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USAID AGRIFUTURO PROGRAM PRODUCTION GUIDE TO MD2-PINEAPPLES IN MOZAMBIQUE

January 2011
Prepared for Agrifuturo with the support of the U.S. Agency For International Development
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Contract No. EDH-I-00-05-00005-00
PROJECT CODE 16175, TASK CODE 1200

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1 INTRODUCTION

The pineapple originates from tropical South America and today is cultivated everywhere within the tropics. Cultivation may be found in some sub-tropical regions but yields are normally lower due to temperature. The pineapple plant is *xerophytic*, surviving many months of drought. Moisture from rain, mist and dew is collected by the leaves and absorbed mainly by roots which emerge from the stem. Pineapples seldom require less than 12 months from planting to harvest, being normally 18 to 24 months and longer if temperatures are cooler (sub tropics).

1.1 CLIMATE

Pineapples do best in a hot climate, particularly if day / night and seasonal temperatures do not fluctuate widely, remaining within a narrow range.

1.1.1 Temperatures

Optimum growing / production temperatures fall between 20°C and 30°C and temperatures below 20°C reduce growth and below 16°C may encourage flowering. Temperatures above 35°C will inhibit flowering.

Optimum mean average temperature - 24°C.

1.1.2 Radiation

Best yields are achieved by crops grown in full sunlight. High irradiance in combination with high temperatures may lead to sunburn. There is no day length requirement for pineapple growth, however the greater the variation in day length the greater the reduction in fruit weight.

1.1.3 Water

Pineapples are capable of growing successfully within a wide range: 600mm to 3200mm of rainfall per annum. Despite the capacity to survive drought, growth and yields are reduced, where water stress occurs. In areas of high rainfall it is essential that water logging is avoided.

Optimum: 1000 - 1500mm annual rainfall.

While the plant will recover from extended periods of drought without irrigation the period of plant growth will be extended and fruit weight will be reduced. Symptoms of drought develop slowly; early symptoms are; reduced growth and wilting of the older leaves. With severe drought, leaf colour changes from dark green to pale green, then pale yellow and finally red. At the later stages, leaf margins curl downward, leaves become limp and growth stops.

The effects of drought are reversible and when water becomes available normal growth will resume. Effects of drought will be brought on more rapidly in soils with low water holding capacity, or where roots have been damaged.

Figure 1: Water stress

Optimum average humidity 70-80%

It may be seen that weather conditions in the Nampula province fall comfortably within the ideal range for pineapple production. (See Annex. Table.

I)

1.2 SOILS

Pineapples are best suited to soils with a neutral to slightly acid range - pH 4.5 to 5.5.

The crop may be grown on a wide variety of soil types, ranging from clay to sand with each type bringing its own consideration. Ideal soils will have a high organic- matter content, with good water penetration and drainage. Water-logging is the main consideration when selecting suitable sites for pineapple production. High soil moisture or standing water will promote the growth of moulds such as *Phytophthora* and *Pythium*.

Figure 2: Example of a contour

The primary concern when selecting very sandy soils is water retention and erosion. The sandier the soil, the more consideration must be given to slope and conservation methods such as waterways and contours.

II. CULTIVATION PRACTICES

2.1 PROPAGATION

Pineapples are propagated vegetatively with planting material being gathered from various parts of the plant in the form of suckers, slips and crowns.

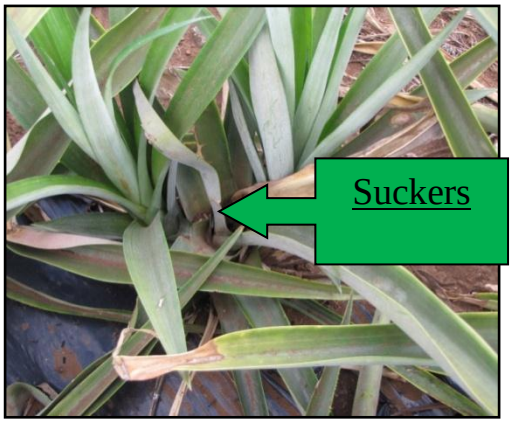

Figure 3: – base suckers

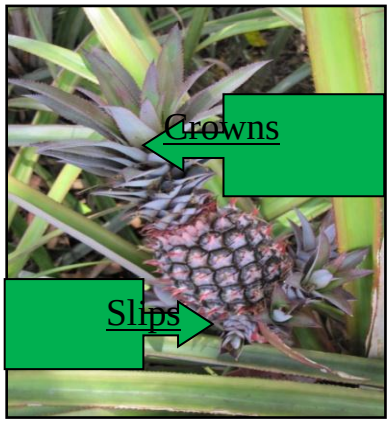

Figure 4: – crown & slips

There are various other methods such as meristem tissue culture; however this manual will concentrate on standard cultural practices when it comes to plant material.

2.2 PREPARATION OF PLANTING MATERIAL

In this section the preparation of crowns, suckers and slips in preparation for planting is covered.

Crowns Usually this form of planting material is lost when selling into the fresh fruit market. If available crowns should be broken off the fruit (not twisted) and place on top of the plants for two to three weeks for the moist base to harden and cure. This is to avoid rotting of the base, and easy access for disease after planting out. Prior to planting out, small dry leaves at the base of the crown should be removed so as not to hamper root development after planting.

Suckers There are two forms of suckers:

- Ground suckers produced from ground level.
- Suckers produced further up the plant and above ground level. (hapas)

These are treated in the same manner as crowns with the exception that no leaves are removed prior to planting out.

