MINISTRY OF AGRICULTURE,
FEDERATION OF MALAYA.

Agriculture Leaflet No. 36

THE PINEAPPLE IN MALAYA

Published by the Ministry of Agriculture,
Federation of Malaya, and
Obtainable from the Department of Agriculture,
Federation of Malaya,
Kuala Lumpur.

JANUARY, 1959.

THE PINEAPPLE IN MALAYA

(*Ananas comosus* Merr.)

Introduction

The Malayan pineapple industry was founded before the turn of the century. In the early days it was closely associated with the rubber industry, the pineapples being planted in the inter-rows of young rubber. Later it was planted as a sole crop on upland (quartzite) soils. The useful life of a pineapple plantation on these soils was five to six years, due partly to soil exhaustion but mainly to soil erosion. In 1938 a move began to transfer the cultivation of pineapple to the deep peat soils and, following its virtual destruction during the Japanese occupation of Malaya, the industry is now developing almost exclusively on these soils.

The greater part of the industry is now in West Johore where there are 12,000 acres of estates and 8,000 acres of smallholdings; in Selangor there is one estate and 3,200 acres of smallholdings and in Perak, one estate and 400 acres of smallholdings. At the end of 1956 the total area planted with pineapples in the Federation of Malaya was about 44,800 acres. Exports of canned pineapples and canned pineapple juice from the Federation and Singapore in 1956 were valued at $31,670,000. Nearly all the fruit processed by Singapore canneries was grown in the Federation.

Description of the Plant

The cultivated pineapple is a monocotyledon, a member of the family *Bromeliaceae*. This family also includes a number of epiphytes. In the genus *Ananas* there are three wild species, which are found in South America, but no wild ancestral form of the cultivated pineapple, *Ananas comosus* Merr., is known. The cultivated varieties are self-in-compatible and therefore usually seedless.

In the early stages of growth the pineapple grows vegetatively, producing leaves and building up a store of starch in the central axis. Later, by differentiation of the growing point, a large number of flowers are formed which in turn produce the individual berry-like fruitlets; these, together, compose the pineapple. On the death of the flowers, the peduncle which extends through the middle of the fruit (the "core") produces further vegetative growth on the top of the fruit; this growth is known as the "crown". As the fruit develops there is further vegetative growth of the mother plant, producing the materials by which the plant is further propagated. Four main types of this planting material (see Fig. 1) are available and they are described in the paragraphs which follow.

CROWNS

The crown is produced on the top of the developing fruit. A single crown is desirable but fasciated and multiple crowns are common. The crown is seldom used for propagation in Malaya as it is, by its very nature, limited in supply and it is also slow to come to maturity; it should not be planted mixed with other forms of propagating material. It is a widespread practice in Malaya to remove the crown when it is a few inches high. Crown slips, which develop beside the crown, are not common in Malaya.

BASAL SLIPS

Basal slips produced on the stem just below the fruit are the principal planting material for the Singapore Spanish and Selangor Green varieties. They are, however, seldom produced by the Sarawak and Mauritius varieties. The slips are collected soon after the harvest of the fruit; their subsequent treatment is described later.

AERIAL AND GROUND SUCKERS

It is the aerial suckers, produced in the axils of the leaves on the main stem, and the ground suckers from the base of the mother plant which produce the ratoon crop when left *in situ*. They can also be used as planting materials.

The stage of growth of the suckers at the time of harvest of the mother plant varies between varieties. Of the varieties in Malaya, suckers of Singapore Spanish are often well grown at the time of harvest, but with Sarawak, few—if any—suckers are present and these are small.

Pineapple Varieties in Malaya

The bulk of the pineapple crop in Malaya is canned and the canning industry uses almost exclusively the Singapore Spanish variety and its mutant, the Selangor Green. For the fresh fruit market two varieties are grown—the Sarawak and the Mauritius. *Ananas cochinchinensis* (Malay: '*Nanas Bunga*') is found in many kampongs, but it is an ornamental only (1).

SINGAPORE SPANISH VARIETY [SINGAPORE CANNING, SINGAPORE QUEEN AND RED JAMAICA (MALAY: *Nanas Merah*)]

The Singapore Spanish is the principal canning variety grown in Malaya. The mature plant is of medium size, carrying up to 50 leaves. In the healthy plant, these leaves are dark green and glabrous above, often with a reddish stripe along the edge, and are often glaucous beneath. The leaves carry very few spines; if present the spines are usually found near the distal end. At harvest time the mother plant may have two or three ground suckers and two or three aerial suckers. Fasciated and multiple crowns are common, although single crowns are more desirable.

The fruit usually weighs from 2 to 4 lb. and is a satisfactory shape. The colour of the flesh is good—a golden yellow. If the proper fertilisers have been used and the fruit is ripe when picked, the flesh is sweet and juicy though sometimes slightly fibrous. The 'eyes' are deep and irregular but the core is of reasonable size.

THE GREEN SELANGOR [SELANGOR GREEN, SELASSIE AND GREEN SPANISH (MALAY: *Nanas Hijau*)]

The Green Selangor is very similar to the Singapore Spanish, of which it is probably a mutant. Its leaves, however, are more yellow-green in colour and are not able to produce the red pigment. Under unfavourable conditions they turn a lighter yellow-green and in severe cases may turn almost white. The leaves usually have a few spines near the tip.

The green fruit turns to a golden yellow when ripe. The flesh colour is good but is sometimes spoilt by white flecks. The 'eyes' are not as deep as those in the Singapore Spanish.

THE SARAWAK VARIETY [SMOOTH CAYENNE AND KEW (MALAY: *Nanas Sarawak*)]

The Sarawak is a larger and more vigorous plant than the other varieties grown in Malaya. Planted at low populations it tends to continue vegetative growth for a long time and is slow to come into flower. The leaves are a deeper green than those of the Singapore Spanish variety and the reddening which is in the centre of the leaf is more prominent. The leaves occasionally bear some spines near the tip. One type has a tree-like habit of growth with a thick stem 5 to 6 ft. in height and bears short, pliant, curved leaves. If a fruit borne on this type it may be up to 25 lb. in weight.

The fruit is much larger (4 to 6 lb.) than that of Singapore Spanish and is often of poor, conical shape. The flesh colour is a pale yellow; fully ripe fruits are of good quality except for an occasional tendency to be fibrous. The core is large. The fruit is sold mainly for the fresh fruit market.

At the time of harvest few suckers are present; they develop in the following two months. Few plants produce basal slips.

THE MAURITIUS VARIETY [MALACCA QUEEN, RED CEYLON AND RED MALACCA (MALAY: *Nanas Moris* AND *Nanas Europah*)]

The Mauritius is the smallest of the Malayan varieties and is grown almost exclusively for dessert purposes.

The leaves are darker green than those of the other varieties and they have a broad, central red stripe. The leaf edges are lined with red spines.

The fruit is small, usually 2 to 3 lb. The flesh colour is good and the core small, but the 'eyes' are deep. Quality is very variable.

Suckers are often produced in excessive numbers following the harvest of the mother plant. Basal slips are rare.

Undesirable Characters in the Plant

Plants showing undesirable characters are quite common and growers are advised to rogue their plantations carefully. The planting materials (crowns, slips and suckers) from plants showing the following characters should be destroyed.

MULTIPLE CROWN (MALAY: *Jambul Ber-chabang Banyak*)

Two, three or more separate crowns are produced (Fig. II) on one fruit. This condition should be distinguished from "fasciated crown" (Malay: *sisir ganjil*) where one enlarged crown is formed (Fig. III). Fasciation may be a result of environment.

COLLAR OF SLIPS (MALAY: *Buah Ber-tunas*)

Basal slips are normally found on the peduncle, just below the fruit, but in the condition "collar of slips" they are found fused to the base of the fruit itself (Fig. IV).

BOTTLE-NECK FRUIT (MALAY: *Buah Tergenchat*)

In this condition the lower half of the fruit develops normally, but the

upper half remains undeveloped and dry, consisting only of swollen bracts and a core (Fig. V).

"FUSED FRUITS" (FASCIATED FRUIT) (MALAY: *Buah Ber-kedua*)

A malformed fruit body appears as two partially fused fruit with a common base, but usually with distinct shoulders and crowns (Fig. VI). This is more common in the Sarawak variety.

DRY FRUIT (MALAY: *Buah Kempis*)

The fruit fails to develop normally and consists only of swollen bracts and a core, like the upper part of a "bottle-neck" fruit.

CANNON BALL FRUIT (MALAY: *Buah Bulat*)

As a result of the failure of the apical florets to develop, a small, round fruit is formed.

SLENDER FRUIT (MALAY: *Buah Bujor*)

A long, narrow fruit develops on which the bracts appear unusually long (Fig. VII).

SPINY LEAVES (MALAY: *Daun Ber-duri*)

Singapore Spanish and Selangor Green plants normally carry only a few spines on the leaf-edge; those bearing many spines (Fig. VIII) should be eradicated.

MANY FINE LEAVES (MALAY: *Puchok Menyerai*)

Little or no fruit is produced but a large number of very fine leaves appear (Fig. IX).

Desirable Characters in the Plant

In addition to removing plants with undesirable characters, growers can search for plants with the following good characters which make them especially suitable for propagation:—

(i) Vigorous, normal growth;

(ii) Good propagating material (normal crowns, six to eight slips, two to three suckers);

(iii) Disease resistance;

(iv) Uniformity; and

(v) Fruits having:—

- (a) "Eyes as shallow as possible:
- (b) Diameter of 4 to 5 in.;
- (c) Rectangular or slightly oval shape;
- (d) Fruits as long as possible within the limits of (b) and (c):
- (e) A small core;

(f) Good quality (this is partly heritable and partly environmental); and

(g) A good colour and relative absence of air cells. It is not normally possible for the grower to be able to judge the characters (a), (e), (f) or (g).

Peat

It has been estimated that there are about one million acres covered by deep peat in Malaya. Most of this is in low-lying swamp deposits (bog-soils) and is found in West Johore, Selangor and Perak, with small areas in Kelantan, Trengganu and East Johore. The land now lies mainly under swamp jungle (3).

Smallholders have grown pineapples on these soils continuously for 40 to 50 years and, following a review of the situation in 1947, it was decided that in rebuilding the Malayan pineapple canning industry these soils should be used (4). Today all the major pineapple-producing areas are found on deep peat.

Peat is defined as an organic soil at least half a metre (19.69 in.) in depth, one hectare (2.471 acres) in extent and with a mineral matter content not exceeding 35 per cent. Such soils, except for small areas of upland peat, are usually found under conditions of forest lying in waterlogged depressions. The thickness varies from a few feet to 18 ft. or more, though it may be traversed by sand dunes or clay belts of higher land laid down in times of flood by rivers which have subsequently changed course (5).

Much work remains to be done on the peat soils. However, early indications are that the peats of the various areas in Malaya are similar, having been developed under the same conditions. Up to 50 per cent of the peat may be composed of timber in varying stages of decay. Chemically, wide variations are found within an area though no consistent variation has yet been found between the different areas. The Malayan peats are all low in mineral matter content, especially calcium and potash. The soil acidity varies widely, pH values varying between 3.3 and 5.1 have been determined.

Preparation of Land

The land being alienated for pineapples today is principally swamp jungle lying on deep peat. In many areas the water level rises above the surface of the land during the wet season. The natural growth is luxuriant and is found in several storeys. The trees show great variation in size and several hundred species are present in addition to palms, climbers and shrubs. Among the more important plant species usually found are (Malay names in brackets):—

Campnosperma spp. (*terentang*)
Cratoxylon arborescens (*geronggang*)
Xylopia fusca (*jangkang paya*)
Eugenia spp. (*kelat*)
Dillenia spp. (*simpoh*)
Tetramerista glabra (*punah*)
Calophyllum spp. (*bintangor*)
Koompassia malaccensis (*kempas*)
Palaquium oboratum (*nyatoh*)
Shorea spp. (*meranti*)
Gonystylus bancanus (*melawis*)

The first step in the usual method of clearing is to cut traces through the area. After that, all undergrowth is slashed and the trees are felled. When the branches have been cut off, the felled timber is left to dry for several months. When the timber is dry and the weather is suitable, the first burn is begun. Men enter the area and move slowly up-wind about three chains apart. At intervals, pieces of sacking saturated with paraffin are lighted and dropped to set fire to the brush. This is followed by a collection of the smaller limbs and a second, smaller burn in which the remaining timber up to a diameter of 4 to 6 in. (as specified by contract) is burned. The drainage system can be put in when convenient, but is usually not complete at the time of burning.

This method of clearing is cheap and quick but has grave disadvantages. All the tree stumps and the larger timbers are left *in situ*, thereby reducing the amount of land available for planting and making all subsequent operations more difficult (see Plate I). A better burn, and therefore better clearing, would be obtained if the drains were put in at the time the traces are cut.

More thorough clearing has been practised on the stations of the Department of Agriculture—sufficient to permit some degree of mechanisation. Such clearing however requires a considerable increase in initial capital outlay.

Drainage is of fundamental importance and it is essential to ensure that it is satisfactory before planting begins. Badly drained soil will result in poor growth of the pineapple and excessive weeds. It is not possible to lay down any hard and fast rules, but on level land, where the outfall is suitable, drains 5 to 6 ft. deep at 10 chain intervals would be adequate. Where it is only possible to have drains 3 ft. deep, the spacing may have to be reduced to two chains. It should be realised that the more frequent the drains, the greater are the difficulties of working and the greater is the waste of land.

Previous to planting the land should be cleaned and levelled.

RIDGING

Ridging is not normally practised. The simple pointed ridge, commonly used for other crops, is not suitable for pineapples as the roots of the pineapple become exposed and frequently the weight of the fruit pulls the plant over. The flat-topped ridge, capable of carrying two rows of pineapples, is sometimes used where adequate drainage is not otherwise obtainable.

SPACING

The traditional spacing giving an initial plant population of only 3,000 to 4,000 per acre (6) can no longer be regarded as satisfactory. Planting pineapples in double rows is now recommended. This permits an increase in the population with continued ease of working. Triple rows are not satisfactory because growth of the centre row tends to be poorer than that of the outer rows. Further, all subsequent operations on the middle row, such as weeding, the application of fertilisers and hormones, harvesting and trimming, become more difficult and require more labour.

Paths between the double rows should be a minimum of 4 ft. wide (Fig. X). When they are narrower than 4 ft. they become overgrown and the difficulty of working the area is increased. Slashing of the leaves of the pineapple plants to clear such paths is undesirable as it results in fruit of poor size.

With the Singapore Spanish variety, a spacing within the rows of 2 x 2 ft. is suitable and will give an initial population of 7,250 plants per acre. This

spacing can be recommended to smallholders who are short of planting material or lack the capital to buy the extra planting material and fertilisers required for higher populations. There is evidence to show that a further increase in initial population up to 14,000 plants per acre will result in greatly increased early yields. The tendency then for a decrease in the size of the individual fruit could probably be off-set by the correct use of fertilisers.

It appears to be essential to plant material of the Sarawak variety at the closer spacing (double rows planted 2 x 1 ft. with a 4 ft. path). Planted at lower densities this variety tends to develop excessive vegetative growth, is very slow and uneven when coming to flower and produces fruits of excessive size which frequently fall over and are affected by sunburn. Close spacing and the use of flowering control substances are therefore recommended.

PATHS

Unless drains or roads make them unnecessary, harvesting paths should be left at intervals of 10 chains. Paths 6 ft. wide are adequate.

Preparation of Planting Materials

Following the harvesting of the fruit, the basal slips will continue to grow on the peduncle and can be collected when convenient and brought to some central position.

Slips and other planting material of plants showing the undesirable characters previously mentioned should be removed and chopped up. Slips less than 8 to 9 in. long should also be discarded. The remaining slips can be graded according to size, so that in any one area only one type of planting material, all of the same size, is planted. The slips can be further graded according to their circumference at the base.

Removal of the small scale leaves at the base of the slips and trimming of the base with a knife will probably accelerate the establishment of the crop but are not essential. Care must be taken that the material is not damaged. When adequate skilled labour is available it may be found economic to carry out these operations.

All slips must be dipped in Bordeaux (copper-lime) mixture (Plate IIa). Any suitable container, such as an oil drum, may be used for the mixture, but it will rust iron or steel; if a vessel is to be specially made, it should be made of wood or brass. A suitable mixture is 1 lb. copper sulphate, 1 lb. quick lime and 10 gallons of water. Ready-slaked lime, however, is frequently used. The copper sulphate should be ground and a concentrated solution of it prepared. This is added slowly to the dilute suspension of lime. The slips should be dipped right into the mixture so that it enters the heart and the leaf axils. The slips are withdrawn and inverted for a moment until the solution has drained off. Then the slips are stacked on dry ground, butts uppermost, in *single* layers and dried in the sun for two or three days (Plate IIb). This operation is essential. The slips are then ready for planting, but if not required can be stored thus without cover for four to six months. For transport, the slips should be tied in bundles of fifty.

Suckers are not normally used as planting material except for the Sarawak and Mauritius varieties. They should be treated in the same way as slips but

more size grades will be required because of the greater variability of suckers. The practice of trimming the leaves severely is undesirable, but light trimming may facilitate transport of the material. Larger suckers (over 2 ft. in length) are unsatisfactory because they tend to come straight into flower after planting and produce either small fruits or fruits with broken core disease.

Planting

The headlands of an area to be planted should be marked out first. The rows should be marked by the erection of poles, and if pieces of cloth or paper are fixed to the ends of these, sighting is made easier. