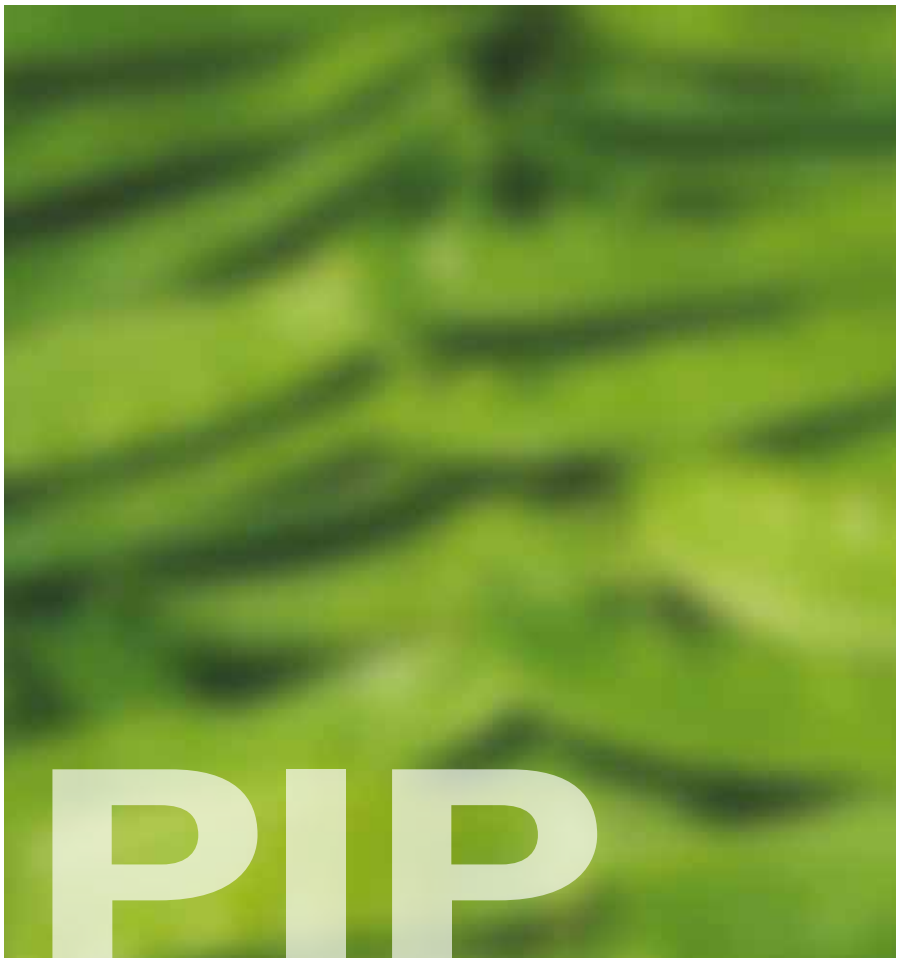


# CROP PRODUCTION PROTOCOL

## PINEAPPLE MD2 (*ANANAS COMOSUS*)

COLEACP is an international network promoting sustainable horticultural trade.

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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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Production guide for the production of the pineapple variety MD2 (a handbook for farm managers and technicians) :

## Introduction

the market for pineapple in Europe has changed dramatically in the past years. The widely in Ghana grown Smooth Cayenne variety is difficult to market, a new variety appeared from Costa Rica, the MD2, known also as Golden Yellow. "Currently the MD2 represents about 70 per cent to 75 per cent of the EU market for pineapple and is priced at about 1.80 Euro to two Euro per kilogram which makes the variety about two times more valuable than the Smooth Cayenne" (Business News of Tuesday, 28 September 2004, www.ghanaweb.com) Del Monte scientists have recently developed the new strain MD2 that is sweeter than regular varieties, always grows to a uniform size and ripens evenly. In short, this strain was developed for a target market looking for extra sweet fruit, uniform in size and ripeness.

## Background

Ghanaian Exporters and growers have started several years ago to deal with the challenge of growing MD2 in **Ghana**.

In 2004 the PIP (Pesticides Initiative Programme) of COLEACP, which is funded by the European Union, organised an advisory mission of two pineapple experts from Costa Rica, to support the Ghanaian export sector in the introduction of a safe production system for MD2. At the end of 2004 the Exporters asked again for support, which resulted in the development of this "Production Guide for the safe production of the pineapple variety MD2". The production guide is tailored on the needs of farm managers and technicians, it aims to support these experts in their practical daily work. The content was developed by the Costa Rican pineapple experts M. L. A. Sanchez and partners. Experienced pineapple growers, can understand well the adjustments in their operations and cultural practices when reading this document that by no means pretend to cover all details in each operation, but it provides the best up to date information on MD2 cultivation avoiding the common agronomic and scientific aspects and the details on the machinery.

## Outlook

The described production system should be seen as a start of the development of a locally adapted and optimised safe production system in Ghana. Taking into account an integrated approach for the production, the growers should focus in the future for example on the optimisation of the fertiliser regime. One tool is the development of so-called nutrient balances, taking into account for example the need of the plants for a proper development, the fixation/mineralisation of nutrients in the soil, the export of nutrients from the field, the leaching of nutrients in the ground etc.. For the development of an integrated pest management system, it seems to be a potential for optimisations of the application technique. The adaptation/development of prognosis models for the development of pests and diseases could lead to a more targeted application of pesticides in time. Aspects like the observation and use of effects related to natural enemies of pests and diseases, as well as the targeted use of these should be considered. The introduction of new environmental friendly pest and disease control systems could be an additional alternative. Specific care must be employed to protect the plantations against the import of Thecla from countries with infestations of this parasite by rigorous controls of imported plant material. Compared with Smooth Cayenne, MD2 needs much more care after harvest. From the point of food safety, namely the post harvest treatments with pesticides need to be done with highest care and accuracy. The ACP Group of States and the European Commission have entrusted responsibility for its implementation to COLEACP, an inter-professional organisation devoted to the ACP-EU horticultural trade. The present document was produced with the support of the European Development Fund. The opinions expressed herein represent those of COLEACP/PIP and not portray the official views of the European Commission.

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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# I. Soil types and site selection

Generally speaking, the MD2 pineapple variety can be cultivated in different soil types originating from volcanic or alluvial deposits located at 20 to 600 meters (60 to 2,000 feet) above sea level. The textures of the soils selected for best performance are: clay loam, loam and sandy loam. Ideally they should be deep with excellent internal and external drainage and should lie on good topographical terrain.

The selected site for planting must be located on a rolling topography with smooth slopes, ideally with 1 to 2 % inclination. Sloping areas with over 3 to 4% inclination are difficult to handle when it comes to planting design, run off and erosion control. Areas with loose sandy soils should not have more than a 1% slope.

The chemical and physical properties of selected soils must be analysed and results interpreted to eliminate risky conditions that could affect future production. Although the nutritional value of the soil is very important, in the selection of the land it is more important to value the physical characteristics of the soil profile and the location of the area for planting.

Limiting factors to produce the MD2 variety economically are the soil conditions that could induce or favour Phytophthora attacks, since one of the major weaknesses of this variety is its extremely high susceptibility to this fungus disease in particular.

Soils with high acidity favour the development of the fungus and they should be avoided for planting; the same occurs when soils are alkaline. Ideally soils selected for best production should have a pH that ranges from 5.0 to 6.5. Soils with pH 4 or below and with pH 7 or above should never be considered for planting. The pH should be measured every 3 to 4 years and corrective measures should be taken by using lime if necessary.

Soil with undesirable physical characteristics such as hard pans, compacted layers, high clay content, etc. which cause poor or impeded drainage, and soils located on low-lying positions and which are marshy or prone to flooding, should also be avoided because poor drainage or excess humidity will induce the fast development of *Phytophthora*, and other fungal diseases such as *Erwinia*.

The analysis of the topography and physical characteristics of the soils is the basis to decide on the type of land preparation, drainage layout and planting design. It is of utmost importance to make sure that internal and surface drainage is managed correctly by installing drains to correct waterlogged conditions, while keeping enough moisture in the soil to facilitate root development and at the same time avoid erosion.

# II. Land preparation and mechanization

Good productivity and high quality of MD2 can only be attained through excellent land preparation. Poor land preparation work will increase the risk of pests such as mealybugs, symphylids, mites, borers, fleas, snails, nematodes, and diseases such as *Phytophthora*. The planting operation, weed control, drainage and the plant growth rate are also affected negatively by poor land preparation. Studies have demonstrated that a better rationing crop is obtained when land preparation is very deep compared with shallow preparation. There is an increase in production when land preparation is done correctly.

The aim of land preparation is to completely eliminate any residues of previous crops planted before the new crop of pineapple is established. All residues are buried deep and allowed to rot into the soil by harrowing and ploughing to avoid proliferation of pests and diseases.

Another important pest that harbours in the residues of harvested old plantations and that is particularly damaging in GHANA is the mealybug (*Dysmicoccus brevipes*). It should be controlled through land preparation to prevent further infestation of the new plantings. Several pests that damage the root system of the pineapple plant also feed on the organic material of abandoned fields, and by incorporating these materials deep into the ground, their life cycle is interrupted and the risk of infestation of the new plantings is eliminated.

The land preparation process requires careful planning and terrain topography studies in order to lay out the position of the beds, the drainage system and the road pattern.

## A. DRAINAGE

Drainage is a very important factor in MD2 variety cultivation because of its extreme susceptibility to *Phytophthora* attacks. Poor or impeded drainage is one of the major factors in the wide spread of this disease and other fungal diseases. Drainage should eliminate excess water in the soil and at the same time maintain enough moisture during the dry period. In the case of GHANA, irrigation must be used in the dry months and as such, drains must be carefully designed for both situations. The design should take the erosion control measures into account.

## B. PREPARATION STEPS

### 1. LAND CLEARING

If the field is going to be planted with pineapple for the first time, clear the land of the existing vegetation as follows:

- With the use of a subsoiler, go over the land once to break up any compacted layers in the soil and bury the shrubs, bushes, weeds, etc..
- With the use of a disk harrow, criss-cross over the land 4 times to break the boulders into fine particles. This should be done in the direction of the planting line the last time.
- Leave the debris of the plants cut and crushed by the harrow to dry.
- Incorporate the organic material into the soil by using a tractor with a deep plough attachment.

The land is ready for planting as indicated below in point “C”.

## 2. PLANT DEMOLITION

When the land was planted with pineapple before, the old crop has to be eliminated completely to eliminate all sources of insects and diseases that remain in the residues of the pineapple plants; then proceed as indicated below:

1. Spray all of the harvested plants with Paraquat. The green tissue will dehydrate to facilitate the process of incorporating the organic matter into the soil and eliminate volunteer plants.
2. Fire can be used to burn the demolished and dried plants, but if fire cannot be used, then opt for a shredder machine to cut plants into fine pieces before they are incorporated into the soil. Burning can also take care of the plastic, which should not be buried in the soil.

After steps 1 and 2 are finalised, the land is ready for the final process in land preparation.

## 3. FINAL STAGE IN LAND PREPARATION BEFORE PLANTING

The main purpose of this work is to break down all soil aggregates and boulders into very fine particles that can easily be used to build the beds where the pineapple will be planted and to facilitate plant growth.

Harrow for land preparation

1. Go over the land once with the subsoiler at a depth of 0.50 to 0.75 m (19.6 to 25.9 inches).
2. Go over the land once with the disc harrow at a depth of 0.36 m (14 inches) across the proposed planting line.
3. Go over the land a second time with the subsoiler crossing the field in the opposite direction of the harrow.
4. Go over the land a second time with the disc harrow in the direction of the beds or definitive planting line. Harrow for land preparation

## 4. BUILDING BEDS FOR PLANTING

This work is done mechanically by using a machine device with the required dimensions to build the fine soil particles into beds to accommodate the desired population. The mechanical device for bedding can be designed to carry out several operations at once when used, namely:

Bedding

1. To build the beds and rows in between with the correct shape and measurements.
2. To apply the chemicals for insect and nematode control.
3. To apply and distribute the fertiliser.
4. To install the plastic mulch to prevent weeds and help in moisture control.
5. To install the plastic pipes used for drip irrigation.

# III. Planting distances and plant population

## BEDDING

Most of the densities and planting layouts observed in GHANA are defined by the way cropping is made and adapted to manual handling of operations. For MD2 production, higher populations than the present ones are recommended in order to obtain good economical results for the operations. High tonnage with good quality fruit is the goal when cultivating MD2, because of the high investment needed. High productivity can only be achieved with densities of up to 70,000 plants per hectare. Generally speaking, densities over 50,000 plants per hectare are very difficult to handle manually, thus requiring mechanisation. Furthermore, in the case of MD2, mechanisation is necessary because this variety is much more susceptible to bruising than other varieties and needs to be handled very carefully to obtain good quality.

## A. PLANT POPULATION

The recommended population of about 70,000 units per hectare (28,500 per acre) is the most adequate for commercial use. This is based on the experience of many years, in high producing areas. The production of fruit with the fruit sizes demanded by the market is obtained more easily with this population, which is also designed for optimal mechanised work.

High populations will increase productivity and make efficient use of ground fungicides and fertilisers which are applied over the whole area with spray booms. It will also help to control weeds in the rows and between the rows, provide better drainage and help maintain more moisture, reduce toppling of lateral fruits and to a certain extent reduce sunburn and produce more uniform fruit size.