Slips These are removed from around the top of the peduncle at the base of the fruit. They may often have small fruits attached to the base. These are to be removed with a sharp knife, without damaging the base of the slip. The curing process then remains the same as for crowns and suckers.

Prior to planting out, new planting material should be dipped in a chemical such as (Alachlor) if there is any possibility of the material harboring pests such as mealy bug. This is not essential; however plant material should be carefully inspected before relocating it to a new site.

Stumps may also be used if plant material is in short supply, however these are best used in a nursery situation were a number of small stem suckers will be produced. These suckers are grown out to a suitable size before removing and planting out.

Meristem tissue culture where plants are propagated in a laboratory is another way to produce large numbers of planting material quickly. This however has the disadvantage of being expensive and small plants have to be grown out in a nursery before planting out.

2.3 SITE SELECTION AND LAND LAYOUT.

When selecting a site and its layout the following point should be considered

.

- Water runoff and the possibilities of erosion and methods off control such as contours and waterways. This will depend on a number of factors such as: slope, soil type and climatic conditions (storm management).
- Good drainage, avoiding lands or areas that have poor drainage. (water-logging or standing water)
- Row orientation. The further North or south of the equator the more advisable it is to orientate rows north/ south. This allows for the even distribution of sunlight to all plants.
- Access for equipment. Equipment for harvesting and spraying is heavy therefore it is important that slope, soil type, obstacles and road access is taken into consideration.
- Security. (theft)

Site Selection Notes

2.4 LAND PREPARATION

The first thing to consider when it comes to planting pineapples is to understand that they are in place for up to five (5) years. Therefore any mistakes made at this point are very difficult, if not impossible; to rectify once the land is planted.

Cutting corners at this stage is false economy and something you will have to live with for a long time.

Each site will vary in its requirements; however the following points should be covered prior to starting.

- Measure lands and formulate a land layout, considering points set out in site selection.
- Soil should be of a fine loose tilth to facilitate planting and allow the soil to form firmly around the plant base without air pockets, which will result in poor root emergence and rotting of the base.
- Any plough pans should be broken up by ripping.
- Soil analysis should be carried out at least (8) months prior to planting to allow any pH adjustment to be carried out at ploughing (6) months prior to planting.
- Testing for nematodes should be carried out on any soils which prone to nematodes.
- It is preferable to plant on beds, especially where standing water may be a problem on heavier soils. At this stage a pre-planting fertilizer application may be incorporated into the bed as well as a nematacide if required.
- Early land preparation will allow for the germination and destruction of weeds prior to planting.

2.5 SOIL CONSERVATION

Great care should be taken in the layout and construction of contours and waterway should they be required.

2.6 MULCHING

Table 1: Advantages and disadvantages of natural versus synthetic mulches.

Natural Mulches	
Advantages	**Disadvantages**
Replacement of soil nutrients and bacteria and organic matter.	Will not inhibit weed growth and may reduce the effect of pre-germinating herbicides.
Moisture retention	White ants may prove to be a problem if no nematacide is applied prior to planting.
Stabilizing soil temperature	If natural mulches have to be brought in then these may prove difficult to acquire or logistically expensive with the large amounts required.
Synthetic Mulches	
Advantages	**Disadvantages**
Inhibits weed growth and reduces the need to apply expensive herbicides	May also prove an obstruction in the development of suckers, which get trapped beneath the plastic mulch.
Easy to locate, transport and apply.	Large initial financial outlay
Helps retain soil moisture	Slow down the free flow of oxygen to the root areas.
May be printed with guide to insure uniform spacing, resulting in more precise plant densities. (Plant populations)	May raise soil temperatures to an unacceptably high level in summer prior to the formation of the plant canopy.

2.7 PLANTING

Plant spacing

- Ridge centre to ridge centre 1,5 m (150cm)
- Spacing between rows 60cm (100mm)
- Plant spacing within the row 26cm (260mm)

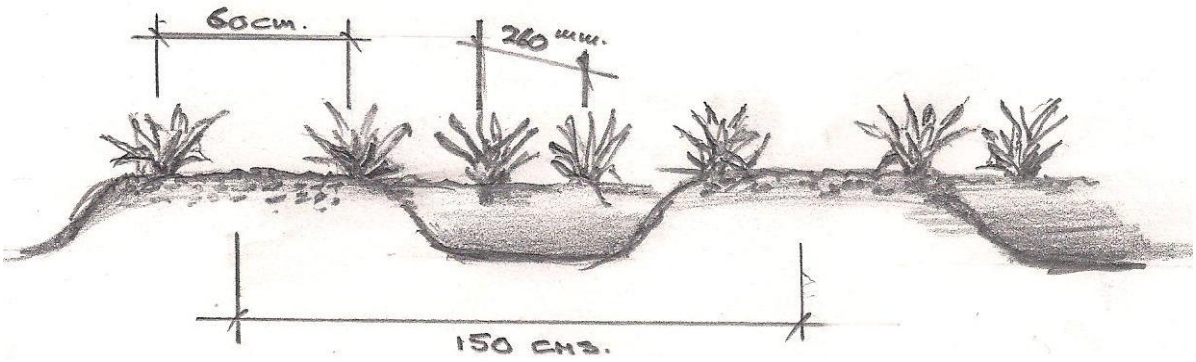

Figure 5 – Plant and ridge spacing

Good tilth and plant setting contribute to an early and uniform plant start. Placing planting material sufficiently deep into the soil is one of the most effective ways of assuring a good plat start. Ensure clean disease, pest free material with cured butts are planted into a well prepared soil. An important aspect of planting is obtaining a good contact between the planting material and the soil. Compress the soil around the base of the plant to remove any air pockets and form a good bond between plant and soil

Figure 6: Tractor drawn planter

Crowns

Sensitive to deep planting should not be planted deeper than half of their height.

