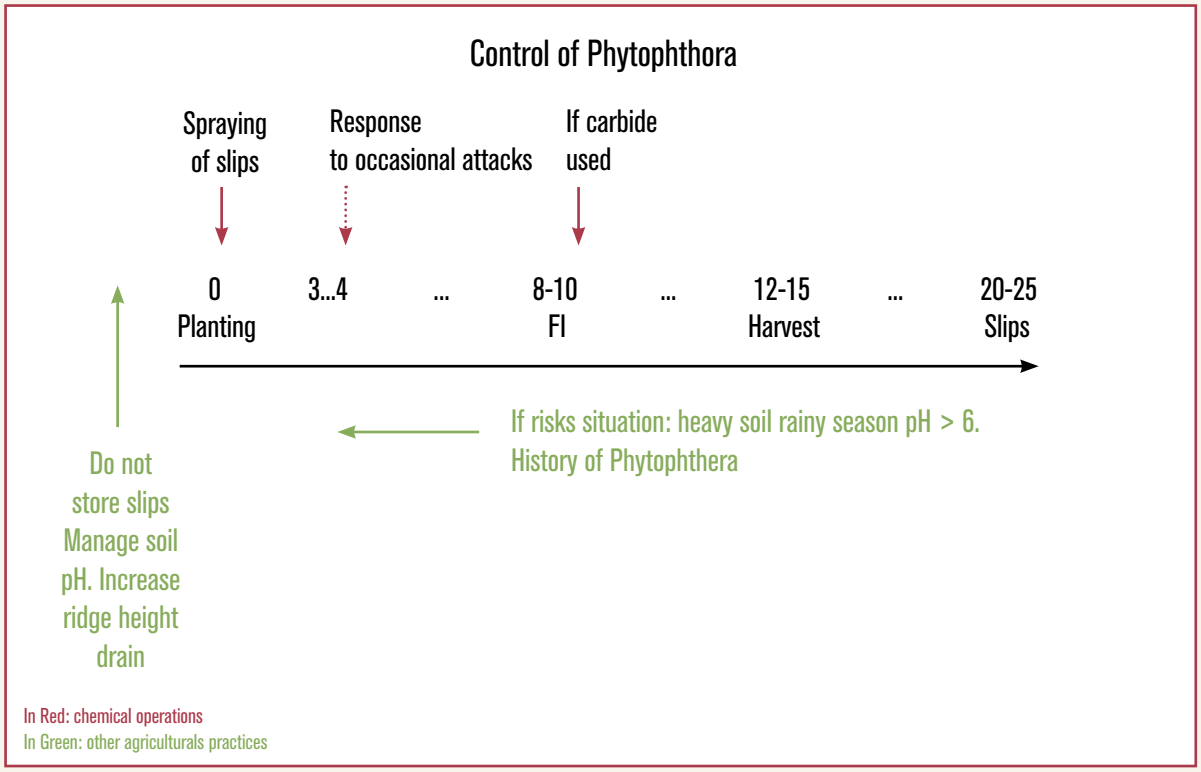
This is performed in response to an outbreak of the disease. Spraying must be early—as soon as symptoms are seen on a few plants. It must be remembered that late reaction makes control of the disease more difficult and may result in considerable spread and the destruction of all or part of the field. The treatment is identical to that performed just after planting but is centred on the infected plants. These are grubbed up and burned. Any transport out of the field must be carried out with care to prevent the spread of the disease. The zone around the infected plants is sprayed.

If there is a history of serious *Phytophthora* attacks or serious risk factors (high pH, clayey soils in the rainy season), it can be planned to spray the entire field.

Protection after floral induction with carbide

The carbide-water reaction gives a solution with pH 12. This is extremely favourable for the development of *Phytophthora*. Fungicides are ineffective at this high pH. It is necessary to wait for a week before spraying in the same way as after planting. Given the large volume of the plants at this stage, spraying is necessarily performed with a large volume of water.

If they are registered in the countries of use and with respect of standards in force in consumer countries, the following substances can be used, for example, for these various spraying operations (see also paragraph 5.4.4): maneb, mancozeb, fosethyl-Al.



5.4.4 Dose recommended in certain countries

Doses in active substance per ha are proposed below for substances recommended in certain countries.

We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country.

Please also see the following paragraph for information about European legislation.

Active substance	Dose of active substance	Mix
Maneb	8 to 9.5 kg/ha	1,000 to 3,000 l/ha
Mancozeb	6 to 12 kg/ha	1,000 to 3,000 l/ha
Fosetyl-al 6	6 to 8 kg/ha	1,000 to 3,000 l/ha

Caution : these are toxic substances and the safety conditions for their use must be respected.

Trials implemented by PIP in Ivory Coast in 2004/2005 with supervision of CNRA have shown that with dithiocarbamates fungicides the last treatment must be at the latest 10 days after floral induction. Treatment done afterwards may lead to residues above the EU MRL. For fosetyl-Al no residues where found above the EU MRL even with a last treatment done 2 months after floral induction.