## B. PLANTING DISTANCES

| | |
|---|---|
| Distance between rows: | 16 to 18 inches or 41-46 cm |
| Distance between plants: | 10 inches or 25 cm |
| Distance between wbeds: | 44 inches or 1.12 m (Centre to centre) |

The width of each bed or dome measures 24 inches or 60 cm at the top so it can accommodate two rows of plants 18 inches or 45 cm apart planted in a triangular pattern. One additional plant is added between each plant at the side of each row along the roads and drains, forming a third row to reduce excess sunlight resulting in oversized fruit. The planting layout is based on the topography of the area, and the drainage and road pattern should follow the design, thus forming blocks depending on machinery used for spray and harvesting operations.

# IV. Planting material: types, weight and selection

The MD2 pineapple variety is a hybrid originating from the crossing of two other hybrids, the PRI 58-1184 and 59-443, and was known originally as PRI73-114. MD2 has several advantages over other commercial varieties:

→ It has a sweeter taste.
→ It has a yellow colouring.
→ It produces more slips.
→ It has a higher pigmentation.
→ The fruit has a square shape.
→ It has a short peduncle.
→ It has a very high ascorbic acid content.
→ It has a longer shelf life.

Its major disadvantages are that it is highly susceptible to *Phytophthora* and to bruising, and should be handled more carefully than other commercial varieties.

MD2 planting material is obtained from crowns, slips and suckers produced by the plant naturally. Normally the planting materials are obtained from the same plantation when pruned from the mother plant during the production cycle.

Crowns from rejected fruit are also used as planting material. Obtaining MD2 planting materials is very difficult mainly because it is very scarce, and presently nurseries use the planting material for development or replanting the harvested fields. The high volumes of material needed for planting and replanting require that every farm keep a percentage of its area as a permanent nursery.

## A. SELECTION OF PLANTING MATERIAL

Whatever system is used to reproduce the planting material, the source must be certified to make sure that the MD2 variety is genetically pure and that no off-type plants are produced. The planting material should be obtained from healthy, high producing mother plants with zero defects, and which are free from pests and diseases, because the undesirable characteristics will be reproduced in the resulting crop reducing yield and quality. Poor planting material will greatly affect the whole production programme and no mistakes can be tolerated when it comes to producing or buying planting material. In the process of planting material selection, poor-quality plants with defects and unwanted characteristics are identified in the field and are marked with lime or any other suitable material to avoid picking planting materials from those plants.

In summary, good planting materials should be:

1. Certified MD2 variety. The source must be known.
2. Free from defects (spiny, diseased, etc.).
3. Uniform in size. The difference in weight between plants grouped together should not be over 56 g (1.8 ounce).
4. Of the highest possible weight so the crop growing period will be shortened.
5. Chemically treated.

Large planting material

Good ratoon crop

## B. PLANTING MATERIAL PRODUCTION

Planting materials are regularly obtained from the desuckering and pruning cycles that each farm has to go through. The pineapple plant produces suckers and slips that are used for reproduction; however, the amounts of planting materials harvested by this method are not sufficient to replant all fields, and several other techniques have been developed to ensure good and constant supply of material for planting.

### 1. SUCKERS AND SLIPS (DESUCKERING)

Each farm conducts regular pruning cycles to remove the slips and suckers naturally produced by the plant and uses them for planting and replanting. However suckers are cultivated to produce the ratoon crop. In the case of MD2, the plant only carries one or two suckers at most, and they are left for production of the ratoon crop; hence the only source left for planting materials is the slips. Slips are then removed by hand at once, selected in the field by size, grouped, collected, treated, transported to the field and planted. The process is repeated after the second crop. Where ratoon appling is practised, suckers are only removed after the second harvest and are selected, weighed and treated before planting. The minimum weight of a good slip or sucker for planting is around 8 ounces or 250 grams. The ideal weight of the planting material would be 15 to 16 ounces or 450 g, i.e. 1 pound (0.4 kg.). Slips should be removed not more than two months after harvest.

### 2. CROWNS

Crowns from the rejected fruits at the packing station are another source of planting material. They are good planting material but need to be sorted and classified to avoid sending material with defects to the field for planting. The weight of crowns ranges from a minimum of 6 ounces to a maximum of 20 ounces or 175 grams to 575 grams. The amount of planting materials obtained from crowns is not big, representing only about 10% of the requirements for replanting in a regular operation. The crowns are collected from the discarded fruit at the packing stations and are selected for defects, grouped by weight, treated and transported to the field for planting.

### 3. TISSUE CULTURE OR IN VITRO PLANTS

The reproduction of the pineapple plants is made at the laboratory. Usually laboratories are not able to produce plantlets in volumes which are high enough to plant extensive areas. The in vitro plants are usually used to establish nurseries. The plantlets need special handling in the nursery during the hardening process before they are planted in the field. As with any other crop, meristems are prone to produce off plant types. They are a good source of planting material if there is not any other alternative, but production is delayed. The in vitro plants are also very costly and growers have to be ready to dispose of plants by making strict selection to minimise losses when planting.

## 4. USE OF GROWTH REGULATORS

The natural emergence of buds from the pineapple plant is enhanced and stimulated by using chloroflurenol. This is a good method of reproduction when planting materials are scarce or unavailable. The process starts after the plant has been forced, and takes 5 days.

On the first day, the application is made with Ethephon at 1.4 kg (3.5 pounds) a.i. dissolved in 3,750 litres (986 gallons) of water per hectare. On the second day, the same dosage is applied. On day five or 72 hours after the second application of Ethephon, apply 2.2 kg (48.8 pounds) a.i. of Chloroflurenol in 2,300 litres (605 gallons) of water per hectare. Chloroflurenol is applied to 4.5 pounds (2 kg) and over suckers size. After 4.5 to 5 months, the planting material can be harvested.

## 5. SECTIONING OF THE STEMS

The leaves from the stem of mature plants are removed. Afterwards the stem is split into four segments. Each segment is then cut in small pieces of 5 cm (2 inches) in length. The pieces are treated and planted in beds in the field.

Three months later the sprouts coming out of the buds are removed, treated again and planted. This practice is recommended to be used only as a last resource.

## 6. GORGING

We do not recommend this technique for MD2, due to the high risk of creating conditions for *Phytophthora* infection due to the mechanical damage that occurs in the process.

## 7. CHOPPING (SLASHING)

There are three ways to produce planting material by using this technique, which basically consist in eliminating the leaves of the plant and the growing point by slashing them with a cutlass to force the bud emergence from the stem. The slashing is done at a certain height on the stem to allow enough space for the maximum number of buds to emerge. Sunlight and fertilisation will enhance fast growth of the suckers.

These are the fastest and cheapest methods to produce planting material:

**Method 1:** Slashing when the plant weighs 4 to 5 pounds (1.8 to 2.2 kg). No harvest.
**Method 2:** Slashing after one harvest only.
**Method 3:** Slashing after two harvests or after ratoon crop.

The decision to use either process is based on the urgency to complete the planting schedule and the availability of planting material.

Chopping

### METHOD 1:

If the grower chooses this method, no harvest or production of fruit is achieved because the plant is slashed at a height of 40 to 50 cm (16 to 20 inches) to eliminate the growing point, and the leaves on the stem are left to produce suckers only. As indicated, the sole purpose of this method is to produce planting material and it starts when the weight sampling results are an average of 1.80 - 2.2 kg or 4 to 5 pounds. No forcing is made - instead the slashing is implemented.

The area selected for this kind of planting material production must have the same fertiliser and pest and disease control programme as any other commercial plantation.

The next step is to select the planting material by type and weight. Once they are grouped, they are collected in carts, tractors, or trucks of a big enough capacity, and are carried to the treatment plant. After treatment, the material is transported again to the planting site.

### METHOD 2:

If this method is chosen, only one harvest is produced, but more planting material is available in a short time. There will not be a second crop harvest. Initiate the process once the harvest has been completed, by slashing the plants with a cutlass high enough above the ground to avoid cutting or harming the emerging slips attached to the stem.

The field is ready to become a nursery bed requiring the same fertiliser and weed control programmes as any commercial plantation. One month after slashing, start collecting suckers that emerge rapidly, and continue the harvest of planting material every month for 7 to 8 complete cycles.

Sometimes the process could continue for up to 12 months if the plantation is very healthy with excellent growth. Planting material collected this way is grouped by size and weight and then treated and transported to the new area for planting. The size of suckers to pick ranges from 224 - 672 grams or 8 to 24 ounces in weight (0.5 to 1.50 pounds).

### METHOD 3:

This method allows the grower to produce 2 crops efficiently and at the same time produce planting material for replanting.

After the ratoon crop has been harvested, follow the same steps indicated in Method 2. Sprouts will emerge very fast and are allowed to grow and be cared for using fertilisers. Once they reach the desired weight and size they are selected, collected, treated and planted. This system is the cheapest, fastest and easiest way to produce planting material. The quality of the planting material is ensured because it comes from the fields that have been cultivated during the plant crop and ratoon crop cycle and do not involve the use of chemicals to promote growth.

## 8. HANDLING OF PLANTING MATERIAL

The planting material is detached from the mother plant by hand once it reaches the appropriate weight and are allowed to cure for two days turned upside-down. No tools are used, in order to avoid wounds.

The next step is to select the planting material by type and weight. Once it is grouped, it is collected in carts, tractors or trucks of a big enough capacity, and are carried to the treatment plant. After treatment the material is transported again to the planting site.

# V. Planting material nutrition

Fields left to produce planting material require proper fertilisation in order to keep the plants well nourished until the end product, i.e. the planting material in this case, is of good quality and can produce a fast growing crop with quality fruit at the same time. We have to remember that a good, highly productive plantation starts from the quality of the seed used. No matter which system is selected to produce planting material, the fertiliser programme is the same in all cases.

The fertiliser is applied by sprays every 15 days. The first cycle is done after harvest has been accomplished. The best way is to prepare a base solution with nitrogen and potassium in the same way it is done for the plant crop, and the minor elements are added later to the base mix. From the first to the last cycle, use the same amounts of elements in order to provide the same nutrition for each plant produced through its growing cycle. For planting material, the following mixtures and cycles are recommended:

- CYCLE 1

  *15 days after harvest*

  - Nitrogen: 17.0 kg (37.7 pounds) per ha (elemental)
  - Potash: 8.5 kg (18.8 pounds) per ha (elemental)
  - Calcium Nitrate: 37 kg (82.2 pounds) per ha (total material)
  - Citric Acid: 0.17 kg (0.37 pounds) per ha
  - Water: 500 gallons per ha (1900 litres/ha)

- CYCLE 2

  *30 days after harvest*

  Use the same amounts of N and K as in Cycle 1.

  Add:

  - Zinc Sulphate: 0.6 kg (1.3 pounds) per ha (total material)
  - Magnesium Sulphate: 55 kg (122.2 pounds) per ha (total material)
  - Citric Acid: 0.17 kg (0.37 pounds) per ha
  - Water: 1900 litres/ha (500 gallons/ha)

- CYCLE 3

  *45 days after harvest*

  Use the same materials and amounts as in Cycle 1.

- CYCLE 4

  *60 days after harvest*

  Use the same materials and amounts as in Cycle 2.

Continue with the programme every 15 days in the same alternating pattern; in that manner calcium is applied every 30 days but is never mixed with Zinc and Magnesium, which are also applied every 30 days in alternation with Calcium. The planting material nutrition programme includes calcium, but does not include boron and iron. This is because these last two elements are required mostly for fruit formation while calcium will produce healthy and strong tissue and will remain in the cell walls long after the planting material is planted to help the new plant develop.

# VI. Planting material treatment

Regardless of the type of planting material used, complete treatment should be received to avoid the risk of contamination and dissemination of pests and diseases. All insects such as mealybugs, symphylids, snails, borers, mites. etc. have to be eliminated in the planting material by chemical treatment with insecticides. Diseases in general, but especially *Phytophthora* which attacks and possibly devastates MD2 plantings very easily, must be eliminated and prevented through chemical treatment with fungicides.

The mixture used to treat *Phytophthora* is made out of three fungicides that have different modes of action against the fungus. One has a preventive action, and the others have a curative and systemic action. In that matter the seeds have full protection for long periods against one of the most feared diseases in MD2 production.

## PLANTING MATERIAL TREATMENT: CHEMICAL MIXTURE

The treatment can be applied by utilising mechanised facilities, specially built to facilitate the handling of enormous amounts of planting material, or in a much simpler way directly in the field for small farms according to the operations' planting demand. In any case, the planting material should stay

no less than 5 seconds when dipped into the mix. To prepare the mixture, place the fungicides and insecticides in 760 l (200 gallons) of water with the following dosages:

| | |
|---|---|
| 25 grams (3.5 ounce) | Triadimefon |
| 920 grams (40.5 ounce) | Fosetyl-Al |
| 50 + 800 grams (1.8 + 28.2 ounce) | Metalaxyl -M + Mancozeb |
| 192 grams (6.78 ounce) | Chlopyrifos-ethyl |

The volume of the mixture to prepare has to be calculated for the daily planting requirement for plants because it is not recommended to leave mix from one day to the next. Any leftover mix should be disposed of or used as part of the water volume needed for the next day's mixing.

Once the planting material has been treated and left to dry, it is transported to the field for planting the day after to prevent human contamination.

** Labourers should wear protective clothes at all times when mixing and handling treated planting material.*

# VII. Drainage

The MD2 pineapple variety requires soils with very good internal and external drainage conditions to reduce the risk of infection of the plant by *Phytophthora* which causes heart rot and root rot; the fungus lives in the soil and needs water for spore production. The susceptibility of MD2 to this fungus attack is extremely high; in fact, it is higher than in any other known pineapple variety, and as such it needs more intense and better drainage than smooth cayenne. It is necessary to eliminate the danger of infection.

Drainage should be well planned to maintain the balance of moisture in the soil and to remove excess water, and at the same time avoid erosion.

Topography plays an important role in the drainage pattern and layout. The best topography should have no more than a 2% slope to maintain good erosion control. The drainage layout should take the main outlets or collectors into consideration, and the existing streams or depressions should be used as the primary and secondary drains respectively. The surface or tertiary drainage system should take the position of roads and beds into consideration. It can be traced across the beds if necessary to eliminate any areas with standing water. These drains should be deep enough to remove excessive rainfall and run off, but with an almost flat slope in a trapezoidal shape to avoid erosion. The final decision to be made regarding the design is the length of the drain and the soil type. On sandy soils, a slope of 0.3% with a bottom width of 0.30 m (10 feet) is recommended if the drain length is over 150 meters (500 feet).

Drainage

# VIII. Fertilization

A well designed fertiliser programme is of extreme importance to produce a quality fruit that meets the standards of the market for MD2 pineapple variety.

Although the sugar content of MD2 is higher than that of other commercial varieties, complete nutrition is necessary to enhance its genetic characteristics, otherwise it will result in dull, tasteless flavour when compared with the best quality on the market.

The MD2 is also a fast growing plant that requires high, intense, and continuous fertilisation, otherwise a delayed and poor plant crop will result which will not produce a healthy ratoon crop which is necessary to obtain the maximum return on investment. When managing the fertiliser programme, some points have to be considered to obtain good results.

- → Each plant should receive exactly the same rate of fertiliser in order to obtain the most uniform fruit size, shape, weight, sugar content and nutrient content, as well as good quality planting material and good ratoon crop.
- → The best way to obtain an even distribution of the fertiliser is by using foliar solutions applied by spray booms pulled by tractors.
- → The programmed cycling has to be followed closely because it is devised according to the plant growth and age needs of the crop.
- → Precise planning and recording is necessary for each planted field in order to avoid mistakes in the programme.
- → The fertilisation programme for plant crop plantings is designed from planting up to forcing time. A cycle of KCL is allowed if applied 15 days after forcing, and no more after that.
- → Only one granular fertiliser cycle applied to the ground is recommended, mostly to add the required amount of phosphorus.
- → An appropriate area with mixing tanks to prepare the nitrogen and potassium base fertiliser mixture is necessary. Wells of a big enough capacity should be ready to supply the high quantities of water required for operations.
- → Minor elements are added last to the N and K base solution directly into the tank by using previously weighed packs of each element, measured according to the area to be fertilised.
- → When using minor elements, always add citric acid to the mix in the recommended doses.

## A. DEVELOPING THE FERTILISER PROGRAMME

Various factors are considered for devising the fertiliser programme.

They are:

- → Characteristics of the variety: Size, weight, flavour
- → Soil properties: Chemical and physical
- → Plant density: Competence for light, water, nutrients, and growth
- → Production target: Plant crop, ratoon crop and planting material production

## B. NUTRITIONAL DEFICIENCIES

Deficiencies are described briefly in the chapter on nutrition, however one should not wait to find deficiency symptoms in the field since it would be too late to make up for the effect of the missing element or an imbalance in production and quality.

We should not expect any deficiency if the submitted programme is followed and if the selection of the soils is adequate.

## C. DESCRIPTION OF THE PROGRAMME

### NITROGEN

This important element is used in large amounts. The total N requirement for the plant crop is 800 kg per hectare applied in 20 cycles depending on forcing time. Nitrogen is supplied from three different sources that are mixed in the following percentages: 50% urea, 25% ammonium sulphate, 25% ammonium nitrate; or 60% urea and 40% ammonium nitrate; or 50% urea and 50% ammonium nitrate. The dose of N per cycle varies throughout the crop cycle and there is an increase of 333% in the dose of N from the initial cycle to the last one in the plant crop programme. There is only one granular application to the soil in the formulation 10-30-10, 15 days after planting. Afterwards, all cycles are foliar applications programmed every 15 days. For the ratoon crop, the N requirement is even higher, reaching 852 kg (1960 pounds) per hectare with foliar application every 15 days. Up to 20 cycles are required depending on forcing time. Unlike the variations in dosages used in the plant crop, they are heavier, and the difference in dose from the first cycle to the last one is only 11%.

For seedbeds, the N requirement is 346 kg (760 pounds) per hectare, applied by foliar sprays every 15 days.

### PHOSPHORUS

This element is vital only in the early stages of the plant crop, specifically at planting time. There is only one cycle of phosphorus, and it is applied to the soil by hand in granular formulation. The sources are DAP (diammonium phosphate) or MAP (monoammonium phosphate) in the 10-30-10 fertiliser mix, or any other similar one. The total requirement of P for the plant crop is 315 kg (700 pounds) per hectare, but none is required for the ratoon crop and for planting material production.

Some foliar spray formulations can be used only if deficiencies are observed at any stage of the crop and are properly measured.

### POTASSIUM

This element is also needed in large amounts for good MD2 production, and a total of 466 kg (1,035.5 pounds) of $K_2O$ is required for the plant crop cycle. Soluble potassium chloride in the white formulation is the recommended source, although potassium sulphate can be used too but commands a higher price.

Cycling is done every 15 days by foliar spray mixed with nitrogen and minor elements. Each cycle carries different doses; in the case of N, the first application to the soil is granular in the 10-30-10 formulation or a similar one, right after planting. The last dose of K increases 284% from the initial one as it changes according to the age of the crop. After forcing, there is one application of $K_2O$ only.

$K_2O$ is lower than Nitrogen because it is the best result from Research thru out many years and up to now. For the ratoon crop, the amounts of K required are even higher than those for the plant crop. A total of 653 kg (1,451 pounds) of $K_2O$are required. The doses used for the ratoon crop are more regular than those of the plant crop and do not change much in every cycle.

For planting material production, the amount of potassium needed is much less than the amounts applied for the other production stages of pineapple, and only a total of 168 kg (373.3 pounds) per hectare is required.

### MAGNESIUM

The plant crop requires 55.5 kg (123.3 pounds) of MgO per hectare. There are 9 cycles every 30 days applied only by foliar sprays mixed with zinc and boron in alternation with iron, which is always sprayed separately. The source for MgO is magnesium sulphate (16%), also known as Epsom salt.

The doses used in every cycle vary very little throughout the crop cycle at 16.2 kg (36 pounds) per hectare per cycle. The amounts of MgO required for the ratoon crop development are higher, for a total of 76 kg (169 pounds) per hectare.

Contrary to the pattern followed with N and K, the magnesium requirement for planting material production goes up to 87 kg (193.3 pounds). Always use citric acid in the mix. Citric acid should be used to facilitate the dilution of Zinc Sulphate, and Iron Sulphate when used and even up the mixture with the other elements in the solution.

## ZINC

This element is applied every 30 days by foliar spray in small amounts which are always mixed with magnesium and boron, but never with calcium and iron. The total amount of zinc required by the plant crop cycle is of 7.30 kg (16.2 pounds) per hectare; 6.57 kg (14.6 pounds) per hectare for the ratoon crop and goes down to 1.11 kg (2.46 pounds) for planting material production. The best source is zinc sulphate heptahydrated (19.5%). Always use citric acid when mixing with the other elements.

## IRON

It is used in small amounts in the plant crop or ratoon crop, but it is not required for planting material production. The amounts required are 7.30 and 6.57 kg (16.2 and 14.6 pounds) per hectare for the plant and ratoon crops respectively.

The recommended source is iron sulphate (19.5%) and it is always applied alone by foliar spray every 30 days in alternation.

Doses of iron per cycle change only when the plantation is 6.5 months old in the plant crop stage, but are fixed for all cycles in the ratoon crop stage of production. Always use citric acid in the mixing

## BORON

This element is used in low amounts, and only 3.39 kg (7.5 pounds) per hectare are needed in the plant crop cycle and 4.79 kg (10,6 pounds) for the ratoon crop. It is not needed for planting material production purposes. The source for boron is borax (sodium pentaborate tetrahidro 20.5%), and it is always used in combination with magnesium and zinc. It is used in a fixed dose every 30 days for the plant crop and ratoon crop. Use citric acid in the mixing.

## CALCIUM

Calcium is incorporated into the soil as lime or gypsum prior to planting when soil analysis indicates it is a limiting factor. In this regard, amounts should be calculated very carefully according to the pH readings so as not to unbalance the other bases and increase the pH without control. Calcium is not applied in the fertilization of pineapple during the plant crop or ratoon crop, but it is required for planting material production at a rate of 180 kg (400 pounds) per hectare per crop. Cycling is applied by foliar spray every 30 days. Calcium is always applied alone or mixed with K and N only. The source for spray application is calcium nitrate. **Always use citric acid when mixing**

## D. FERTILIZATION PROGRAMME

TABLE 1. PLANT CROP MANAGEMENT

| ACTIVITY | D.A.P | M.A.P | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Vol. $H_2O$ l/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Granular Fertiliser | 15 | 0.5 | -- | -- | -- | -- | 10-30-10 | 1235 | -- | -- | -- | -- | -- | -- | -- |
| Foliar Fertiliser 1 | 30 | 1.0 | Nitrogen | 13.0 | $K_2O$ | 10.13 | Citric Acid | 0.17 | Sulph Fe | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 2 | 45 | 1.5 | Nitrogen | 19.5 | $K_2O$ | 8.9 | Citric Acid | 0.17 | SulphZn | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 3 | 60 | 2.0 | Nitrogen | 19.5 | $K_2O$ | 8.9 | Citric Acid | 0.17 | Sulph Fe | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 4 | 75 | 2.5 | Nitrogen | 19.5 | $K_2O$ | 8.9 | Citric Acid | 0.17 | SulphZn | 3.40 | Boron | 1.65 | Mg. Sulphate | 33.4 | 1900 |
| Foliar Fertiliser 5 | 90 | 3.0 | Nitrogen | 26.3 | $K_2O$ | 10.23 | Citric Acid | 0.17 | Sulph Fe | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 6 | 105 | 3.5 | Nitrogen | 26.3 | $K_2O$ | 10.23 | Citric Acid | 0.17 | Sulph Zn | 3.40 | Boron | 1.65 | Mg. Sulphate | 33.4 | 1900 |
| Foliar Fertiliser 7 | 120 | 4.0 | Nitrogen | 26.3 | $K_2O$ | 10.23 | Citric Acid | 0.17 | Sulph Fe | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 8 | 135 | 4.5 | Nitrogen | 30.4 | $K_2O$ | 13.6 | Citric Acid | 0.17 | Sulph Zn | 3.40 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 9 | 150 | 5.0 | Nitrogen | 30.4 | $K_2O$ | 13.6 | Citric Acid | 0.17 | Sulph Fe | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 10 | 165 | 5.5 | Nitrogen | 30.4 | $K_2O$ | 13.6 | Citric Acid | 0.17 | Sulph Zn | 3.40 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 11 | 180 | 6.0 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Fe | 3.40 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 12 | 195 | 6.5 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Zn | 4.50 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 13 | 210 | 7.0 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Fe | 4.50 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 14 | 225 | 7.5 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | SulphZn | 4.50 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 15 | 240 | 8.0 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Fe | 4.50 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 16 | 255 | 8.5 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | SulphZn | 4.50 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 17 | 270 | 9.0 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Fe | 4.50 | -- | -- | -- | -- | 1900 |

| PLANT CROP MANAGEMENT (continued) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY | D.A.P | M.A.P | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Vol. $H_2O$ l/ha |
| Foliar Fertiliser 18 | 285 | 9.5 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Zn | 4.50 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 19 | 300 | 10.0 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Fe | 4.50 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 20 | 315 | 10.5 | Nitrogen | 43.0 | $K_2O$ | 29.0 | Citric Acid | 0.17 | Sulph Zn | 4.50 | Boron | 1.65 | Mg. Sulphate | 40.0 | 1900 |

D.A.P = DAYS AFTER PLANTING M.A.P = MONTHS AFTER PLANTING

**Note:** 1 kg = 2.205 pound

| TABLE 2. RATOON CROP | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY | D.A.H | Product | kg/ha | Product | kg/ha | Product* | kg/ha | Product | kg/ha | Product | kg/ha | Vol. $H_2O$ l/ha |
| Foliar Fertiliser 1 | 15 | N | 40 | $K_2O$ | 28 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 2 | 30 | N | 40 | $K_2O$ | 28 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 3 | 45 | N | 40 | $K_2O$ | 28 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 4 | 60 | N | 40 | $K_2O$ | 28 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 5 | 75 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 6 | 90 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 7 | 105 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 8 | 120 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 9 | 135 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 10 | 150 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |

| RATOON CROP (continued) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY | D.A.H | Product | kg/ha | Product | kg/ha | Product* | kg/ha | Product | kg/ha | Product | kg/ha | Vol. $H_2O$ l/ha |
| Foliar Fertiliser 11 | 165 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | | -- | -- | 1900 |
| Foliar Fertiliser 12 | 180 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 13 | 195 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 14 | 210 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 15 | 225 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 16 | 240 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 17 | 255 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 18 | 270 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |
| Foliar Fertiliser 19 | 285 | N | 44 | $K_2O$ | 34 | Iron Sulphate | 3.5 | -- | -- | -- | -- | 1900 |
| Foliar Fertiliser 20 | 300 | N | 44 | $K_2O$ | 34 | Zinc Sulphate | 3.5 | Boron | 2.3 | Mg. Sulphate | 40.0 | 1900 |

D.A.H = DAYS AFTER HARVESTING * ADD CITRIC ACID TO EACH CYCLE = 0.17 KG/HA

**Note:** If natural flowering conditions exist, the cycle must be shortened to every 10 days. Normally, after 6 months old, crop aged

**Note:** 1 kg = 2.205 pound

| TABLE 3. FOR PLANTING MATERIAL | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY | D.A.C | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Vol. $H_2O$ l/ha |
| Foliar Fertiliser 1 | 01 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 2 | 15 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 3 | 30 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 4 | 45 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 5 | 60 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 6 | 75 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |

| FOR PLANTING MATERIAL (continued) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY | D.A.C | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Product | kg/ha | Vol. $H_2O$ l/ha |
| Foliar Fertiliser 7 | 90 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 8 | 105 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 9 | 120 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 10 | 135 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 11 | 150 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 12 | 165 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 13 | 180 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 14 | 195 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 15 | 210 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 16 | 225 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 17 | 240 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 18 | 255 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |
| Foliar Fertiliser 19 | 270 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Calcium Nitrate | 37 | -- | -- | 1900 |
| Foliar Fertiliser 20 | 285 | N | 17 | $K_2O$ | 8.4 | Citric Acid | 0.17 | Zinc Sulphate | 0.57 | Mg. Sulphate | 54 | 1900 |

D.A.C = DAYS AFTER CHOPPING

**Note:** 1 kg = 2.205 pound

# IX. Nutrition

It is estimated that a two-crop healthy plantation of MD2, producing 100 MT of good export fruit will consume great amounts of nutrients as indicated in the fertiliser chapter. Nitrogen, potassium, magnesium, phosphorus, iron,
zinc, boron and calcium are all necessary for the nutrition of the plant. The role of each element has long been studied and deficiencies have been identified and described. They are briefly discussed in this chapter.
However, the fertiliser programme is devised to avoid deficiencies, and if any nutritional problem is observed, corrective measures must be taken immediately after the problem is diagnosed.

## NUTRITIONAL DEFICIENCY SYMPTOMS

### NITROGEN

This element is required in very high amounts by the plants, and the deficiency symptoms are:

→ Pale colour. General yellowing of leaves.
→ Older leaves show first symptoms. Reddish edges.
→ Narrow leaves.
→ Poor and stunted growth.
→ Delayed fruiting.
→ Deficiency detected by visual observations.

Critical level: 0.10 % dry weight. Sample the centre portion of the D leaf foranalysis.

### POTASSIUM

It is also required in high amounts. The deficiency symptoms are:

→ Leaves are very narrow.
→ In young plants leaves have dark green colour.
→ In older plants leaves are yellow.
→ Crown growth is excessive.
→ Siamese crowns are produced.
→ Slow growth of slips.
→ Tips of old leaves die off.

Critical level: 0.3% dry weight. Sample the basal portion of the D leaf for chemical analysis.

### MAGNESIUM

The required amounts of this element are medium. The deficiency symptoms are:

→ Older leaves have bright yellow colouring.
→ There are less leaves per plant.
→ Leaves are weak and necrotic.
→ Plants have short stems.
→ Appearance of leaves resembles sunburn.
→ Poor root system.
→ Poor fruit development.

Critical Level: 0.025% fresh weight. Sample the basal portion of the D leaf.
Visual symptoms are difficult to observe and laboratory analyses are necessary to assess deficiencies.

## PHOSPHORUS

It is required in medium and small amounts. The deficiency symptoms are:

→ Very dark green leaves.
→ Poor root growth.
→ Delayed growth.
→ Older leaves have purple/red colouring.
→ Leaves have yellow edges.
→ Poor fruit development.

Visual symptoms are rarely observed with normal fertiliser practice. The symptoms can be noticed only when the deficiencies are severe. For this reason leaf tissue analysis is required for diagnosis.

Critical level: 0.020 % fresh weight. Sample: basal portion of the D leaf. Excess of phosphorus can reduce plant growth.

## CALCIUM

It is required in large amounts when used as an amendment to the soil, but not in direct foliar sprays to the plant except for planting material production. The deficiency symptoms are:

→ Growth is stunted.
→ Corky leaves.
→ Short leaves.
→ Stems are malformed.
→ Fruit is abnormal (Siamese, multiple, fasciated).
→ Plant has yucca appearance.

Critical level: 0.010% fresh weight. Sample the basal portion of the D leaf
for analysis because the colour of the leaves is not a key guide in determining deficiencies. Check pH of soil periodically.

## IRON

This element is required in small amounts. Deficiencies appear on the youngest leaves.

→ Leaves are yellowish with green mottling.
→ Tips of leaves become necrotic.
→ Fruit is small.
→ Fruit has red skin and is hard.
→ Crowns have yellowish colour.
→ Fruit shows cracks.

Critical level: 3 ppm fresh tissue. Sample the middle portion of D leaf.
Visual symptoms are used as a diagnosis for deficiencies and laboratory analysis is not always representative of the deficiency.

## ZINC

This element is required in small amounts. Deficiencies are identified visually.

→ Crooked neck on young plants.
→ The heart leaf becomes hard and brittle.
→ Blisters appear on the upper surface of leaves.
→ The crowns are small and rosette.
→ The plants become bunchy.

Critical level: Only the sampling of the tip of the stem will provide a reliable indication of the zinc content. Leaf analysis is not reliable. Look for visual symptoms.

### BORON

It is required in small amounts. Boron deficiencies will only be identified in the fruit. Deficiencies are identified visually.

– Peel will develop corky tissue.
– Corky flesh develops on and in between eyes.
– Cracks develop on and between fruitlets.

Critical levels: The symptoms are unknown. Deficient plants will not have any symptoms in leaves, stems or roots. Check fruit visually for symptoms of deficiency

# X. Weed control

Weeds can reduce the yield and harbour pests and diseases that attack the planted fields if not controlled in time. Roadsides and abandoned fields must be clean of weeds, to avoid the danger of contamination by keeping a buffer around the plantation. Volunteers' plants should also be eliminated with herbicides. Residual herbicides can effectively control grasses that are abundant in GHANA.

## A. PRE-PLANT WEED CONTROL TREATMENT

After the land has been cleared and prepared, the next step before planting is to prevent the growth of weeds on the exposed ground by using pre-emergent herbicides. The treatment is initiated 10 days before planting, with the following mixture:

| | |
|---|---|
| Bromacil: | 1.34 kg (2.95 pounds) per ha |
| Ametryn: | 3.76 kg (8.3 pounds) per ha |
| Spreader sticker: (Non ionic surfactant) | 1.3 kg (2.86 pounds) per ha |
| Water: | 3300 litres per ha (868 gallons) |

## B. POST PLANT WEED CONTROL TREATMENT

The 2nd cycle is applied 25 to 30 days after the 1st cycle with the same dosages according to weed density.

## C. POST HARVEST WEED CONTROL TREATMENT

There will be a herbicide application only if the sampling indicates the need for it.
The same products and dosages used for the pre-plant treatment are used at this stage too.

## D. PLANTING MATERIAL BED WEED CONTROL TREATMENT

The weed control programme is more intense at this stage because of the ground's exposure to sunlight. The treatment is scheduled every 60 days, but only if the sampling results indicate the need for weed control:

15 days after slashing.
75 days after slashing.
135 days after slashing.
195 days after slashing.

The planting density and the use of plastic covers would minimise the spread of weeds, but in any case, spot applications can be done when necessary using the same recommended products and indicated doses for pre-plant and post-plant treatment.

# XI. Phytosanitary approach

A properly managed integrated pest and disease control programme in harmony with the environment is the key to success in any pineapple operation. The purpose of the programme is to have a healthy plantation that will produce clean fruit with the minimum amount of chemical residues as specified by EU requirements. The pest and disease control programme is based on two criteria:

**A. REGULAR APPLICATION** of chemicals planned on the basis of the technical knowledge of crop needs and the behaviour of pests and diseases in order to prevent attacks. Monitoring and scouting play a very important role in this planning.

**B. SPOT CHEMICAL APPLICATIONS** to control any outbreak of pests and diseases. These applications are based on and strictly regulated by a previously established sampling calendar and methodology.
The decision to proceed with any specific treatment is the responsibility of the technical staff for each farm or project. Each treatment is specifically designed to control disease and insect attacks at different stages of crop development and they are to be programmed accordingly

# XII. Sampling and sampling procedures

Sampling is necessary to determine when, where and how a pest or disease problem can be treated, and to avoid attacks that are out of season or not properly controlled by the regular preventive control cycles.
They are also needed to evaluate the right timing for special plant and fruit treatments such as forcing and ripening. Sampling is a way to keep an eye on every step of the operation to detect problems in advance and also serves to evaluate the effectiveness of the treatments applied in the regular cycling.
The sampling procedures for a specific problem or for testing plant and fruit conditions are discussed in detail and serve as a guide for surveyors and supervisors when making decisions about doses, products, location and timing of treatment.

## A. WEED SAMPLING

The objective of this sampling is to identify weed problem areas in order to decide on the type of treatment to solve the problem at hand, based on the identification of each kind of weed, their growth status and grade of infestation.

### 1. METHOD

A field inspection of all planted blocks is made on foot or motorbike to assess the weed condition visually by checking inside the planted area as well as drains, roadsides and border areas.

### 2. SCHEDULE

Normally the first evaluation is made 1 month after planting and the next evaluations are scheduled every 1.5 months. During the rainy season, the sampling cycle should be shortened and the same must be done in hot spot areas.

### 3. REPORTS

A written report of each evaluation should be submitted, indicating dates, field number, type of weeds, density, area affected and action taken indicating doses, recommended products, etc.

When the plantation reaches 6.5 to 7.5 months of age and until forcing or induction time, no use of chemicals is allowed, and all controls should be strictly manual.

## B. SAMPLING PESTS AND DISEASES IN THE PLANTATION

The objective of this sampling is to detect and treat any disease or insect problem affecting the plant at a very early stage of infection, to stop them from developing into an endemic and a production problem.

The process of sampling comprises:

### 1. METHOD

Sampling for pests and diseases is done over the whole area planted and the method used varies according to the crop age measured in months after the planting date. The area is divided into two groups for the survey, i.e. the young plantings and the adult plantings:

#### Group 1

Young planted areas of 1.5 months and 3.5 months of age after planting.

#### Group 2

Mature planted areas of 6 months, 8 months, and 10 months of age after planting.

### 2. PARAMETERS FOR EVALUATION

The parameters for evaluation and the severity level scale are established for each region, zone or farm depending on the problems encountered, and the ranges must be known by well trained and skilled field surveyors.

### 3. SCHEDULE

Based on the planting date records, two samplings are scheduled.

The first sampling is done when the pineapple plants are 1.5 months old and the second sampling is done when they reach 3.5 months of age after the planting date. Blocks with a difference of 2 weeks of age between them are grouped together to facilitate the sampling work.

Every other block located along the plantation borders are selected for sampling. Once a block has been sampled for the first time, it should be sampled again in the next cycles.

### 4. REPORTS

The reports are submitted to the farm manager and technical staff for final recommendations with all supporting data.

## C. SAMPLING BY MONTHS

### 1. SAMPLING 1.5 MONTH- AND 3.5 MONTH-OLD CROPS

#### SAMPLING SITES

The sampling for pests and diseases is done on a minimum of 10 plants per acre (25 per hectare), distributed in 4 beds. To locate the sampling sites, measure 15 steps from the centre of the upper boundary of the block and mark the first plant. Continue measuring 30 steps in line from that first site and so on up to the lower boundary of the bed.

## BEDS TO SAMPLE

They are selected according to the crop age as indicated below:

For 1.5 month-old plantation sample beds3-6-12-15.

For 3.5 month-old plantation sample beds4-7-13-16.

All sampling sites and bed locations remain in place for future surveys in order to keep records and a history of events.

## SAMPLING PESTS AND DISEASES IN FOLIAGE

This sampling is directed only at the pests and diseases in the leaves. To initiate the survey, select 10 plants aligned one after the other starting from the first plant of the sampling site and remove by pulling off the youngest leaf on each plant. Collect each leaf and analyse them to evaluate and identify any symptoms of attack from *Phythophthora*; *Erwinia*, *Thecla*, *Naphaea* and borers, or symptoms of burnt and lost plants.

## SAMPLING PESTS AND DISEASES IN ROOTS

Plants number 1 and number 10 in every sampling site are removed gently with a shovel or long knife to evaluate the root system and soil condition in detail. Then proceed to evaluate the presence of or damage caused by any pests or diseases and rate them according to the level of infection and infestation. After the evaluation, proceed to replant the plants on site. This sampling evaluation is directed towards identifying problems caused by symphylids, snails, mealybugs, white grubs, rodents, as well as the general condition of the roots system.

## SAMPLING FOR MEALYBUGS IN FOLIAGE

To sample the plantation for mealybugs, pick plant number 1 and plant number 10 on each sampling site and remove 2 leaves from the middle of the plant; check the base of each leaf to detect the presence of mealybugs. Place the leaves in an upside down position on top of the plants, to indicate the sampling location.

## ADDITIONAL CHECKS

All other pests and diseases are also checked in the plants sampled for mealybugs and their surroundings, taking note of the number of plants affected. Based on the analysis of this sample, the necessary controls should be planned and action should be taken.

## MEALYBUG INFESTATION AND WILT DISEASE

Mealybugs

Wilt

One of the major problems observed throughout the pineapple fields in GHANA is the widespread wilt virus disease infestation which accounts for poor root development, fruit quality and production. The virus disease is transmitted by mealybugs that live and feed on the roots, stem, flowers, leaves and fruits of new plantings and on the residues of harvested plants in abandoned fields which are already infected with the virus.

There are several (8) species of mealybugs that live in pineapple, other grasses and sugarcane. The most known species are: *Dysmiccocus*; *Neobrevipes* (Beardsley); *Dismiccocus brevipes*; and *Pseudoccocus longispinus*. In the newly planted fields, the root system is already heavily infested and damaged by the high population of mealybugs.

This can be observed by uprooting some plants at random even when symptoms of the virus are not visible. On occasion, the disease symptoms are mistakenly related to a lack of water, and when rainfall begins the symptoms disappear but the plants are already infected. Sampling is always necessary to detect any attack on time and check on the effectiveness of the regular treatments.
For an effective and preventive control it is necessary to take the following steps:

a. Destroy the harvested and abandoned fields. (Do not take any planting material from infected fields).
b. Initiate and maintain an adequate ants control programme.
c. Establish a regular chemical spray control programme.
d. Sample the fields regularly as indicated in the sampling chapter.
e. Develop a good seed selection and treatment programme.

Ants are the main cause for the fast spread of the disease inside the plantation because they carry and protect the mealybugs since they use the digested pineapple sap produced by mealybugs as a food source.

## RECOMMENDATIONS FOR PREVENTIVE CONTROL OF WILT DISEASE

### Plant demolition in harvested and abandoned pineapple plantations

- After harvest, destroy all plants left in the field with the use of machinery.
- Treat the shredded plants and leftovers with herbicide. Use 3,2 kg (7 pounds) of paraquat in 600 litres (158 gallons) of water per hectare. Add 15 kilograms (33 pounds) of urea to the total volume.
- Spray all boundaries with herbicide to eliminate tall grasses and broad leaves. Use Glyphosate, Ametryn or Paraquat. When allowed, use fire to burn the debris, but it is preferable to avoid this practice because fire also destroys the organic matter in the soil.
- No suckers should be taken from infected and treated fields.

## ANT SAMPLING CONTROL

- Prepare wood sticks 90 cm (36 inches) high by 30 cm (12 inches) long and 1 cm (0.4 inch) wide.
- Use TUNA OIL as bait, or mix 50-50 peanut butter and soy sauce.
- Dip 25 cm (10 inches) of each stick into the bait.
- Place each stick firmly into the soil along the boundaries every 40 meters (133 feet).
- Distribute a small amount of Hydramethylnon in a circular fashion 10 centimetres from the base of the stick. AVOID MOUNDS AND SPREAD EVENLY ON THE GROUND.
- Distribute and place the sticks in the field early in the morning from 3:00 am to 5:00 am every day.
- Check and count between 7:00 am and 9:00 am every day.
- The ant nest can be treated with Hydramethylnon., using the amount required according to the size of the nest.

## 2. SAMPLING 6 MONTH-, 8 MONTH- AND 10 MONTH-OLD CROPS

After the 3.5 month-old plantation samplings have been completed, the approach changes and only the foliage is sampled for pests and diseases, since the thick canopy does not allow root problems to be observed and controlled. This brings about some differences with respect to the procedure criteria used for sampling younger plantings. The blocks to sample are the same blocks sampled 1.5 to 3.5 months after planting, by checking all the borders and every other block inside the area to be sampled.

### SAMPLING SITES

In the same sampling sites used in the 1.5 to 3.5 month-old plantings, 10 plants are selected from four beds, placing the first site 15 steps from the upper border of the block with 30 steps in line between each of the following sampling sites.

### BEDS TO SAMPLE

They vary according to the crop age:

| | |
|---|---|
| For 6 month-old plantings sample beds | 3-6-12-15 |
| For 8 month-old plantings sample beds | 4-7-13-16 |
| For 10 month-old plantings sample beds | 2-5-11-17 |

As in the surveys after 1.5 and 3.5 months, sampling sites and beds are identified for future surveys and records. By using the same sampling sites for all evaluations, we make sure that the survey is done in the same place throughout the life cycle of the crop.
The same pests and diseases evaluated in the young plantings are evaluated in this group, but the root sampling evaluation is not done at this crop age. No sampling will be required in blocks with crops that are 10 months of age or under after planting and are ready for forcing.

### DESCRIPTION OF SOME SYMPTOMS OF PESTS EVALUATED IN THE SAMPLING SITES

- ROOT PESTS

The surveyor should try to identify the pests by observing any of the following symptoms:

#### Nematodes

The root system is severely damaged by nematodes.
The most important species known are: *Rotylenchulus reniformis*; *Meloidogyne javanica; Melodoigine incognita; Pratylenchus bracyurus*; *Helicontylenchusnannus* and *Criconemoides* sp. Nematodes reduce production, affect quality and greatly limit the development of the ratooning.
When applying chemicals to control nematodes, full protection gear should be used by all personnel involved in the operation as indicated on the label and according to Eurep-gap and local human health regulations.

#### Snails (several species)

There is severe damage to the roots. Sometimes the feeding roots are totally eliminated. The plant cannot absorb nutrients and water, and stops growing.

#### Symphylids (*Hamseniella* sp.)

They are large centipedes measuring 2 to 16 mm, of whitish colouring with long antennae and 12 pairs of legs. They move very fast and hide when exposed to the sunlight. They live in the soil and feed on the organic matter and root tips, stimulating the emergence of short branching roots causing the condition known as witches' broom effect. These roots are not capable of feeding the plant sufficiently to produce well.

#### White grubs (*Coleoptera scarabaeidae*)

There are three larval stages of various species of this beetle that live in the soil and feed on the root systems of the pineapple plant. They can cause severe damage to the roots. Without feeding roots the plant lacks the capacity to uptake nutrients and water and turns yellow.

## ▪ PESTS AND DISEASES ON FOLIAGE

### Mealybugs

This pest attacks the roots as well as the foliage. Besides damaging the plant and fruit, it is responsible for the transmission of the wilt virus disease which is a serious problem in GHANA (see specific note on this pest in addendum #1).
The virus will reduce the capacity of the plant to grow normally and the leaves will turn soft and yellow in MD2, but reddish in Cayenne. The root system becomes stunted and the yield is reduced.

### Borers (Metamasius sp.)

They attack the pineapple plant in any of their two stages of growth, as larvae and as adults, causing damage for long periods of time. The larvae feed inside the plant forming caves and holes to build their nest where the pupae will grow, and emerge as adults 30 to 50 days after. The complete life cycle of the borer is around 100 days and a severe attack can kill the plant.
They also feed in the fruit and foliage, thus damaging quality and productivity.

### Thecla

It is a *Lepidopterae* that belongs to the *Lycaenidae family* and the *Strymon basilidis* family. The reference is provided because in Africa, this pest was not detected before, but could appear in the future if large plantings of MD2 are developed, and it is a serious problem in other areas. The larvae feed on the fruit and their life cycle lasts about 50 days.

Thecla attack

Thecla internal damage

### Rodents

They feed on the fruit causing a lot of reject fruit, and also damage the base of the plant when populations are high. They hide near streams, ponds and tall grasses.

### *Erwinia* (*crisantemi*)

This bacterial disease is very damaging and can kill the plant. The bacteria penetrate the plant through any wound or lesion. Symptoms are very distinct because the strong, unpleasant odour produced by the fermentation of rotten tissue from the leaves and the air pockets at the base of the sheaths. The leaves finally die, falling off their bases and leaving the base of the plant exposed on the ground until the plant dies.

### *Phytophthora* (*parasitica* and *cinamoni*)

*Phytophthora* attack to the crown

*Phytophthora* attack due to waterlogged condition

This fungus disease seriously attacks the MD2 variety. The *P. parasitica* is more virulent and its symptoms are the rotting of the plant starting with the youngest leaves and then the older ones. Symptoms are rarely observed in the early stages of infection, but when the youngest leaf is pulled it comes out easily showing the rot at the base of the plant that produces the unpleasant odour. In advanced stages of infection the plant becomes yellowish and leaves turn reddish brown and start to die.
The *P. cinamoni* mostly affects the root system and may also cause heart rot. In all chapters there is a reference made to this disease that affects the crop throughout the crop cycle.

### Lost or missing plants

Lost or missing planting sites in the plantings due to any reason are checked to determine the replanting needs and mortality rate in the survey which takes place 1.5 months after planting. It also serves as a double check for plants infected with *Erwinia* and *Phytophthora*.

### Regrowth

Plants that have stopped growing normally and that have their growing point stunted, are forced to produce lateral buds that can not grow well either. They produce a delayed poor fruit that will not reach an optimum weight at forcing time.

### Burnt

Fertiliser sprays - mainly granular formulations - will burn the leaves if not applied properly. It is easy to observe the damage because the leaves will show the same distinct burnt aspect at the level where the application took place. This problem is very obvious in Ghana, and is inducing fungus attacks and rots in the MD2 plantings.

### Drainage

All waterlogged areas or poorly drained spots are identified by sectors, blocks, etc., placing marks for location and drainage installation.

### Ants

They carry the mealybugs inside the plantation, and when mealybugs are observed the ant sampling should be done to proceed with control if results indicate the need for it.

## 3. PLANT WEIGHT SAMPLING BEFORE FORCING

The objective of this sampling is to determine the optimum weight of the plant to initiate the application of the recommended treatment with Ethephon for forcing or floral induction. Depending on the correct timing of the treatment, the fruit quality will be uniform in size and weight.

### SAMPLING METHOD

In the plant crop the first sampling is done 6 months after planting, and afterwards the samplings are scheduled every 2 weeks until the average weight of the plant reaches 4.8 to 4.9 pounds (2.2 kg). After the plant has reached 4.9 pounds (2.2 kg) , the sampling continues on a weekly basis until the weight of the plant is 5.25 to 5.50 pounds (2.3 to 2.5 kg) in the plant crop, and 4.0 to 4.25 pounds (1.8 to 1.9 kg) in the ratoon crop.
For the ratoon crop, the sampling starts 4 months after harvest and is repeated every 2 weeks until the average weight of the plant reaches 3.25 to 3.50 pounds (1.5 to 1.6 kg). Afterwards the sampling is done every week.
The surveyors review the block where sampling will take place and select a line of plants 50 meters (166.6 feet) long which is most representative of the average growth condition of the plantation. A stake is placed in the middle of the sample area to identify the sampling site.
To obtain the average plant weight of the block, the surveyors have to follow two steps:

### STEP 1

#### Ranking plant weight

The weight distribution of the plant population is rated visually by two surveyors. Each of the surveyors samples 50 plants at 8 different sites inside the block (total of 400 plants), and proceeds to note and rank the plants according to the different weight scales indicated below. The ranking of plant by weight is different for plant crop and for ratoon crop.

| PLANT CROP WEIGHT | | | | | | | |
|---|---|---|---|---|---|---|---|
| RANK | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| WEIGHT | - 500 grams | 500 to 1,000 gr. | 1,000 to 1,500 gr. | 1,500 to 2,000 gr. | 2,000 to 2,500 gr. | 2,500 to 3,000 gr. | + 3,000 grams |

| RATOON CROP WEIGHT | | | | | | | |
|---|---|---|---|---|---|---|---|
| RANK | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| WEIGHT | - 400 grams | 400 to 800 gr. | 800 to 1,200 gr. | 1,200 to 1,600 gr. | 1,600 to 2,000 gr. | 2,000 to 2,400 gr. | + 2,400 grams |

**Note:** 1 gr = 0.035 oz

### STEP 2

#### Verifying the average plant weight

After the different plant sizes have been ranked and the percentage of each category has been calculated, the 5 highest ranked groups are separated and weighed to get the average plant weight in the plant crop case. To determine the average plant weight in the ratoon crop, all ranks over 5% are selected for weighing.
From each of the ranked sizes, 3 plants are segregated by the surveyors, and after removing the roots they are weighed by one surveyor while the other records the average plant weight of each plant per group and calculates the average weight of the sampled area. This serves as a test to evaluate the field inspectors' skills in their judgement of weights and sizes which they had previously done visually. If discrepancies are encountered between real weight and the sizes selected visually, the survey has to be repeated completely.

### REPORT

The report is submitted daily and should include all data to make the final decision on the date that forcing or floral induction treatment will be applied. The report will include:

- → Block number and location
- → Area per block
- → Crop age at sampling date, indicating days after planting for plant crop, and days after harvest for second crop
- → Planting material type used
- → Average plant weight
- → Average weekly growth rate

### POST-FORCING SAMPLING

The objective of this sampling is to evaluate the efficacy of the forcing treatment applied. If the results are less than those desired in terms of the percentage of plants that respond to the treatment, another Ethephon treatment has to be applied. Sometimes the application fails, due to poorly calibrated boom sprays, malfunctioning of nozzles, parts, rough topography, weather, etc.

### METHOD

The sampling is usually done 15 days after forcing date, but sometimes it is possible to start after 7 or 8 days. Several plants are picked and brought to the roadside. They are split along the stem to observe the development of the growing point or the meristem internally. The differentiation of the inflorescence is checked and the various stages of the floral induction initiation process are evaluated.

### SAMPLING

10 to 12 plants per acre (25 plants per hectare) are picked from the block sampled. The location of the plant site is chosen with 4 plants located at both ends of the block, 2 plants in the centre and 2 more along the axis in between the centre of the block and the boundaries. The beds selected for sampling are: 1, 9, 10, and 18.

The report on the sampling results for each of these beds will indicate the percentage of plants with negative response to the treatment with Ethephon or Calcium Carbahyde. If the result is less than 100%, another treatment must be applied. MD2 responds very well to the treatment and it is easy to obtain very efficient results.

## 4. SAMPLING FOR DEGREENING OR RIPENING

### METHOD

To get the best results in terms of quality, harvesting has to be done at the right time, and therefore the fruit translucence, Brix grade, colour, etc., should be at the optimum.

The timing for ripening or degreening should then be determined through sampling by well-trained and experienced surveyors. The procedure is as follows: start taking the sampling readings 130 to 140 days after the plant has been forced and repeat every 5 days. Increase the readings to every two days as the translucence increases, until the surveyors' reports show readings for translucence and Brix grade (in that order) which indicate that the application of the treatment can be initiated.

To proceed with the sampling, the surveyors will pick three (3) fruits that are representative of the highest amounts of the fruit in the block. They are collected from the border of the sampled block and their sizes are normally 5, 6, and 7. In the centre of the block, the number of fruits to pick for sampling is increased to five (5) and must be representative of the higher sizes too. The surveyors will initiate the evaluation on the roadside, grouping the fruit by sizes and colours, checking a slice of the fruit to evaluate the degree of translucence and collecting the juice to measure the Brix grade. The precise time to initiate ripening or degreening will be when the translucence reading, taken visually, is between 0.7 and 1.0, and the Brix grade in the fruit juice is not less than 14 units, measured with a calibrated refractometer.

When the fruit translucence readings reaches 0.7 to 1.0 units, immediately initiate the application of Ethephon for ripening, even if the Brix readings are not yet 14 grades regardless of the elapsed number of days after forcing.

The sampling will also evaluate other problems in the fruit that are caused by animal damage, diseases, high colour, low colour, oversized fruit, undersized fruit, etc. that will serve to anticipate any problem at the selection line and forecast shrinkage and the final production estimate for the block.

# XIII. Pest and disease control programme

The programme for control is indicated following the criteria explained in the previous chapter.

## A. REGULAR APPLICATIONS, DOSAGES AND PRODUCTS

These are preventive treatments applied to keep the plantation free of pests and diseases. Cycles are pre-programmed to be carried out on schedule according to the age of the crop, season, life cycle of the parasites, insects and fungus that attack the pineapple.
The programme for control of the most relevant pests and diseases that attack the MD2, is presented below:

**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. Maximum number of applications should be 3. Registration should be soon obtained in Kenya and West Africa.

| PLANT CROP PRE-FORCING CONTROL | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Weeds | Preplant | Bromacil<br>+ Ametryn<br>+ Spreader sticker | Bromacil 2,000 g<br>Ametryn 4,000 g<br>Spreader sticker 1.6 l<br>Water 1,900 l | Before planting<br>1-2 weeks |
| Nematods<br>Snails<br>*Phylofaga*<br>Symphilids | 1 month after planting | Ethoprophos | 0.15 g/plant | Circling around the plant |
| Ants | 2 months<br>4 months<br>6 months | Hydramethylnon<br>Hydramethylnon<br>Hydramethylnon | 0.73 g /meter Inside and outside plantation.<br>0.73 g /2 meters | Spread evenly on soil<br>Avoid mounds |
| Mealybugs | 3 months<br>5 months | Ethoprophos<br>Diazinon | Ethoprophos 3,630 g<br>Water 875 l<br>Diazinon 3,000 g<br>Speader sticker 14 l<br>Water 2.850 l | Rotate products, do not apply near housing areas |
| *Phytophthora* | 3.5 to 4 months<br><br>5.5 to 6 months<br><br>7.5 to 8 months | Fosethyl-AL<br><br>Fosethyl-Al<br><br>Fosethyl-Al<br>Metalaxyl-M | Fosethyl-AL 4,600 g<br>Water 2,100 l<br><br>Fosethyl-Al 4,600 g<br>Water 2,100 l<br><br>Fosethyl-Al 4,600 g<br>Metalaxyl-M 4,600 g<br>Water 2,100 l | Preventive treatment<br><br><br><br>Do only if infection is detected by sampling, add metalaxyl-M |

**Note:** 1 gr = 0.035 oz
1 kg = 2.20 pound
1 litre = 0.26 gallon

| PLANT CROP AFTER FORCING CONTROL | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Rodents | 1 month after forcing | Flocumafen | | All fields forced plus boundaries |
| Thecla | 43 days a.f. (*) | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 l | This is not necessary in Ghana<br>(For reference only) |
| Thecla | 53 days a.f. (*) | Diazinon | Diazinon 2,250 g<br>Water 1,900 l | |
| Thecla | 63 days a.f. (*) | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 l | |
| Thecla | 73 days a.f. (*) | Diazinon | Diazinon 2,250 g<br>Water 1,900 l | |
| Thecla | 83 days a.f. (*)<br>* Alter forcing | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 l | |
| Mealybugs | before degreening | Diazinon | Diazinon 3.000 g<br>Spreeder sticker 14 l<br>Water 1.900 l | One week before degreening |

**Note:** 1 gr = 0.035 oz
1 kg = 2.20 pound
1 litre = 0.26 gallon

| RATOON CROP BEFORE FORCING | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Mealybugs | 2 months a.h. * | Ethoprophos | Ethoprophos 3,630 g<br>Water 3,325 l | |
| Mealybugs | 4 months a.h. * | Diazinon | Diazinon 3,000 g<br>Spreeder sticker 12.55 l<br>Water 2,850 l | Use around housing areas |
| Mealybugs | 5.5 months a.h.* | Ethoprophos | Ethoprophos 3,630 g<br>Water 3,325 l | Only for delayed growth |
| Ants | 50 days a.h. *<br>* after harvest | Hydramethylnon | As required | Outside planted field<br>Avoid mounds |

**Note:** 1 gr = 0.035 oz
1 kg = 2.20 pound
1 litre = 0.26 gallon

| RATOON CROP AFTER FORCING | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Rodents | 1 month after forcing | Flocumafen | | All fields forced plus boundaries |
| Thecla | 43 days a.f. (*) | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 l | This is not necessary in Ghana<br>(For reference only) |
| Thecla | 53 days a.f. (*) | Diazinon | Diazinon 2,250 g<br>Water 1,900 l | |
| Thecla | 63 days a.f. (*) | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 l | |
| Thecla | 73 days a.f. (*) | Diazinon | Diazinon 2,250 g<br>Water 1,900 l | |
| Thecla | 83 days a.f. (*)<br>* Alter forcing | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 l | |

**Note:** 1 gr = 0.035 oz 1 kg = 2.20 pound 1 litre = 0.26 gallon

| RATOON CROP BEFORE DEGREENING | | | |
|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA |
| Mealybugs | 4 to 7 days before degreening | Diazinon | Diazinon 3,000 g<br>Spreeder sticker 14 l<br>Water 1,900 l |

**Note:** 1 gr = 0.035 oz 1 kg = 2.20 pound 1 litre = 0.26 gallon

| PEST AND DISEASE CONTROL ON SEED BED AFTER CHOPPING<br>PLANT PRODUCTION | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Ants | 3 months a.ch.* | Hydramethylnon | 0.73 gram / meter | 0.73 gram outside plantation |
| Ants | 5 months a.ch.* | Hydramethylnon | 0.73 gram / 2 meters | 1.46 grams inside plantation |
| Mealybugs | 3 months a.ch.* | Ethoprophos | Ethoprophos 3,630 g<br>Water 3,325 l | Can use Diazinon |
| Mealybugs | 3 months a.ch.* | Diazinon | Diazinon 3,000 g<br>Spreeder sticker 12.5 l<br>Water 2,850 l | Can use Mocap |
| Mealybugs | 5 months a.ch.* | | Same | |
| Mealybugs | 7 months a.ch.* | | Same | |
| Phytophthora | 3 months a.ch.* | Fosethyl-Al | Fosethyl-Al 4,560 g<br>Water 1,900 l | If infection is detected add Ridomil<br>at 16 kg to the Aliete mix |
| Phytophthora | 5 months a.ch.* | Fosethyl-Al | Fosethyl-Al 4,560 g<br>Water 1,900 l | |
| Phytophthora | 7 months a.ch.*<br>*after chopping | Fosethyl-Al | Fosethyl-Al 4,560 g<br>Water 1,900 l | |

**Note:** 1 gr = 0.035 oz 1 kg = 2.20 pound 1 litre = 0.26 gallon

## B. SPOT TREATMENT (BASED ON SAMPLING)

### SPOT TREATMENT

Some of the chemicals used for treatment can control several pests and diseases at the same time. These products can prevent outbreaks of pests and diseases, but when sampling detects diseased plants or areas, the treatments are applied only to the spot and surroundings as a shock treatment to stop the infection as fast as possible.

| 1. SPOT TREATMENT | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Weeds | 1-5 months after planting up to induction | Bromacil | Bromacil 1,600 to 2,000 g<br>Water 3,800 l | Depending on density of weeds and species |
| Snails | 2 to 4 months after planting | Ethoprophos | 0.1 gram per plant | Depending on sampling conducted farm 1.5 to 3.5 months. Days after planting |
| Mealybugs | 6.5 M.A.P | Ethoprophos | Ethoprophos 3,630 g<br>Water 3,250 l | Only affected lots and nearby planted lots sample at 6 months |
| Mealybugs | 6.5 M.A.P | Diazinon | Diazinon 3,000 g<br>Spreeder sticker 14 l<br>Water 2,850 l | do |
| Mealybugs | 8.5 M.A.P | | same | do |
| Mealybugs | 10 M.A.P | | same | do |

**Note:** 1 gr = 0.035 oz 1 kg = 2.20 pound 1 litre = 0.26 gallon

| 2. POST FORCING PLANT CROP | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Rodents | 80 days after forcing | Flocumafen | As needed | Sample all fields 70 days after forcing. Apply all boundaries |
| Thecla | 91 days after forcing | Diazinon | Diazinon 2,250 g<br>Water 1,900 l | |
| Thecla | 113 days a.f. | Carbaryl | Carbaryl 1,680 g<br>Water 1,425 g | |
| Thecla | 133 days a.f. | Diazinon | Diazinon 2,250 g<br>Water 1,900 l | |

**Note:** 1 gr = 0.035 oz 1 kg = 2.20 pound 1 litre = 0.26 gallon

| 3. AFTER FORCING RATOON CROP | | | | |
|---|---|---|---|---|
| CONTROL | AGE | ACTIVE SUBSTANCE | DOSAGE/HA | COMMENTS |
| Rodents | 2.5 to 3 months after forcing | Flocumafen | As needed | Sample 70 days after forcing<br>Apply affected plot as all around it and 1 of 3 internal |
| Thecla/Mealybug | 3 months after forcing | Carbaryl<br>Diazinon | Carbaryl 1,680 l<br>Water 1,400 l<br>Diazinon 2,250 g<br>Spreeder sticker 14 l<br>Water 1,900 l | Both products are mixed<br>If only Mealybugs use diazinon |
| Thecla/Mealybug | 115 days after forcing | Carbaryl | Carbaryl 1,800 g<br>Water 1,425 l | Same |
| Thecla/Mealybug | 135 days after forcing | Diazinon | Diazinon 2,250 g<br>Spreeder sticker 14 l<br>Water 1,900 l | Only Diazinon is allowed<br>because is nearing<br>harvest time |

**Note:** 1 gr = 0.035 oz  1 kg = 2.20 pound  1 litre = 0.26 gallon

# XIV. Pest and disease control based on sampling

In spite of the regular programme of control there is a need to sample regularly because the crop has to be protected at all times from sudden attacks that occur due to errors in the application of the products, wrong doses, poor calibration of equipment, weather conditions, etc.

The method for sampling has been described in the chapter on sampling, and the treatment for outbreaks, or hot spots areas, is described in the chapter on pests and diseases, under the SPOT TREATMENT heading chart.

# XV. Forcing or floral induction treatment

## A. PRODUCTS AND DOSAGES

The forcing process is one of the most important steps in pineapple production because it will artificially induce the plants to flower in a uniform manner and at once. There are several ways to treat the plants, using Ethylene gas or Ethephon, and in the case of GHANA, Calcium Carbide. The use of Ethylene is strongly recommended for MD2 because the results are much better in terms of uniform fruit size, shape, and quality in general.

Sampling is necessary to determine the exact time to initiate the forcing treatment. The pre-forcing sampling procedure to decide on the application of the treatment, and the post-forcing sampling to check on its effectiveness, are discussed in the chapter on sampling.

## B. USE OF ETHYLENE GAS

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

For large scale fields the application requires specially designed machines, which are basically the same spray boom equipment used regularly for fertiliser application, but modified in such a way so as to allow the charcoal mix with the water to be discharged at a pressure of 20 p.s.i. and the ethylene gas at 35 p.s.i. The pressure then has to be reduced from 1200 p.s.i. to 35 p.s.i. to avoid freezing, and then, the activated charcoal dissolved in water is pumped by the boom pump at 20 p.s.i. to facilitate the entrance of the gas into the solution, to be adsorbed by the charcoal and deposited on the plants, and then released evenly and slowly.

The recommended dosages are:

| | |
|---|---|
| Ethylene gas: | 2.47 kg (545 pounds) per Hectare |
| Activated charcoal: | 34 kg (75 pounds) per Hectare |
| Water: | 5100 litres (1,342 gallons) per Hectare |

A second application is made 2 to 3 days after the first one, and a third application is made only if the post-forcing sampling indicates the need for it.
A method for small producters 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 details in a technical sheet edited by PIP/COLEACP in 2007.

## C. USE OF ETHEPHON

| | |
|---|---|
| Ethephon : | 1.440 to 2.256 kg (3.17 to 4.98 pounds) per Hectare |
| Urea: | 98 kg (216 pounds) per Hectare |
| Calcium Carbonate: | 1 to 2 kg (2,2 to 4.4 pounds) per Hectare |
| Water: | 3800 litres (1000 gallon) per Hectare |

Calcium hydroxide can be used instead of carbonate, at the same rates.
The pH of the ethephon mix should be around 7 to 8.

## D. USE OF CALCIUM CARBIDE

Besides the ethylene gas effect on floral induction, other gases like the acetylene gas that is produced by the use of calcium carbide mixed with water, have the same effect on the plant, and can also be used for forcing.
Calcium carbide is widely used in GHANA and there are no other known experiences with MD2 elsewhere. However, it can be used as it is presently applied.
There are two known ways to force with calcium carbide:
1. Solid application. Apply at night hours till morning (8:00 PM to 6:00 AM) 0.5 grams/plant (0.018 oz) placed at the heart of the plant and repeat 5 days later. A third application may be necessary based on sampling. 2kg/200 litres (4.4 pounds/52.6 gallon) of water.
NOTE: If there is not enough moisture or if the dose is higher than recommended, severe burning can occur inducing *Phytophthora*.

2. Dissolve 1.5 to 2.0 kg (3.3 to 4.4 pounds) medium grade to gross grade in 180 litres of water, preferably cold water.
NOTE: This product is explosive if handled improperly. Extreme care must be exercised to avoid human hazard. Also avoid knapsacks made with copper, or other materials that can cause explosions.

# XVI. Colour and transluscence evaluation

## A. COLOUR GRADES

The fruit colour is classified according to a universal scale.

SHELL COLOR 0

SHELL COLOR 1

SHELL COLOR 2

SHELL COLOR 3

SHELL COLOR 4

SHELL COLOR 5

SHELL COLOR 6

Colour 0: Fruit is totally green. No traces of yellow colour.
Colour 1: Majority of the eyes have yellow colour in 20% of their area.
Colour 2: Majority of the eyes have yellow colour in 40% of their area.
Colour 3: All the eyes have yellow colour in 70% of their area.
Colour 4: All the eyes have yellow colour in 90 % of their area with some green colour.
Colour 5: All the eyes have 100% yellow colour with green colour traces around each fruitlet.
Colour 6: All the eyes have 100% yellow colour with no green colour at all.

## B. TRANSLUCENCE GRADES (SEE APPENDIX)

The translucence grades refer to the colour of the pulp and the amount of juice in the fruit tissue, and are related to the maturity process of the fruit which starts from the bottom and progresses upwards to the top of the fruit.

The translucence grade in MD2 is more important than the Brix grade in the decision to initiate the ripening or degreening process.

There are four grades for evaluation of the translucence and they are measured visually in the field by well-trained personnel following the sampling procedure established for this difficult task.

### GRADE 0

The pulp has a whitish or light colour, and when observed in the interior side of the transversal cut portion it is opaque with no translucence at all.

### GRADE 0.5

There is some degree of translucence on the border of each fruitlet starting from the distal to the basal area, but only less than half of the flesh inside the fruitlet shows translucence. About 50% of the fruitlets observed in the interior side of the sample have translucence.

### GRADE 1

Some degree of translucence as in grade 0.5 but the ratio between peel and peduncle is over 50%. Translucence is observed in all fruitlets of the sample.

### GRADE 2

Over 50% of the ratio between peel and peduncle is filled with translucence in each fruitlet. Some strains of translucence are observed between fruitlets and inside them, which reduces the whitish colour of the pulp.

### GRADE 3

Fruitlets are fully translucent and coupled with the strains their structure is hardly visible and is difficult to differentiate from the rest of the pulp.

### GRADES 4, 5 AND 6

When the sampling results are 4.5 and 6, the shelf life will be very short and therefore fruit will be rejected.

## C. BRIX GRADES

They indicate the soluble solids concentration in the fruit juices and are measured in grams of saccharose per 100 ml of extract using a refractometer. Samples are taken directly in the field at the same time the translucence is measured, to decide on the initiation of the degreening treatment, but never attempt to initiate the degreening treatment if the translucence reading is over 1, even if the Brix concentration is not yet 14. The fact that the translucence is always predominant over the Brix grade in the decision making for ripening treatment in the MD2 variety cannot be overlooked without affecting the quality of the fruit.

# XVII. Degreening treatment

## A. PRODUCTS AND DOSAGES

The purpose of ripening or degreening the fruit artificially with ethrel is to even up the colour to facilitate harvest. The sampling procedure to determine the right time to apply the treatment begins around 20 weeks after forcing and is discussed in the chapter on sampling.

## B. USE OF ETHEPHON

The application of ethrel is made with the use of a spray boom and the mixture preparation is simple. The MD2 variety responds very easily to the treatment and the dose to use is half of the dose used for ripening Cayenne.
The recommended mixture and application for DEGREENING is made for two treatments.

The first treatment is:

| | |
|---|---|
| Ethephon: | 240 g (8.46 oz) per Hectare |
| Phosphoric acid: | 7.0 litres (1.8 gallon) per Hectare |
| Water: | 1900 litres (500 gallon) per Hectare |

The pH of the mix must be 2 to 3.

The second treatment is applied 3 to 4 days after the first one using:

| | |
|---|---|
| Ethephon: | 360 g (12.69 oz) per Hectare |
| Phosphoric acid | 7.0 litres (1.8 gallon) per Hectare |
| Water: | 1900 litres (500 gallon) per Hectare |

The pH of the mix must be 2 to 3.

Sampling is made to programme the harvest which usually starts 3 to 4 days after the treatment when the fruit has reached Colour One. Generally, the harvest starts at the borders along roadsides and where the fruit is bigger.

## C. TYING (TO PREVENT TOPPLING)

Around 120 days after forcing, the plants along the borders, roadsides, and main drains are tied together to avoid sunburn damage and toppling which occurs due to excess sunlight. These fruits along the roadsides fall and tip off because they do not have any support, and grow faster than the ones located further inside. The procedure is to tie several lines of ropes to the end row of the bed along the roads and borders to avoid toppling. In many instances the leaves are also tied over the fruit to avoid sunburn.

# XVIII. Harvesting operation

The harvesting operation is the end result of all agricultural practices implemented during the crop cycle of the plantation. The end product or the pineapple fruit will be best if the proper steps have been followed. These steps are:
Planting material quality:

- → Certified MD2 variety
- → Excellent planting material treatment
- → Plant density adjusted to market demands
- → Specific fertiliser programme
- → Integrated pest and disease management programme
- → Good agricultural practices

The importance of good harvesting practices cannot be over emphasised.
It is the final step in the growing period of the fruit and it is the first time that the fruit will be handled individually across the fields. The handling of the fruit should be made with extreme care because the MD2 variety is highly susceptible to BRUISING and cannot withstand rough handling, and should therefore be carried gently. In each step of the post harvest process, the fragility of the MD2 fruit and the problems in quality that can arise from poor handling should be kept in mind.

## USE OF MACHINERY

Harvesting is done regularly with special machines to minimise bruises. The harvesting machine moves by itself but has to be pulled by a tractor of 70 to 80 HP with a cart attached to it to collect the fruit in the bins.

There are different designs; one is made with three conveyor belts that collect the fruit directly from the harvester who picks the fruit by hand from the plant. The fruit is then transported by the belt to another conveyor that lifts the fruit towards the loading area. Fruit is selected and transferred to the cart or truck and loaded by hand into the cart in an upside down position, with the crown supporting the rest of the fruit, arranged in such a manner so as to avoid bruising. Some recent modifications include a harvesting machine with one single conveyor belt that works on one side of the block while the trucks with the bins collect the fruit on the opposite side.

After the fruit is placed gently and the bins are fully loaded, the hauling of the fruit to the packing station begins by transporting the bins. The roads should be kept in good condition to avoid bruising. Good road maintenance is therefore very important to ensure the good quality demanded by the market. The fruit must be delivered to the packing station as soon as possible without rushing, and not more than 6 to 8 hours before the cooling process begins.

Good internal and external roads are of utmost importance. In spite of the mechanisation, manual harvesting can be done in small areas as is the tradition in Ghana, if the concept of quality for MD2 is understood fully by the farmer and labourers, if training is provided and if all the rest of operations are mechanised.

Harvesting operation

# XIX. Post harvest handling guideline

## A. PROCESSING AT THE PACKING HOUSE

After harvest, the fruit must be carried to the packing house very slowly to ensure that no bruising will occur. Once the fruit reaches the packing house, it has to go through different stages of handling that should be well monitored and recorded to ensure the traceability of fruits intended for display on market shelves.

### RECORDS

It is necessary to keep track of each step in the operation, the productivity of each block, the quality of the fruit recovery and shrinkage. The records to keep are:

#### 1. Harvested area: block, section or lot

The traceability process starts at this point and all of the data regarding the origin of the fruit is collected from records indicating the type and kind of planting material, and treatments to the planting material, plants and fruit up to harvest time.

#### 2. Date and time of harvest

The fruit is processed according to the number of hours after harvesting to ensure that the cooling process will start with the earliest harvested fruit. The quality control starts by sampling 2% of the fruit in each bin upon arrival at the packing plant to evaluate damages caused by harvest or transport, and the internal condition of the fruit.

## B. FRUIT HANDLING AT THE FLOTATION TANKS AND PACKAGING

The fruit should always be packed and refrigerated as fast as the facilities permit, ideally within 6 to 8 hours but never over a maximum of 18 hours after harvesting.

In the most advanced and modern designs for packing house, the bins loaded with fruit from the fields are unloaded mechanically with lifters and placed directly into flotation tanks filled with chlorinated water at 100 ml/100 l concentration. The overripe fruit known as sinkers will separate by itself, facilitating handling and sorting. The chlorinated water will avoid contamination of diseases from infected ones and will remove some dirt, but will not wash soil and other residues off totally, or remove mealybug traces on the fruit. This pest is widespread in Ghana and must be considered very damaging if not properly controlled at the packing plant.

The water tanks have water pumps that push the fruit onto a conveyor belt that carries the fruit towards the selection line. In the process the fruit temperature goes down and nobody touches the fruit by hand ensuring the quality.

There are other means that can be used in small plantings without facilities such as those found in Ghana. The procedure could be done by hand with extreme care to avoid damage to the fruit, and must start with the manual unloading of the fruit from the trailers, selecting and dipping the sorted fruit into a wax solution mixed with fungicide, followed by packing.

This variation in the handling of the fruit does not require big investments and eliminates the use of water.

## C. FRUIT SELECTION

Once inside the packing house the fruit selection process is initiated according to the quality standards required by the market, which are generally taking into account all defects in the fruit, bruising damages and colour grade.

The criteria for the selection of the fruit and reasons for rejecting are described separately.

Fruit selection

## D. WAXING PROCESS

The respiration of the fruit after harvest continues and the rate increases as the temperature rises, and goes down if the temperature is reduced. The shelf life increases when the respiration rate is low, therefore temperatures must be kept at a low level. The addition of waxes to further reduce the respiration rate and keep the fruit fresh is also necessary.
Wax is added to the fruit after the selection process to ensure that the internal and external quality is preserved and will reach the customer at the supermarket in the same condition as it was at packing time. In mechanised packing plants, the fruit is drenched automatically with the mixture of waxes when it is transported by a conveyor belt towards the packing area.
In the case of small operations and lack of facilities as in Ghana, this treatment can be done by dipping.

The recommended products and dosages are:

| | |
|---|---|
| WAX : see the local recommandation | |
| TRIADIMEFON | 0.142 kg (0.31 pound) |
| WATER | 190 litres (50 gallon) |

The mixture should be reinforced as it is used, and after 3 hours of use the mixture has to be replaced completely for best results. Some markets and dealers, mostly in the USA, request an insecticide application directed to the crown that cannot be mixed with the wax solution.

### DRYING

While the fruit is transported on the conveyor belt, it is subjected to a drying process which basically has the effect of fans blowing air onto the fruit along the line.

### TAGGING

The next step is to tag the fruit with the respective company seal.

## E. PACKAGING, WEIGHTING AND TAGGING

After the fruit has been selected and screened, the following step is to separate the pieces by size. Extreme care must be exercised by a labour force well trained and experienced in the operation to avoid mistakes in weight, amount of fruit per box, sizes and packing pattern.
Packagers should always be able to keep the correct weight per box.
Boxes should not be overweight or underweight.
The colour code should be the same for all fruit in each box and never mixed. Fruit size should be uniform for each unit in every box and never mixed. All work is done manually and includes the tagging of each fruit.

## F. BOX SIZE

Most international markets demand 12kg gross weight per box especially for MD2. The traditional weight of 40 pounds per box is avoided for MD2 packaging due to the susceptibility of the variety to bruising, as mentioned above. It is normally required that the first four lines in the pallet be reinforced in every corner, and sometimes an extra divider is also used in between lines to maintain the rigid structure of the load and to avoid bruising.

## COOLING PROCESS

As indicated previously, the temperature must be controlled to maintain the longest possible shelf life of the fruit on supermarket shelves. The fruit is very susceptible to temperature changes and the respiration rate is influenced by an increase or decrease in temperature. Low temperatures help to maintain the respiration rate at a minimum, increasing the shelf life and preserving the fruit quality.

After the harvest, the fruit should be placed inside the cooling chamber in the shortest period of time. An average of 6 to 8 hours after harvest is most desirable to attain the best quality.

The fruit is warm when it comes from the field and could be pre- cooled in the water tanks located at the entrance of the packing plant.

After the fruit pallets are assembled, they are placed inside the cooling room as soon as possible in order to preserve the quality and ensure the customer that the good flavour, colour, aroma and appearance selected at the packing house will not change. The recommended cooling temperature for the fruit must be from 7 to 8 degrees Celsius or 45 degrees Fahrenheit. The time required to reach the desired temperature will depend on the kind of cooling system used, but in most cases will take at least 24 hours for best results. When the farm does not have facilities or lacks electricity, the cooling can be done using refrigerated containers.
After the fruit is cooled down at the pack house, it is placed in refrigerated containers which transport the fruit to the port where the fruit continues to be refrigerated until it is finally loaded onto the ship where it is also refrigerated for transport to the market display.

## SANITATION AT THE PACKING HOUSE

The fruit is produced for human consumption and the packing area should be kept clean and disinfected at all times. The floors, store rooms, cold room, conveyor belts, tanks, toilets, etc. should be washed with chlorinated water in a 1.5 % solution. Disinfecting is also needed to keep the area free from diseases. Wood is not recommended for structures and floors because it retains humidity, which favours the development of fungal diseases. Steel, iron and cement buildings and structures are therefore preferred.
Furthermore, all requirements of EU- regulations must be implemented in each step of the operation.

# XX. Quality and quality control

Quality is the summary of good agricultural practices conducted according to the market demands and regulations. If they are properly planned and managed, the result will be good productivity with good quality. Two aspects are considered in the concept of quality: the preventive quality and the subjective quality.

PREVENTIVE QUALITY involves all the production process from planting to harvest, and starts with land preparation, planting material selection, etc..

All agricultural practices should be on schedule and well managed in order to achieve the goal to produce high- quality fruit.

SUBJECTIVE QUALITY has to do with the evaluation and appearance of the end product in the box ready for export, which takes the uniformity of colour, sizes, number of units and the condition of the box itself into consideration.

The defects in the fruit are evaluated in the packing station and the degree of damage will dictate if it is accepted or rejected for packing.

# XXI. Fruit defects

Two different kinds of fruit defects are evaluated: the external and internal damages. The external damages are those that affect the quality and appearance of the fruit and can be visually detected and evaluated.

The internal damages are the defects that cannot be observed from the outside so that the fruit has to be sampled, opened and checked inside toe-valuate and determine the extent and origin of the damage to the pulp.

## A. ORIGIN OF DEFECTS

The causes of defects are of different origins and can be classified as follows:

### ENVIRONMENT

Weather, rain, sunlight, dust, etc. affect the fruit skin and flesh, as is the case, for example, with sunburn.

### GENETIC

The damage which results from mutations, poor planting material selection, unknown genetic parent material etc., i.e. cripple, abnormal crowns, neck. Animals Damage caused by any animal feeding on any part of the fruit, such as with rodents, borers, Thecla, etc.

Crop damage The result of poor agricultural practices such as burning due to herbicides and fertilisers.

Handling Damage caused by rough handling of the fruit at any stage of the production cycle, i.e. bruising, dirt, etc.
Diseases Bacterial and fungal attacks cause rotting of the inside and outside of the fruit, totally damaging the fruit's appearance and flavour.

### MECHANICAL

Any damage from machinery used in the production process for cultivation, causing wounds and bruises in the peel and pulp of the fruit.

## B. DESCRIPTION OF DEFECTS

### MEALYBUGS

The damage caused by *Pseudococcidae* can be eliminated at the selection line by washing all residues and stains left by insects with brushes. The work is all done by hand before the waxing process, involving a lot of labour.
There is zero tolerance for this damage.

### CROWN DAMAGE

Any bruising and friction of the fruit during harvest, transport, and contact with other fruits, conveyor belts etc. can severely damage the crown.
Tolerance of damage in the crown ranges from 15 to 25 % of the area affected depending on customer acceptance. Evaluation is visual. MD2 fruit crowns are highly susceptible to this damage.

### MULTIPLE CROWNS

Fruits with more than one crown are evaluated visually and rejected.

### TILTED CROWNS

Phototropism causes bending or tilted crowns in the fruit. The problem is more evident in second crop plantations. Crowns with an inclination angle of more than 30 degrees are discarded. The evaluation is visual.

### SPINY CROWNS

This is a genetic defect and is the result of poor selection of the planting material. In Ghana this problem is relevant with in vitro plants, and material with this characteristic should be eliminated when evaluated visually.

### ABNORMAL CROWN SIZE

Large or small crowns that appear in some fruit due to nutritional problems, shade, and physiological problems, are measured and sorted out. The correct crown size should not be over 1.5 times the size of the fruit, or less than 0.5 times. All fruit below or over that size is rejected, or a special job known as pull crown is applied by removing the central part of the crown to meet the standard size. However, it is better not to use this system for MD2.

### ROSETTE CROWNS

This is caused by a nutritional disorder that produces stunted small crowns, sometimes with several of them growing together. If the size of the crown is below 0.5 times the fruit size, the fruit is discarded. The evaluation is visual.

### CRIPPLED FRUIT

A physiological disorder that produces a cleavage on the side of the fruit resembling a split peel. It is evaluated visually.

### BOTTLE NECK

A growth malformation around the base of the junction between the fruit and the crown. It is evaluated visually and there are several criteria for acceptance depending on the market.

### BOTTLE SHAPE

This originates from the use of Ethephon when forcing.

## C. INSECT AND DISEASE DAMAGES TO THE FRUIT

### THECLA

One of the most feared attacks on the fruit in the pineapple industry is the one caused by Thecla (*Strymon basilides*). At present we could not detect any presence of the insect in GHANA, but it is included in this paper due to the importance it has in production and quality elsewhere. The insect larvae feed on the fruit at a very early stage of growth forming gulls and caves inside the pulp and deformities in the skin, which can be observed from the outside as exudates or gummosis. All fruit has to be evaluated closely and rejected if any presence of damage is observed.

### BORERS

Mainly caused by *Metamasius* sp. which feeds on the base of the fruit, producing brown spots. The wounds will produce exudates or gummosis as in the case of Thecla and is easily observed. All damaged fruit is rejected.

### RODENTS

They feed on the young fruit causing severe wounds, scarring and perforations that will eventually be rejected at the packing station by the quality control inspectors due to the poor appearance. Evaluation is visual.

### SUNBURN

The exposure of the fruit to excessive sunlight will eventually burn the peel.

Fruit alongside roads and drains are the most affected. Toppling and missing plants are the cause for sunburnt fruit inside the plantation. At first the peel turns yellowish, but as the damage increases, the colour changes to dark brown and cracks are formed on the borders of the fruitlets, with eyes affected. Depending on customer acceptance, up to a maximum of 3 fruit eyes damaged with sunburn can be tolerated and packed.

## D. FRUIT DAMAGE CAUSED BY DISEASES

Fruits can be seriously damaged internally and externally by attacks caused by bacteria such as *Thielaviospis* and fungus such as *Phytophthora*. Both diseases cause rotting and severe discolouration of peel and pulp. Post harvest treatment and cooling helps to prevent the spread of these diseases after packing and during transport.

### BRUISING

The extra care that MD2 requires in handling cannot be over emphasised.

The high susceptibility of this variety to bruising of the flesh could easily become the major problem with respect to quality and shrinkage. This weakness must be considered in every step of the operation in order to take corrective measures. There is some slight and medium tolerance of the severity of damage but to obtain the best quality, no bruising should be accepted.

### MALFORMED FRUIT

These are fruits with a conical and irregular shape unlike the well-defined MD2 square and rounded uniform shape. The regular square shape of MD2 can be affected by the floral induction treatment when Ethephon is used. The use of Ethylene gas is highly recommended to eliminate this problem but if not available then calcium carbide may be used, since the malformation damage is less than that caused by Ethephon. Most of the malformed fruit cannot be used for export and only very slight damage is accepted by some customers. The evaluation is visual.

### OVERWEIGHT AND UNDERWEIGHT FRUIT

Fruit weighing over 6.5 pounds and less than 2.5 pounds is seldom exported.

Sometimes small amounts of the underweight fruit are requested by the European markets. The evaluation is done by weighing the fruit.

## DIRTY FRUIT

Fruit with soil particles, oil, grease and any other residues is not accepted for packing and export and should be rejected. Normally this problem occurs during harvesting and transport operations because tractors and other machinery operators contaminate the fruit due to careless handling.

## CORKINESS

The fruitlet nipple engrosses and some bracts show some burning. In advanced stages the fruitlets in the middle of the fruit start to grow slowly, changing the regular shape of the fruit. Inside the fruit the eyes become corky and very irregular . In severe cases the peduncle of the fruit becomes hard and rigid. Evaluation is made visually.

## SHADED FRUIT

Because of the high plant population and the high plant stand, there is a reduction in sunlight inside the plantation. This causes a reduction in the colour of the peel that is abnormal and produces fruit with uneven colour.

The damage is external and is evaluated visually.

Damage covering up to 30% of the area of the fruit is accepted by some companies.

Basal spot This is caused by a high concentration of organic matter at the base of the fruit coming from dead floral parts and debris, as well as deposits left by some animals that feed on the fruit. A brownish colouring at the base of the fruit is produced, changing the natural healthy and even yellow colour of MD2.

Evaluation is made visually and acceptance depends on market demands.

## BROWN EYE FRUIT (NIPPLE)

A dark brownish colouring develops around the nipple of the fruitlet, and grows from the centre towards the border, resembling a dark stain.

This damage originates from the same weather conditions mentioned above and is external, damaging the appearance of the fruit.

Acceptance of the fruit for export depends on the market demand.

## OLD PEDUNCLE FRUIT

Fruit that is harvested before the regular harvesting cycle for any reason, shows hard dry peduncles that are sometimes mixed with mould, seriously affecting quality to the point that all the fruit is discarded. Evaluation is visual.

## SINKER FRUIT

Fruit that is harvested with very high translucence and a high Brix grade cannot float because they are very dense and sink to the bottom of the flotation tanks. Normally the sinker fruit has some degree of fermentation.

All fruit that sinks is rejected. In cases when the water tanks are not available, intense sampling is needed in order to detect this problem on time before packaging.

# XXII. EU regulation, Codex MRLs and registrations in ACP countries

| Active ingredient | EU regulation | | CODEX MRL | Registrations in ACP countries | | | | |
|---|---|---|---|---|---|---|---|---|
| | Regulation 1107/2009 | MRL | | Côte d'Ivoire | Ghana | Cameroun | Kenya | Tanzanie |
| Acetylene | Approved | 0.01* | / | | | | | |
| Ametryne | Not approved | 0.01* | / | X | | various crops | X | |
| Bromacil | Not approved | 0.01* | / | X | X | | X | various crops |
| Carbaryl | Not approved | 0.05** | / | | | various crops | | |
| Chloroflurenol | Not approved | 0.01* | / | | | | | |
| Chlorpyrifos-ethyl | Approved | 0.05** | / | X | X | various crops | X | various crops |
| Diazinon | Not approved | 0.3 | 0.1 | 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 | |
| Flocumafen | Not approved | 0.01* | / | | various crops | various crops | | |
| Fosetyl-al | Approved | 50 | / | X | X | various crops | X | various crops |
| Glyphosate | Approved | 0.1** | / | various crops | various crops | various crops | various crop | various crops |
| Hydramethylnon | Not approved | 0.01* | / | X | | | | |
| Mancozeb | Approved | 0.05** | / | various crops | X | various crops | various crops | various crops |
| Metalaxyl-m | Approved | 0.05** | / | | X | various crops | | |
| Spirotetramat | Pending | 0.1** | / | | | | | |
| Triadimefon | Not approved | 3 | 5 | X | | various crops | X | |
| Vegetal wax | / | / | / | | | | | |

Approved : active substance authorized in EU countries

Not approved active substance not authorized in EU countries but could be used in countries out of EU if the EU LMR is respected for the imported products in EU.

X means that it is a specific registration on pineapple

* = default value

** = LOQ value

/ = for these active substances 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.

# Appendix


Transluscense grades (see Page 47)

## 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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