Suckers and Slips

These should be graded before planting out. There is no need to remove basal leaves from suckers or slips provided soil is in close contact with the plant. Suckers may be planted to depths of 10-15 cm without adverse effect. Suckers should be left on the mother plant as long as possible, as the larger the sucker the shorter the period to harvest in the ratoon crop. Planting out may be done either by hand or with the aid of a planting machine which results in a more uniform plantation.

III. NUTRITION

Soil analysis is essential in determining the amount and type of fertilizer application required. Ideal standards for pre-plant soil nutrition status of Phosphate and Potassium are shown in Appendix 2.

3.1 POINTS TO CONSIDER

- The pineapple plant is ideally suited for foliar fertilization and most nutrients are readily taken up through the leaves or aerial roots found around the leaf axils.
- Pineapples have high nutrient requirements, in particular nitrogen and potassium, which have a direct effect on fruit size and quality.
- Nitrogen and potassium have a limited effect on plant growth for the first 4 months after planting.
- If nutrition is adequate at induction, additional fertilizer applications are not required during fruit development.
- Excessive potash will lead to increased fruit acidity.
- Excessive nitrogen will result in increased peduncle length, which will lead to increased fruit lodging and sun burn.
- The over application of nitrogen will as a result of leaching lead to the contamination of ground and surface water. Ultimately leading to environmental issues. (international standards and certification.)
- Phosphate and potash should be applied prior to planting and incorporated into the bed (ridge); Nitrogen should not be applied at this stage.
- Nitrogen requirements should be applied in equal amount as a top dressing from four months after planting until induction. Micronutrients may be applied at the same time. This is best achieved with the spraying of water soluble nutrients.
- Large quantities of residual nutrients are removed from the land in the form of propagation material such as crowns, slips, and suckers.

3.2 SYMPTOMS OF MAJOR MINERAL DEFICIENCIES

Nitrogen
Nitrogen is required by pineapples in greater amounts than any other nutrient, other than potassium. Leaf number, leaf and fruit size, and crown mass are all reduced with a shortage. Slips may be absent from those plants that normally produce them. Leaf colour is an important diagnostic indication in nitrogen deficiencies. Normally the older plant leaves should show yellowing as nitrogen in translocated to the new young leaves. However because of shading of the lower and older leaves by adjacent plants younger leaves will be the first to show signs of yellowing.

Potassium
Deficiencies will result in reduced photosynthesis and as with nitrogen; reduce plant and fruit size and the production of slips. The fruit will also have a paler colour, with reduced levels of sugar and acid. Reduced diameter of the peduncle will also result in the peduncle breaking or lodging and increased risk of sunburn and rotting. In the early stages leaves are dark green in colour with shorter leaves that are narrower in relation to their length. As the deficiency develops necrotic spots can be seen in the green photosynthetic tissue and leaf tips will die back.

Phosphorus
The entire plant is affected by any deficiency. However phosphorus requirements of pineapples are low and as phosphate doesn't move easily within the soil, plant requirements are best met with applications prior to planting. Symptoms of phosphate deficiencies may be easily confused with plants suffering with root damage as a result of nematode damage, water stress or mealybug wilt. Phosphorus-deficient plants have erect, long narrow leaves. Older leaves show chlorotic or red-yellow areas, which extend downwards along the leaf margins leaf-tip will eventually dieback young leaves appear to be dark green but with considerable red pigment. Most deficiencies of both macro and micronutrients should not be a limitation to crop production,

as they are easily correctable by folia application of soluble nutrients which are readily available commercially.

IV. PEST CONTROL

4.1 MEALY BUG

A small scale insect slightly pink in colour found around the base of the plant on the lateral roots, just below soil level or nestled into the axils of the outer leaves of the plant and on the developing fruit. The presence of ants is often the first indication of an infestation. Mealy bugs are dependent on ants for the removal of excess honey dew produced by the mealy bug and the protection they provide the mealy bug from predators and parasitoids. This symbiotic relationship is known as the "Ant/ mealy bug association"

Prevention is the best control of the spread of mealy bug, and careful inspection of planting material and dipping prior to moving material to site is critical. There are chemicals available for plant protection if required on established crops.

The most important aspect of mealy bug control is in controlling the ants. Keeping lands and verges clean and free of weeds and grass are essential in preventing the development of ant colonies. The use of bait stations in an IPM (Integrated Pest Management) approach increases the efficiency of insecticides and reduces the negative effect on the environment.

Other pests such as mites and borers are not a significant problem and are normally kept under control with the regular spraying program implemented for the control of mealy bug.

4.2 NEMATODE CONTROL

Three main species of nematodes are associated with and cause the most damage to pineapples. Light sandy soils with a slightly acid pH are more prone to nematode infestation and should be tested prior to planting. Nematode testing is done in commercial laboratories and should be carried out prior to land preparation.

Symptoms of ***root knot nematode*** are found on the root tips where club shaped gall are formed as a result of the infection of the root tip. This infection of the root tip, causes poor plant anchorage with the soil, inhibits root growth and results in stunted plant growth and water stress. As a result infected plants are easily pulled free from the soil.

In contrast the ***Root-lesion nematode*** is identified by a black lesion that progresses along the as the nematode moves during feeding. Secondary roots and root hairs are also destroyed in the process.

Reniform nematodes show the same symptoms as root knot nematodes, with the exception that they have good soil anchorage due to the lack of root tip galling. However secondary root growth is severely limited. Infected roots appear to have nodules, which are in fact fine soil particles attached to the female nematodes embedded in the roots. Infestation is mainly associated with ratoon crops.

Chemical control is possible with the application of chemicals incorporated at ridging. It is important when applying chemicals for the control of nematodes that the soil is of a fine tilth. Large clods will result in significant loss of soil fumigant and ineffective nematode control. Post plant application of nematacide may be applied as foliar sprays or through drip irrigation systems. Natural control may be implemented by sufficiently long fallow periods or good rotation practice and the planting of nematode resistant crops or lays such as Rhodes grass.

4.3 DISEASE CONTROL

4.3.1 Mealy Bug Wilt

Viral infection associated with the mealybug. Showing very similar symptoms to water stress and may easily be narrowed down by the presence of ants around the infected plant, closer inspect will reveal the presence of the mealybug in the lower leaf axis and attached to the plant roots just below the soil surface. Control is by removing weeds and grasses from the lands (thus eliminating the ant population with which the scale enjoys a symbiotic relationship and without cannot survive. Planting scale free material, regular scouting and pesticide sprays once the pest has been identified (IPM).Removal and destruction of all infected plant material.

4.3.2 Fungal Heart rots (Phytophthora cinnamomi)

Found under moist cool conditions on heavy wet high-pH soil. *cinnamoni* infections are limited to the stems and the white basal portions of the leaves. Infection is primarily through the roots and progressing up the root to the stem apex, causing the heart rot symptoms. Initial symptoms are the failure of the younger leaves to elongate. Later symptoms are yellowing to bronzing of the younger leaves, which may lean to one side of the plant. A slight pull on the young symptomatic leaves will easily remove them from the plant, confirming the presence of the disease. Phytophthora infections are limited to the stem and basal white portion of the leaves.

4.3.3 Bacterial heart rot

Characterized initially by water soaked lesions on the white basal portion of the leaves in the central whorl. The infection may spread to include the entire white basal portion of all the leaves of the central whorl. This may spread into the green mid-portion of the leaves, resulting in an olive green leaf colour and a bloated appearance. Fungal heart rots can be distinguished from bacterial heart rot by the absence of extension of the infection into the green areas of the leaf.

4.4 WEED CONTROL

Pineapples are slow growing and do not cover the ground sufficiently or quickly enough to suppress weeds and once established within the mature pineapple beds weeds are extremely difficult to remove. It is therefore essential that good weed control is established early through physical or chemical control. Mulching is also a very effective method of weed suppression, while having the added advantage of moisture retention.

4.4.1 Physical control

Physical control of weeds has to be done by hand and should be used in conjunction with chemical control as hand control alone will probably not be sufficient to achieve effective control of weed and grasses, particularly during periods of inclement weather. Grasses such as *Panicum maximum, Paspalum dilataum* and the sedge *Cyperus rotundus* common name (water grass or nut grass) are particularly difficult to manage especially when the fields are fully grown.

4.4.2 Chemical Control

The pineapple plant is quite tolerant of many good herbicides, particularly during the first few days after planting and before root initiation. Plastic mulch is another method of achieving weed control as discussed earlier. When applying Fertilizers or Chemicals it important to know the pH of the water and to add a "buffer agent" if pH balancing is required.

4.4.3 Physiological Damage

4.4.3.1 BLACK ROT (FRUIT)

A fungal disease associated primarily with fresh fruit sales and is as a result of fungal infection of the fruit as a result of physical damage, levels of inoculums on the fruit and storage temperature. Black rot will only occur in the field when the fruit is overripe. Black rot is characterized by a soft watery rot, which usually starts at the point of the fruit detachment from the peduncle. High moisture (rainfall) just prior to harvest is conducive to increased infection.

4.4.3.2 INTERNAL BROWNING (BLACK HEART)

The disorder is also of great importance in the marketing of fresh fruit when refrigeration is used to extend shelf life or the plants are grown under cool conditions and is characterised by a small greyish translucent zone, beginning at the base of the fruit, which later darkens becoming brown to black.

4.4.3.3 SUN BURN

Sun burn is associated with fruit development during periods of high temperature an irradiation. The problem is most severe when the fruit lodges or the peduncle breaks and the fruit is exposed to direct sunlight and not shaded by the crown or the longer leaves of neighbouring plants. Protection of the fruit from direct sunlight during periods of extreme irradiation is possible by various methods.

4.4.3.4 PHYSICAL DAMAGE

- This may take the form of bruising during harvesting and transport.
- Rodent or insect damage can occur to the fruit while still in the field.

4.4.4 Multiple crowns

Reduce the value of the fruit in both the fresh fruit and canning market. Environmental conditions that promote the multiple-crown disorder are high fertility and rapid growth at the time of inflorescence if this follows a period of prolonged drought. Increased incidence of multiple crowns is correlated with periods of high irradiance and high temperatures during early inflorescence. Increased plant density reduces the incidence of multiple crowns as a result of shading from neighbouring plants. The incidence of multiple crowns is therefore more likely on the outside rows of the field.

4.4.5 "D" Leaf (Identification)

The **"D"** leaf represents an easily identifiable standard leaf that is used to evaluate the plant nutritional state. (Leaf analysis)
These leaves are easily identified by clumping all the taller leaves together and selecting the longest (Tallest) leaf. This is the **"D"** leaf.

V. IRRIGATION

While most of the world's pineapple production is dry-land, long periods of inadequate rainfall seriously compromise both plant growth and fruit development. Plant stage, soil type, climatic conditions all have a direct effect on plant water requirements; however the application of between 25mm- 30mm per week should prove sufficient for optimum plant growth under normal conditions. Frequency of Irrigation scheduling will depend on the soil permeability and water holding capacity.

Table 2: Advantages and disadvantages of overhead versus drip irrigation

OVERHEAD IRRIGATION	
ADVANTAGES	**DISADVANTAGES**
Ease of Management	Excessive water usage.
Flexibility	Promotes weed growth.
Applies water over the whole plant	Wind effect on spray pattern

DRIP IRRIGATION	
ADVANTAGES	**DISADVANTAGES**
Precise placement of water and nutrients	High initial investment
Maximizing available water usage.	Lack of flexibility
Ease of application	High levels of management

With overhead irrigation it is important to assess the sprinkler application rate per hour at a known pressure and consider the following when assessing spray period (Hours) at each station.

- Relative humidity.
- Overhead conditions (Cloud cover)
- Wind speed.

These will affect evaporation and therefore the amount of water that actually becomes available to the plant. Adjust irrigation length to compensate.

DETAILS

Nozzle	Size	
Operating pressure	Bars	
Delivery rate (mm)	Per hour	

NOTES

VI INDUCTION AND FLOWERING

Fig.7 Smooth Cayenne

Fig.8 MD2

Induction

This is the reproductive phase of the pineapple plant and begins in response to natural or artificially induced induction, through the application of plant growth regulators. Once inflorescence begins the formation of new leaves cease and fruit development continues uninterrupted until the fruit reaches full maturity. The period from induction to maturity will vary according to temperature and variety and must be determined region by region for each variety.

Natural Induction

Pineapples need to attain a minimum weight before natural induction of inflorescence development can occur. This weight is not precisely known and will vary between varieties, however of importance is the fact that this weight will increase in warmer climates. Natural induction may be induced by various factors once the critical weight is attained and is promoted by slow plant growth. Cold weather and smoke from bush fires being the primary causes. In contrast inhibition of natural induction is associated with vigorous plant growth. (High night temperatures and excessive nitrogen)

Forced induction

Pineapple inflorescence development may be artificially induced with the application of ethylene or ethephon. This ability to influence inflorescence is commercially significant. Where the climate is favorable it is possible to produce fruit throughout the year allowing the producer to make efficient use of land and labor, while providing a steady supply of pineapples to the cannery or fresh fruit market.

To achieve optimum results and fruit size, plants should be uniform in size actively growing and have a plant weight of ±2.2 Kg's with no less than 25 leaves. Ethrel in liquid form is applied in a 0.1-0.2% spray solution. Urea is added to the spray solution at a rate of 2% to enhance the performance. Application should take place during the cooler parts of the day, preferably late afternoon.

Induction to fruit maturity will be ±5-6 months depending on variety, altitude, temperature and day length.

VII HARVESTING

Fruit size is set by plant weight at induction and this in turn will be affected by variety.
The" red centre" of the cayenne plant Fig. (7) Or in the case of MD2 the "white centre" Fig. (8) Occurs 40-70 days after induction. Fruit set from first to last flower takes between 20-30 days and the period of last flower to fully ripe fruit is between 90-110 days.
Fruit maturity is evaluated by the flatness of the fruit eye and shell yellowing, which begins at the base of the fruit and progresses upwards towards the crown. Consumers similarly judge fruit ripeness on colour and aroma.
Various factors determine the exact time of harvest; however these are primarily market related.

- Type of market
    - Canning
    - Fresh fruit market.
- Distance to market and shelf life. (logistics and refrigeration)

Harvesting is very labor intensive and may be done manually with baskets, where fruit is transported to trailers by the harvester or by mechanical means with the use of conveyor booms.

The later method has the following advantages;

- Initial fruit sizing may be carried out.
- Harvesting time is reduced as more time is spent picking.
- Productivity is improved as the speed of harvesting is controlled.
- Labor fatigue is reduced.
- Fruit damage (bruising) is reduced.

As a guide the following base may be used :(full crop)

Hand picking into baskets: (tons per laborer per day.)

- Plant Crop – 2.2 tons.
- Ratoon crop – 1.6 tons

Hand picking onto Boom.

- Plant crop - 3.5 tons
- Ratoon crop - 2.5 tons

Boom harvesting will require a harvesting tractor and extra transport trailers, as fruit comes in faster. This does not increase transport costs but is brought about by harvest compression.

VIII POST HARVEST HANDLING

In tropical areas temperature management and cold chain is important due to the high field heat of freshly harvested fruit. If picked correctly and managed carefully half ripe Smooth Cayenne fruit can be held for about 10 days at 7.5 to-12.5°C and still have about a week of shelf life with no chilling induced internal browning. Thus the availability and type of cold storage and logistics determines the markets that are reachable from proposed Mozambican production areas.

8.1 POST HARVEST PHYSIOLOGY OF PINEAPPLES

8.1.1 Cooling and optimum temperature

Temperatures between 7.5-12°C have been recommended for storage, with relative humidity of 70-95%. Higher humidity significantly reduces water loss. Recommended temperatures are 10-13°C for partially ripe pineapples and 7-10°C for ripe pineapples. Chilling damage occurs both pre and post harvest at temperatures below 7°C.

8.1.2 Response to ethylene

Response to ethylene post harvest may result in slightly faster de-greening (loss of chlorophyll) possibly without influencing internal quality.

8.1.3 Physiological disorders

Chilling injury on pineapple is severe with internal browning of the fruit and can occur at temperatures below 7.5°C when internal browning will develop. Flesh translucency is also a chilling disorder and is seen if temperatures are low two to three months prior to harvest. Bruising can occur during harvest and handling, as pineapples are very sensitive to mechanical damage.

8.1.4 Pathological disorders

Black rot, soft rot, and water rot, occur when fruit is bruised and other wise mishandled during harvest and careless handling is a primary cause of black rot as it allows entry points for the fungus. Control is basically a matter of good farm management and pack house hygiene and careful handling. Yeasty fermentation can also occur as the fruit contains many organisms inside the flesh. Harvest at the correct stage of maturity. Reject all fruit with fresh skin injuries. Do not pack wet fruit and only use dry packing material.

8.1.5 Harvest maturity of pineapples

Pineapples are harvested at full maturity as there is no increase in sugar after being removed from the plant.

8.2 HARVESTING AND HANDLING

8.2.1 Picking management

Fruit should be harvested when physiologically mature. Great care in the harvesting, transport to pack house and packing out should be exercised in order to minimize damage and possible contamination with spoilage organisms. Fruit quality cannot be achieved by applying good post harvest management to poor fruit! Therefore it is important to implement all growing practices outlined in this manual. A summary of harvest and post harvest requirements for delivery in the best condition for processing is given in Table 3 at the end of this document.

Cool as quickly as possible after picking starting by placing fruit under a cover out of direct sunlight as quickly as possible. Ideally harvest in the early morning and take them to a cool, well-ventilated place as soon as possible. Instruct workers to harvest pineapples carefully to minimize fruit and plant damage.

8.2.2 Correct picking

Break the stem leaving a stalk about 2 cm inches long; do not twist free. The stems make it more difficult for rots to enter the fruit.

8.2.3 Farm transport to pack-house

Use a dedicated tractor and trailer rig that will collect fruit continuously and bring it into the pack-house within 1 hour of reaping. Sacking or shade cloth should be on the trailer to ensure that fruit is kept out of the sun.

Load promptly, keeping fruit under shade. Handle gently. Loading beds of vehicles must be cleaned daily. Containers used for transport to the pack-house must be clean, disinfected and free of sharp edges. Minimize transport in bad conditions or maintain roads prior to harvesting season. Cracked or bruised fruit may break in shipment or begin to decay. Rough handling also may damage the flesh.

8.2.4 Receiving and grading

Fruit is delivered to the raw material intake area and graded, and packed as rapidly as possible.
The pack-house should be cool and airy.

Once fruit is placed in lugs or cartons it should be placed in the dispatch cold store and cooled to the desired temperature.

Fruit must be graded and dispatched as soon as possible after harvesting. Workers must maintain personal hygiene at all times (uniforms, headpieces, regular washing of hands). Soil and organic matter must be removed from fruit. Plant debris and waste fruit must be removed from this area.

8.2.5 Transport from the pack-house

Cooled product should be loaded into a refrigerated truck pre-set and running at the correct temperature. Each delivery should be tagged with a continuous temperature recorder placed in a pallet/bin at the end of the sorting process.

8.2.6 Identification

All dispatched fruit must be clearly marked from picking onwards with the following information:

- Cultivar
- Grower name and number
- Picking date
- Grading date

8.2.7 Pack-house hygiene

- No waste fruit accumulation must be tolerated

- Brushes, graders, packing lines; cleaned daily
- Waste fruit; cleared from the site on a daily basis
- Bins or packaging materials used to deliver the fruit must be clean

8.2.8 Records to be kept at the pack-house

- Orchard spray records
- Basic meteorological records
- Harvesting data for each field (date and number of pick)

8.2.9 Summary of pineapple harvesting, handling and shipping protocols

A summary of the ideal treatment to be given to pineapples from point of harvest to arrival and customer receiving is given in Table 3.

Table 3: Summary protocol for handling, transport and arrival of pineapples from farm to market

ACTIVITY		**SPECIAL NOTES**	**TIME ALLOWED**	**T (°C)**
1. Harvest		Pineapples placed in lugs out of direct sunlight. Spray with water and/or kept in wet wall cold store		Field heat less 5-10°C
2. Transport to Pack-house		Move in lugs on a covered trailer	< 1H for activities 1+2	Field heat less 5-10°C
3. Pack-house	a. Receipt	Check and weigh in load in a covered ramp		Field heat less 5-10°C
	b. Holding	Move to covered store and stack lugs as per diagram	3a and 3b < 0.5 H	Field heat less 5-10°C
	d. Sorting	Handle carefully but ensure that fruit is not held for an excessive amount of time before going	3d < 0.5 H	Field heat less 5-10°C
	e. Cooling	Place 'HOBO' tag in a lug/bulk bin	Until dispatch.	12°C (10 – 13°C)
4. Dispatch and transport		Check that reefer unit is working and at the correct temperature (7.5-12°C)		12°C (10 – 13°C)
5. Receipt at market		Check that reefer unit is working and at the correct temperature (7.5-12°C) Proper palletising to ensure load does not fall over	3e to 5 not to exceed 22 hours	12°C (10 – 13°C)

APPENDIX I: RATOON CROP

A single sucker from the mother plant is left on the plant after harvest and developed much the same as the plant crop. Although the amount of fertilizer used may be reduced slightly Harvest of the ratoon crop will normally be within 12 months. Fruit will in most instances be slightly smaller than fruit produced by the mother plant this will result in a yield reduction of about 20%. Successful ratoon crops are dependent on a healthy root system and may prove to be a problem where nematode infestation is a problem (Particularly in the case of reniform nematodes.) A second ratoon while feasible will more than likely prove uneconomical.

It is important that local environmental conditions are used in conjunction with this guide and that careful accurate crop production records are kept and adjustments to production norms are carried out, until a specific standard suitable to the area is formulated.

APPENDIX II: CLIMATIC DATA FOR NAMPULA.

Table A2.1: Climatic data for Nampula including the calculated Penman equation for reference crop evapotranspiration

Weather data	Min Temp °C	Max Temp °C	Mean Average °C	Humidity %	Sun (hours)	ETo (mm / day)
January	21.4	31.6	26.5	79	6.2	4.62
February	21	31.5	26.25	80	6.5	4.57
March	20.7	31.5	26.1	80	6.4	4.32
April	20	31.5	25.75	77	7.7	4.39
May	16.7	30.6	23.65	73	7.8	4
June	16.6	29.5	23.05	73	7.3	3.58
July	16.1	28.8	22.45	71	7.6	3.81
August	16.6	28.6	22.6	71	8.2	4.25
September	17.9	29.2	23.55	71	9.2	4.9
October	19.5	29.9	24.7	70	10	5.53
November	21	30.8	25.9	69	9.4	5.8
December	21.5	31.3	26.4	73	7.7	5.22
Average	**19.1**	**30.4**	**24.75**	**74**	**7.8**	**4.5**

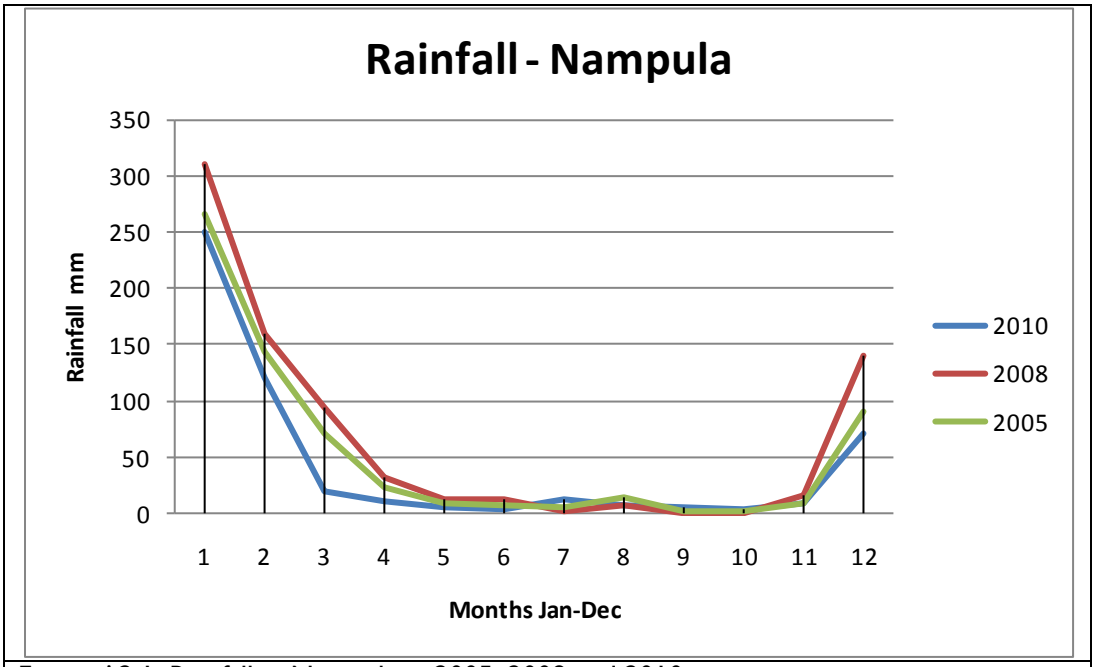

Figure A2.1: Rainfall in Nampula in 2005, 2008 and 2010.
Pineapples grown in this climate are in water deficit for 7 months of the year.

APPENDIX III: SOIL NUTRITION STANDARDS FOR PINEAPPLES

The pre-plant soils norms for pineapple are shown in Table A2.1. Analysis of samples should be complete 3-4 months prior to planting and in the case of ratoon crops - at first harvest

Table A2.1; pre planting soil norms for pineapple.

Key to Table	Ca (meq)	K (meq)	Mg (meq)	CEC	P (ppm)	pH
LOW	<5.5	<0.1	<0.2	05-15	NA	<5.5
MEDIUM	NA	0.1-0.3	0.2-0.5	15-25	<15	5.5 - 8.0
HIGH	NA	>0.3	>0.5	25-40	>15	>8.0

During growth (post planting leaf analysis is the most common method of correcting nutrient deficiencies. Plant part: Sample the most recently fully matured leaf of plants (known as the 'D leaf' during vegetative growth before flower initiation. Collect 20 leaves to represent a uniform area. The sample should be taken prior to a fertiliser application. Interpret the results based on the concentration ranges in Table A2.2.

Table A2.2: Concentration range for nutrients in pineapple leaves

Nutrient	Deficient	Marginal	Critical	Adequate	High
N(%)	1.40			1.5-2.5	
P(%)	<0.13	0.13-0.14		0.14-0.35	>0.35
K(%)	<2.8	2.9-4.2		4.3-6.4	>6.4
S(%)	<0.07			0.07-?	
Ca(%)	<0.04	0.05-0.21		0.22-0.40	>0.4
Mg(%)	<0.13	0.14-0.4		0.41-0.57	>0.57
Cu(mg/kg)				10-50	
Zn(mg/kg)				15-70	
Mn(mg/kg)				150-400	
Fe(mg/kg)				80-150	

For correction of deficiencies apply the amounts indicated in Table A2.3. The table shows the amount of nutrient (in elemental form) required to raise levels in the leaf.

Table A2.3: Amount of each element necessary to raise leaf levels by a given amount

Element	To raise leaf level by - (%)	amount of element (kg)
P	0.005	12 - 15
K	0.05	40 - 80
Ca	0.005	3
Mg	0.005	2 - 4

The fertilizers and the concentrations used for foliar applications to correct deficiencies in pineapples are shown in Table A2.4.

Table A2.4: Correction of micronutrient deficiency in pineapples

Nutrient	Application
Zn	Apply as ZnO or Zn SO_4 as 0.5 % solution in 2 000ℓ/ha
Cu	2 kg $CuSO_4$ + 2 kg slaked lime in 500 ℓ/ha
Fe	$FeSO_4$ 1% solution with citric acid (pH 5.6) in 2000 ℓ of water
B	Solubor at 2 kg in 500ℓ water/ha

APPENDIX IV: PLANT MULTIPLICATION METHODS

Multiplication methods may be divided into four methods

1. Natural propagation
2. apical Dominance
3. Sectional division
4. Vitro propagation (Tissue Culture)

1. Natural propagation

As discussed under "preparation of planting material" various vegetative materials can be used, the most common being crowns, slips, hapas and suckers. Many factors affect the production and timing of this material including climate, variety, and nutritional levels at inflorescence especially nitrogen. Natural propagation may prove to be insufficient for area multiplication or in the case of fresh fruit production, maintaining current plant populations, as crowns are lost with the sale of the fruit.

2. Apical dominance

Apical destruction (Mechanical) Known as gouging it will stimulate lateral bud production. This involves the physical removal of the apex of the growing plant. Young leaves are pulled out and the apex is destroyed to a depth of about 1 cm below the apical bud. Destroying the plants apical dominance will induce auxiliary buds to break from dormancy. Plants must be treated with a fungicide after gouging. Plants weighing between 50 and 100 g may be moved to propagation beds to be grown out, while plants weighing more than 200 g may be planted out as direct commercial planting.

Apical Stimulation (Chemical) with the application of Maintain CF125 (chlorfurenol) applied at the beginning of differentiation and within five days of forcing at a rate of up to 400 ppm in 3000 litres of water per hectare. This will stimulate the production of slips and crownlets known as propagules. This form of planting material may prove to be important in a fresh fruit market, where crowns are sold with the fruit and slips and suckers prove inadequate to provide sufficient replacement planting material.

3. Sectional division

Sectioning Any vegetative shoot of the pineapple plant can be sectioned for propagation material, as long as the sectioned pieces have at least two auxiliary buds and some leaf material. Large stems may have the leaves cut off, quartered and then cut into sections 3-5 cm in length with a small amount of leaf material still attached. These sections are cured and/ or treated with a fungicide. They are then planted into a fertile soil in a well prepared nursery. Crowns may also be divided in four or more sections. Small crown sections should be started in sterile medium and grown in well drained soils (sand) inside a greenhouse.

All plants produced from sections must be grown out to an adequate size for field planting, and hardened prior to planting if produced in a greenhouse or under shade.

4. In-vitro propagation

Done in a laboratory from plant tissue culture, this is the most rapid way of propagating large volumes of a specific planting material. The greatest draw-back being the expense.

APPENDIX V: MECHANICAL IMPLEMENTS PHOTOGRAPHS

There are many alternatives to every aspect of pineapple production and the following photographs are purely of interest to the grower when considering mechanization.

Mobile Dipping Tank used to soak plant material in an insecticide against mealy bug and other pests. The material is agitated within the drum before being picked up and deposited onto an elevator for transportation into a trailer. This particular trailer is fabricated with stainless steel to limit corrosion and rust and driven from the tractor PTO.

Single axle mesh trailer used for transporting planting material. Side opening panels facilitate the removal of planting material by labor which is spread along the beds in preparation for planting. Material may also be placed directly into planting machines Fig. 6 - Planting.

Bedding machine - Tractor drawn, Incorporating fertilizer boxes, fumigant tanks with cam pump and rear roller to flatten and shape beds the roller is also used to drive the fumigation pump. Double discs are used to help move soil towards the bed. Discs are on a hydraulic slide to adjust the position of the discs when operating on slopes.

Contour former "V" shaped tractor mounted. Adjustments are made via the tractor hydraulics or the centre semi circular pivot, clearly seen in the photograph.

Storage tanks of liquid fertilizer used for topdressing the growing crop. Urea is decanted into 20lt containers and carried on the spray rig. Enough containers are loaded for the days spraying. This provides an easily monitored method of applying the correct amount of fertilizer per spray tank.

Nursing tank used to carry water to the operating spray rig. Water is collected from any nearby source and transferred to the spray tank using either a donkey engine or PTO pump. Platform helps protect the tank and facilitate the storage of chemicals or fertilizers in transit. A rear cage and platform are used to transport support staff.

Spraying rig designed to haul a five thousand litre spray tank while operating a tractor mounted boom with counter weight and hydraulically operated height adjustment. The boom as with the harvester sprays nine rows in one direction. Requires a fairly well skilled operator to manage speed and control the boom especially if the roadways are uneven as a result of contour construction. P.T.O driven pump.

Harvesting boom showing the twin conveyors used in the initial sorting of fruit by size. Boom length will depend on land layout. This particular boom supports nine harvesters which covers eighteen rows. Two support staff and a driver are also required.

Harvesting tractor showing where the boom is attached. The fruit is deposited and moved by conveyor forward to the haulage trailer. The Boom is detached when moving from field to field. More efficient harvesting requires extra haulage trailers to avoid down time.

General Notes

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