006 – Floral induction

6.1. The issues

Pineapple flowers naturally when days are short and night temperatures low. The climatic conditions in many countries are such that 'natural' ('wild') flowering rarely occurs and it happens on plants with substantial vegetative growth. It is therefore infrequent in export cultivation with a usually short cycle. Planters control their production cycle by means of floral induction (FI).

The average weight of the harvested fruit is proportional to plant development at the time of FI and therefore to its age. The weight of the last leaf is a possible criterion for the evaluation of plant weight. As a general guide for Smooth Cayenne, the production of 1.5-kg fruits generally corresponds to the treatment of plants whose most recent leaf weighs 70 g.

Practice and the planter's sense of observation nevertheless remain the main elements of decision making.

Successful control of flowering is a condition for the profitability of the farm. Beyond its effectiveness, the essential quality sought is success of at least 98% all the year round. For this, whatever substance was used, the same strict principles must be respected:

- maximum effectiveness is achieved by treatment at night.

Application at the end of the night is preferable;

- two repetitions at 3 to 4 day intervals are necessary;
- rainfall occurring less than 3 hours after treatment cancels the effect. The high frequency of rainfall in June and July in Ivoiry Coast sometimes make treatment difficult at this time of year;
- the water used must be cool for better dissolving of gases. The tank to be used for induction treatments should therefore not be left in the sun all day. Water should come from a drilled well or if necessary from a shaded flowing stream;
- an imbalance in nitrogen nutrition (substantial application of nitrogen at the end of the growth cycle after a shortage or the restarting of growth after the dry season) reduces efficacy of FI.

6.2. The different types of treatment

Beware, the gases used are inflammable and explosive. Do not smoke during treatment. Contact between acetylene and copper gives a very unstable compound that can explode spontaneously. Any contact between the two is therefore forbidden. All the recipients used for treatments, between each treatment, must be stored open to prevent the accumulation of gas and risk of accident.

Acetylene treatment using calcium carbide :

The mechanisation of this technique is dangerous and so it has remained manual. Acetylene is produced by a reaction between water and calcium carbide. A 200-litre steel drum is half filled with water and 500 g calcium carbide added in small pieces. A volume of air must always be left in the recipient. The drum is closed immediately and shaken vigorously for 10 minutes to ensure complete release and dissolving of the gas. The resulting mix is immediately poured into the heart of each plant in sufficient quantity to soak it (at least 50 ml). Two treatments must be performed at an interval of 3 or 4 nights.

Given the effect of carbide on the pH in pineapple hearts, the risk of *Phytophthora* may be high depending on the climatic conditions and a subsequent fungicide treatment will then be necessary.

Ethylene treatment :
This treatment can be carried out by mechanisation (for large scale fields) or by use of a knapsack sprayer or a powder dispenser (for small scale fields).

The mechanisation requires a heavy investment. It also requires a large amount of water. The principle is the injection under pressure of bottled gaseous ethylene into water containing active carbon that is immediately sprayed on the plants (using a boom sprayer). Spraying one hectare requires 6,000 litres of water, 800 g (or approximately 650 l) of ethylene and 3 kg of active carbon. Treatment can be performed during the night or early in the morning. It must be repeated after 3 days. The water used must be as cool as possible for easier dissolving of the ethylene.

The main problem in this treatment is the difficulty of injecting ethylene in water and ensuring that there is no leakage. The entire gas circuit must receive regular maintenance. And the injector very well selected.

A method for small producers to enrich activated carbon with ethylene was developed in 2006.

The enrichment process for activated carbon requires readily available material: an explosion-proof vacuum pump, a bottle of ethylene with a regulator, an adapted airtight container, a gauge and some tubes, valves, fittings and filters.

Assembly of the prototype requires standard workshop material.

Two methods of application can be used: a dry treatment with granules of enriched activated carbon, whereby the enriched granules are applied directly into the heart of the plants using a powder dispenser; and a wet application, whereby enriched powder is mixed in the tank of a knapsack sprayer immediately before treatment and the spray is applied directly into the heart of the plants using the sprayer. These techniques are described in detail in a technical sheet edited by PIP/COLEACP in 2007.

Ethephon treatment:
Synthetic products releasing ethylene (the bestknown being ethephon) are commonly used in production zones at higher latitudes than that of the West African coast. Treatment with ethephon is easier than the two preceding methods. One daytime treatment is sufficient and a knapsack sprayer can be used. The effectiveness of treatment is increased with the addition of urea to the solution. Application can be by the general spraying of 2,000 to 3,000 l/ha of a solution containing 100 to 500 ppm ethephon and 2.5 to 5% urea.

6.3. Monitoring response to treatment – Repeat treatment of plants not flowering

It is important to know the result of the treatment as soon as possible when ever it has not been performed under the best conditions for success.

Two weeks after treatment, a longitudinal section of the terminal part of the stem is pyramid-shaped if an inflorescence is forming. The tip of the stem remains flat and slightly rounded if there is no flower formation.

Non-destructive examination can be carried out a few weeks later. The base of a young leaf pulled out from the rosette is examined. The edges of the lamina in profile are parallel if there is no response. If an inflorescence is present, the basal part of the edges of the lamina tend to curve inwards.

This phenomenon can be observed from the fourth week after treatment. When the inflorescence is ready to appear (5th week), a kind of rounded

serration forms. It is preferable to wait until all the plants that have responded to treatment (about 2 months after treatment) display their inflorescences before individual treatment of those that have not responded.

007 – Pre-harvest fruit care – harvesting and packing

7.1. Pre-harvest fruit care

7.1.1 Sunscald

Sunscald is caused by local excessive heating by the sun. At best, the burn causes discoloration of the skin of the fruit (straw yellow) and at worst destruction of the skin and the pulp (deformation of the fruit, brown zones on the skin and translucent pulp).

The phenomenon occurs especially during strongly sunny periods. Fruits that have lodged and those on too long a peduncle or those on plants with inadequate foliage are most exposed to sunscald.

During risk periods, it is essential to protect the fruits during the 4 to 6 weeks prior to picking. Several methods can be used :

- tie the leaves in a sheaf above the fruit;
- stretch lines on each side of the rows (double rows) of pineapple to pull the leaves towards the centre of the row;
- place a white sleeve kept open by a leaf slipped into it with the fruit;
- over the tops of the fruits with just a moderate quantity of straw as too much shade increases fruit acidity.

7.1.2 Control of insect pests of fruits

Insect attacks on fruits are generally seasonal and can be caused by:

Augosome beetles :
Large beetles with shiny brown wing cases. The males have large horns. They eat fruits and inflorescences by making a hole and then digging out an immense cavity. In Ivory Coast attacks are most frequent in December close to felled palm trees.

Grasshoppers :
The main grasshopper pest on pineapple is the variegated grasshopper (*Zonocerus variegatus*) that appears in the dry season (from January to October) especially in cultivation zones on the 6th parallel. It eats the extremities of the crown leaves.

Oviposition is in the soil, generally at the edge of plantations. Hatching is spread over several months with peaks in October and January in West Africa. After hatching, the larvae remain closely grouped in the young stages and then gradually disperse as they develop.

Crickets:
These bore small round cavities in the skin of ripe fruits.

Control of augosome beetles is difficult because the closeness of the harvest period prevents the use of pesticides that are effective in controlling these insects. However, it is possible to spray the edges of the fields, taking care that the wind does not blow insecticide on to the fruits. It is also possible to set out light traps at a good distance from the pineapple fields. As the beetles only fly in the early part of the night the lights can be turned off at about 9 p.m.

Certain substances with low persistence can be sprayed to control grasshoppers and crickets but with strict respect of the recommendations for use (dose per ha and number of days between spraying and harvesting).

Control of grasshoppers can be very effective by attacking the oviposition and hatching sites when the larvae are still grouped on the ground. The treatments should be repeated following hatchings. It is therefore important to monitor populations in order to take action at the right moment.

If registered in the countries of use and with respect of the standards in force in consumer countries, examples of substances that can be used are, deltamethrin and lambda-cyhalothrin.

The doses of active substance per ha recommended in certain countries are listed below for these substances:

Active substance	Active substance per ha	Mix volume per ha
Deltamethrin	12.5 g	600 to 1,500
Lambda-cyhalothrin	20 g	600 to 1,500

We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country. Trials implemented by PIP in 2005 have shown that one application (7 days before harvest) of these active substances at doses indicated does not give detectable residues (<0,01 mg/kg).

7.2. Degreening pineapple before the harvest

7.2.1 The problem

Pineapple colour is a strong factor in European consumers' decision to buy. Depending on the climatic conditions, the natural colour of the fruit is more or less developed and artificial degreening is frequently performed on certain varieties to obtain fruits that match market demand. This is obtained by ethephon, an ethylene generator, several days before the harvest.

The natural colour capacity of pineapple depends on the variety, the stage of maturity of the fruits, the climate and fertilisation (excess of nitrogen and lack of potassium are not favourable to coloration). The Smooth Cayenne variety, widely grown in ACP countries, has weak colour capacity, especially in zones with unfavourable climates. This weakness with regard to colour makes it difficult to respect both the MRL (the harmonised MRL for ethephon in pineapple is 2 mg/kg) and commercial constraints (good colour). Indeed, under certain conditions, good colour can result in residues above the MRL for the fruit.

7.2.2 Current practices

Degreening is generally performed by manual application of an ethephon solution to the surface of the fruit. It can also be performed by general spraying with large volumes of water. The latter technique involves a risk of crown burn. Treatment is performed 7 to 10 days before harvesting. In local application, a dose of 1,5 kg/ha of active substance in 800 litres of water at 15 ml per fruit (55,000 fruits treated) applied 8 days before the harvest generally enables the respect of the MRL of 2 mg per kg of fruit for medium-sized fruits (1300 g). However, under certain unfavourable climatic conditions, this dose does not give commercially satisfactory colour all the year round. Furthermore, the MRL may be reached or exceeded under severe drought conditions or in small fruits. Rainfall during the hours following treatment can wash off the product applied and greatly reduce its efficacy. A second application is then necessary and the risk of exceeding the MRL is then increased. A new MRL of 0.5 should enter into force towards the summer of 2009. Between now and then, the current value of 2 mg/kg will remain applicable. This will bring up difficulties to respect the EU MRL.

Deltamethrin Listed in Annex 1 of Directive 91/414* European MRL 0.05 (limit of quantification) Lambda-cyhalotrin Listed in Annex 1 of Directive 91/414* European MRL 0.02 (limit of quantification) Deltamethrin Ghana, Tanzania (various crops) Lambda-cyhalotrin Ghana, Tanzania (various crops).

7.2.3 Possible strategies for reducing residues

The crop management sequence must enhance the capacity for the fruit to gain colour. Fertilisation must therefore be planned with respect of the mineral requirements described above. Excess nitrogen always makes it more difficult to obtain fruit colour.

Fruits colour better when the treatment is performed of approach at ripeness. The choice of harvest date is therefore a determinant element in the success of degreening treatment. Fruits harvested too soon will not only have little colour but will also be little sweet.

It is possible to wash and brush the fruits after the harvest to remove dry residues remaining on the surface. However, the decrease in residues is not always sufficient and the technique is expensive.

TABLE 8. SYNTHESIS OF FAVOURABLE AND UNFAVOURABLE FACTORS FOR THE EFFECTIVENESS OF COLOURING TREATMENT

	Favourable for colouring	Unfavourable for colouring
Variety	+++ New, naturally coloured varieties (MD2)	+++ Some varieties do not have good natural colour
Excess nitrogen		++ Excess nitrogen contributes to persistent green in pineapple
K/N ratio of 2 to 2.5	++ Potassium enhances fruit colour	
Climate (complex action related to cloud cover and temperatures)	++ Geographical zone and season favourable for fruit colour	++ Geographical zone and season unfavourable for fruit colour
Rainfall after treatment		++ Washing off by rain during the hours following treatment
Fruits not ripe enough		+++ Fruits colour is related to ripeness. Insufficiently ripe fruits will not gain colour

7.2.4 Potential strategies that can be used after trials or strategic consideration

Studies could be pursued on the use of adhesives with ethephon to avoid repeated treatments after rinsing by rain.

Present colour criteria are defined at a transaction stage well before purchase by the consumer. Fruits that have undergone little or no treatment can gain colour in the final phases of marketing. Such fruits will have better taste potential (ethephon decreases sugars and increases fruit acidity).

When possible, choosing a more favourable climatic zone with more sun, less cloud cover and cool nights makes it possible to grow better coloured fruits.

Finally, varieties with naturally good colouring capacity can be chosen. Some new hybrids have this advantage.

7.3. Harvesting

The final choice of harvest date should make it possible to harvest fruits close to maturity (sweet, fragrant and well-coloured) with no external or internal quality defects. Account should also be taken of the constraints involved in the organisation of harvesting and transport and freight reservation. Finally, the fruits must keep throughout the transport and marketing phase, which can be long (often more than 20 days from the farm gate to release for sale in Europe).

The choice of harvest date is one of the most important and most delicate decisions to be made by a pineapple grower. Experience is determinant in this difficult exercise. However, several factors can guide the decision.

7.3.1 FI – harvest interval

The time elapsing between FI and the stage of maturity justifying cutting the fruit displays seasonal and varietal variation that must be carefully taken into account in the forecasting of the harvest date. The interval depends essentially on the movement of the temperature after FI. It displays seasonal evolution modulated by annual fluctuations.

As an example, the interval in Ivory Coast between FI and the harvesting of Smooth Cayenne for export by sea is on average between 138 days and 155 days over the year[12]. The interval is shortest after FI in January and reaches a maximum 5 months later for FI in May[13].

The interval can be very different in countries at a higher latitude or at higher elevations. In Madagascar, the time between FI and harvesting varieties ranges over the year from 144 days in the summer to 221 days in the winter.

Each planter must therefore take into consideration this seasonal evolution in the choice of harvesting date. He can use regular observations made by cutting fruits to evaluate their internal maturity. These observations are made regularly using the same sampling protocol (number of fruits, fruit size, position on the ridge). Comparison of these observations from one field to another and with the results of quality control and clients' comments will make it possible to adjust picking from one week to the next.

7.3.2 Black spot

This defect depreciates fruits exported fresh to such an extent that fruits are picked early as almost systematic practice, and this has disadvantages. The symptoms are rarely visible from the outside. The fruit has to be cut in cylinders or slices for detection. Black spot is visible as browning in the centre of the fruitlets, starting below the floral cavity and able to go as far as the core. The flesh blackens but remains more or less firm. It is generally limited to a single eye but may sometimes spread to the neighbouring ones.

Black spots are more numerous:

- in large fruits than small;
- in the most coloured fruits;
- six days after picking than on picking day;
- in the basal half than in the half close to the crown.

Although it is observed all over the world, the disease is not very well known and no fully effective control method has been found, whether genetic, ecological or chemical.

Black spot can be caused by two fungi, Penicillium funiculosum and Fusarium moniliforme, and take several forms (fruitlet core rot when a brown spot develops from the centre of the eyes of the fruit and leathery pocket when a small hard, black pocket forms). Penicillium appears to be the main agent in West Africa. The fungi penetrate at a very early stage when the inflorescence is still in the heart of the rosette of flowers before emergence.

[12] Results obtained in 2001 from the monitoring of 60 fields on several plantations in lower Ivoiry Coast

[13] Results for the variety Smooth Cayenne obtained under the climatic conditions of Ivoiry Coast

Susceptibility to black spot is aggravated by damp weather with little sunshine at the emergence of the inflorescence and sunny dry periods near to the harvest. Variations in the intensity of black spot cannot be predicted and may be very sudden.

As the spots develop rapidly while approaching maturity, the problem is mainly limited by picking earlier. As for time between FI and harvesting, regular observation of the fruits makes it possible to adjust the picking date and conserve the taste quality of the fruits.

The excessive use of ethephon (degreening) to colour the fruits for early harvesting to overcome the black spot problem is dangerous for the following reasons:

- it requires more applications of ethephon resulting in a greater risk of exceeding the MRL;
- it results in the picking of immature fruits that are not sweet and that have little fragrance;
- the decrease in quality is aggravated by the application of ethephon as this reduces sweetness (loss of 1° Brix) and increases fruit acidity.

7.3.3 Handling the fruits

The fruits can suffer injury during picking, transport and packing. This affects the appearance of the fruits and opens the way to pathogens that can cause serious deterioration. It is commonly reminded that an antibruising chain must be organised throughout these operations.

7.4. Packing

7.4.1 *Ceratocystis* (*Thielaviopsis*) *paradoxa*

The problem

The main cause of post-harvest deterioration of fruits is the fungus *Ceratocystis* (*Thielaviopsis paradoxa*), responsible for black rot (or soft rot). It enters via injuries to the fruit (caused by impacts during harvesting) and also by the cut section of the peduncle.

Ceratocystis paradoxa is an injury fungus that also causes:

- slip stem butt rot (drying the base by exposing it to the sun is sufficient);
- leaf rot (low incidence).

Soft rot of fruits is to be feared most and can lead to loss of more than 50% in some batches. It is a soft, watery rot with a pleasant smell of ether. The fruits infected liquefy and are no longer saleable.

Ceratocystis is very common in plantations on all pineapple debris (fragments of leaves, bracts, etc.) where it develops in hot wet weather. Infection occurs at harvesting or packing via spores spread by the wind from old debris of fruits or plants on the plantation or near the packing station.

The fungus is an injury pest that cannot penetrate the intact skin of a fruit but enters the slightest bruise or the cut. It causes lateral and peduncle rots. The symptoms appear 3-4 days after infection. Evolution is very rapid at 25°C and above, slowed at 12° and stopped at 8°. However, it resumes rapidly as soon as the temperature rises after landing.

Control methods

Effective control consists of a combination of several types of measure: -handle the fruits as carefully as possible to prevent any impacts or bruising. Never heap, throw or hit fruits. Use suitable equipment (transport crates, padding, padded belt for sorting fruits, etc.);

- keep the packing shed clean : clean up and remove wastes after each cut (bracts, rejected fruits, etc.), disinfect the floor, harvest crates, fruit carriers, sorting and collection tables by spraying commercial formalin (3% an irritant, beware) or quaternary ammonium (3 ppm);
- scrub the crates and belt regularly with bleach solution.

Disinfection of peduncles with fungicide

Peduncles must be disinfected rapidly by soaking or moistening with a sponge and a fungicide applied.

If registered in the countries of use and with respect of the standards in force in consumer countries, examples of substances that can be used are:

- triadimefon, imazalil

Other substances such as triadimenol are now proposed for pineapple and are to be tested.

The doses of active substance per ha recommended in certain countries are listed below for the substances :

Active substance	Active substance per litre used for dabbing the pedunclees
Triadimefon and triadimenol	0.05 g
Imazalil	0.1 to 0.2 g

Caution : these are toxic substances and safety conditions for their use must be respected.

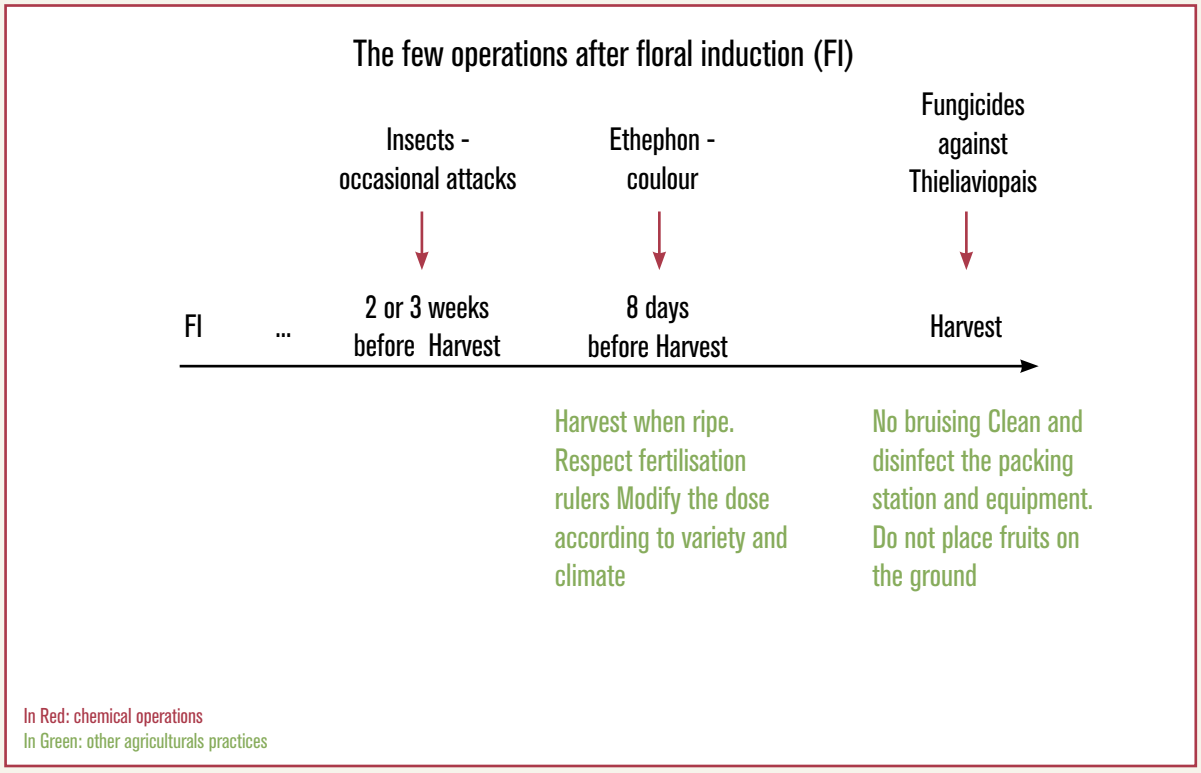
We advise you to consult your pesticide supplier to find the corresponding commercial product and to find out the most appropriate conditions of use in the respect of the legislation in your country.

Trials implemented by PIP in Ivory Coast in 2004/2005 with supervision of CNRA have shown that it is easy to respect the current European MRL for tradimefon and triadimenol used at the recommended doses but not for imazalil. Residues found for imazalil are far above the MRL.

In ACP countries known registrations on pineapple are as follows :

Triadimefon	Ivory Coast, Kenya
Imazalil	Ivory Coast
Triadimenol	

As *Ceratocystis* evolves very rapidly at temperatures higher than 25°C, the fruits must be chilled to 8°C as soon as possible and therefore packed, transported and loaded rapidly into pre-refrigerated holds.



7.4.2 The main packing operations

Packing must be performed as early as possible on the day of picking. The fruits must never be left in the sun or on the ground (risk of contamination by *Thielaviopsis*). Fruits should not be packed at the edge of the field because sorting is difficult, fruits and boxes may be wet or dirty and fungicide treatment is practically impossible.

Trimming consists of adjustment of the peduncle length and removal of bracts. It is recommended that the peduncle should be cut 2 cm from the base of the fruits. Brushing to remove mealybugs is often necessary and is generally performed when the fruits arrive at the packing station.

Immersion is performed to identify the denser fruits that sink and are overripe or affected by yellow disease. The latter is a physiological disorder in which the fruit is overripe internally in relation to the outside colour.

Disinfection. It is advised that this should be limited to the cut section of the peduncle.

Sorting. Fruits with the following features are rejected:

- 'yellow', underripe or overripe;
- too small or too large (for instance: < 700 g or > 2,300 g);
- bruised and with any type of injury (sunscald, insect or yeast damage);
- with multiple or damaged crowns (withered, yellow, damaged by pests);
- with deformations caused by wilt, etc.;
- with broken peduncle.

The fruits are then graded, sorted by stage of ripeness and packed in boxes. A floor is constructed above the calibration lines in the better equipped stations. This is where boxes are stored and sent down on chutes as required by the packing lines.

Full boxes are batched on palettes by category (based on grade and stage of ripeness). Storage at both the plantation and the port of shipment must be conducted under the best possible conditions (shade, ventilation, protection from moisture).

When the fruits have been packed in boxes they must be taken to the port as quickly as possible. Fruits can be refrigerated in the packaging room but subsequent re-warming should be avoided before packing in the hold to prevent condensation that would weaken the boxes and increase risks of fungal infection.

It is reminded that 8°C is the optimum temperature for the transport of Smooth Cayenne. The MD 2 is less exigent regarding optimal transport temperature.

008 - Sucker production

The quality of the slips used determines the productivity of future fields. Neglecting the fields after the harvest prejudices the future. Unfortunately, it is a frequent mistake.

8.1. General observations

Slips or hapas (slips at base of peduncle) are generally used as planting material for pineapple grown for export as fresh fruits and are not present at harvesting. The plants must therefore be maintained before destruction until enough slips have been produced for replanting. The maintenance of slip production fields is not limited to weeding. Good mineral nutrition must be provided together with effective protection against pests and diseases throughout the harvesting of slips. This will give sufficient vigorous, well-developed healthy slips.

Slip production is strongly handicapped by the following features:

- nematodes. The state of the root system after the fruit has been harvested is determinant for the growth of slips. Growth of the latter will be earlier if nematode control has been effective during the growth stage;
- climate and especially drought and high minimum night temperatures appear to be unfavourable for the early growth of slips;
- weeds invasion.

8.2. Maintenance of slips production fields

It is recommended that the following tasks should be carried out immediately after the harvesting of the last fruits:

- manual weeding followed by the spraying of a contact herbicide (e.g. glyphosate, on condition that it is registered in the production country);
- severe pruning of the foliage of the mother plant. This is strongly recommended as it has the following advantages:
  - a mulch of cut leaves can be formed between the ridges to reduce soil drying and weed germination;
  - easier access for workers and machines;
  - slip growth is accelerated during periods with little sunshine;
  - easier cutting and choosing of slips;
  - easier application of fertiliser to the mother plants.

In dry, sunny weather, it is better to prune more lightly than in the cloudy, rainy season. If no suitable mower is available, this is done by using a machete to reduce the top and side leaves in the rows by at least a third of their length.

Manual weeding must then be performed when necessary. Special care must be taken to control patches of the most invasive weeds such as *Cyperus*. Fertilisation after the harvest is essential as it improves slip production and vigour but it is not necessary to apply much more potassium than nitrogen. An N/K20 ratio of 1 is common, with 0.5 g of each applied by spraying. This should be repeated about every 6 weeks. The use of multinutrient fertiliser reduces the number of applications.

Continued mealybug control is also essential. It is the best way of obtaining healthy slips and limiting wilt development in the future production fields. Mother plants with large mealybug populations should be destroyed. Regular insecticide spraying as applied to fields at the vegetative growth stage is recommended. This can be combined with liquid fertiliser. Good control of mealybugs during this phase gives healthy slips that do not require disinfection just after planting.

8.3. Harvesting slips

Slip production generally takes 6 to 10 months according to the weather conditions, pests and mineral nutrition. Slip collection should be performed frequently–every 2 or 3 weeks–so that suckers are as homogeneous as possible and do not grow too large and slow the subsequent growth of younger slips. Optimum average weight is 400 to 500 grams. Smaller slips can nevertheless be used (but preferably weighing not less than 300 g) to accelerate the shooting of the next slips and if planting conditions are favourable. Larger slips can be used (but no heavier than 600 g) if short cropping cycles are wanted.

Slips should be laid on the mother plant for a few days with the base upwards so that the cut heals rapidly. This helps to control *Ceratocystis paradoxa* that causes black rot of the slip stem and mealybugs exposed to the sun after a slight trimming of the plants.

This can be carried out before or after the sorting, trimming and bundling of slips.

8.4. Storing slips

Long storage of slips should always be avoided as they lose vigour and regrowth is slower and more heterogeneous. It is sometimes necessary to plan this however. In rainy or cool, dry weather, it is best to store the slips on the mother plants base upwards as described above.

In hot, dry weather, it is preferable to store them vertically in light shade after the exposure of the base to the sun for a few days.

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ANNEX 1 : EU regulation, Codex MRLs and registration in ACP countries

Active ingredient	EU regulation		CODEX MRL	Registrations in ACP countries				
	Regulation 1107/2009	MRL		Côte d'Ivoire	Ghana	Cameroon	Kenya	Tanzania
Acetylene	Approved	0.01*	/					
Bromacil	Not approved	0.01*	/	X	X		X	various crops
Cadusaphos	Not approved	0.01*	/	X		various crops		
Carbosulfan	Not approved	0.05*	/	X	X	various crops		
Chlorpyrifos-ethyl	Approved	0.05**	/	X	X	various crops	X	various crops
Deltamethrin	Approved	0.05**	/			various crops		various crops
Diazinon	Not approved	0.3	0.1	X		various crops	X	various crops
Dimethoate	Approved	0.02**	/	X	X	various crops		various crops
Diuron	Approved	0.1	/	X	X	various crops	X	various crops
Ethephon	Approved	2	2	X	X		X	
Ethoprophos	Approved	0.02**	/	X		various crops	X	
Ethylene	Approved	n.a.	/	X			X	various crops
Fenamiphos	Approved	0.02**	/	X		various crops	various crops	
Fosetyl-al	Approved	50	/	X	X	various crops	X	various crops
Fosthiazate	Approuvée	0,02**	/			diverses cultures		
Glyphosate	Approved	0.05**	/		various crop	various crops		various crops
Imazalil	Approved	0.05**	/	X		various crops		
Lambda-cyhalothrin	Approved	0.02**	/			various crops		
Mancozeb	Approved	0.05**	/		X	various crops		various crops
Maneb	Approved	0.05**	/			various crops		
Oxamyl	Approved	0.01**	/			various crops	X	
Paraquat	Not approved	0.02**	0.01 tropical fruit with inedible peal		various crop	various crops		various crops
Spirotetramat	Pending	0.1**	/					
Triadimefon	Not approved	3	5	X		various crops	X	
Triadimenol	Approved	3	5					
1-3 Dichloropropene	Not approved	0.05**	/	X		various crops		

Approuvée substance active dont la vente est autorisée dans les pays de l'EU
Non approuvée sactive substance not authorized in EU countries but could be used in countries out of EU if the EU LMR are respected for the imported products in EU.

X means that it is a specific registration on pineapple
* = default value
** = LOQ value
/ = for this active ingredient CODEX don't precise the LMR or LOQ value
n.a. = not applicable
Caution : this information updated in September 2011 is provided as a guide. Regulations may change. Consult your pesticide distributor or the competent authorities.

ANNEX 2 : Identification of main pests, diseases and weeds

Pictures credits:

- Jean-Yves Régnier
- Mamadou Doumbia

NEMATODES	
Pratylenchus brachyurus, Meloïdogyne sp., *Helicotylenchus dihystera*	
	
Roots of a plant after the attack of nematodes	In the case of *Pratylenchus brachyurus*, there are less or no root hairs, and lesions as well as necroses appear of the leaf sheath, which can easily be separated from the stele, as shown (under the thumb) on the picture above
	
Formation of root knots (galls) du to *Meloidogyne* presence	

SYMPHYLES (MYRIAPODA)

Hanseniella ivorensis

Adult *Hanseniella ivorensis*

Reduced root system

Decay of roots due to symphyles

Gravelly soil is favourable to symphyles

MEALY BUGS

Dysmicoccus spp.

Colonies of *Dysmicoccus* spp. located at the fruit basis

Colonies of ants (as a factor for spreading of the mealy bugs in pineapples)

INSECT ATTACKS ON FRUITS

Augosome beetles	Locusts
	
Damage due to *Augosoma centaurus* on a fruit	*Zonocerus variegatus*
	
Symptoms of wilt	
	
Left: wilted fruit	Right: healthy fruit

PHYTOPHTHORA

Phytophtora nicotianiae var. *parasitica* and *Phytophtora cinnamomi*

Plants damaged by *Phytophtora*

THIELAVIOPSIS

Thielaviopsis (Ceratocystis) paradoxa

Initial infection stage following lateral shocks several days after harvest

PENICILLIUM

Penicillium funiculosum

Fruit with several floral cavities affected by ear rots

WEEDS	
Imperata cylindrica	*Cyperus rotundus, Cyperus esculentus*
	

CROP PRODUCTION PROTOCOLS

Avocado (*Persea americana*)
French bean (*Phaseolus vulgaris*)
Okra (*Abelmoschus esculentus*)
Passion fruit (*Passiflora edulis*)
Pineapple Cayenne (*Ananas comosus*)
Pineapple MD2 (*Ananas comosus*)
Mango (*Mangifera indica*)
Papaya (*Carica papaya*)
Pea (*Pisum sativum*)
Cherry tomato (*Lycopersicon esculentum*)

GUIDES TO GOOD PLANT PROTECTION PRACTICES

Amaranth (*Amaranthus* spp.)
Baby carrot (*Daucus carota*)
Baby and sweet corn (*Zea mayis*)
Baby Leek (*Allium porrum*)
Baby pak choy (*Brassica campestris* var. *chinensis*), baby cauliflower (*Brassica oleracea* var. *botrytis*), baby broccoli and sprouting broccoli (*Brassica oleracea* var. *italica*) *and head cabbages* (*Brassica oleracea var. capitata* and *var. sabauda*)
Banana (*Musa* spp. – plantain (*matoke*), apple banana, red banana, baby banana and other ethnics bananas)
Cassava (*Manihot esculenta*)
Chillies (*Capsicum frutescens, Capsicum annuum, Capsicum chinense*) and sweet peppers (*Capsicum annuum*)
Citrus (*Citrus* sp.)
Coconut (*Cocus nucifera*)
Cucumber (*Cucumis sativus*), zucchini and pattypan (*Cucurbita pepo*) and other cucurbitaceae with edible peel of the genus *Momordica, Benincasa, Luffa, Lagenaria, Trichosanthes, Sechium* and *Coccinia*
Dasheen (*Colocasia esculenta*) and macabo (*Xanthosoma sagittifolium*)
Eggplants (*Solanum melongena*, *Solanum aethiopicum*, *Solanum macrocarpon)*
Garlic, onions, shallots (*Allium sativum, Allium cepa, Allium ascalonicum*)
Ginger (*Zingiber officinale*)
Guava (*Psidium catteyanum*)
Lettuce *(Lactuca sativa*), spinach (*Spinacia oleracea* and *Basella alba*), leafy brassica (*Brassica* spp.)
Lychee (*Litchi chinensis*)
Melon (*Cucumis melo*)
Organic Avocado (*Persea americana*)
Organic Mango (*Mangifera indica*)
Organic Papaya (*Carica papaya*)
Organic Pineapple (*Ananas comosus*)
Potato (*Solanum tuberosum*)
Sweet potato (*Ipomea batatas*)
Tamarillo (*Solanum betaceum*)
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)
Yam (*Dioscorea* spp.)

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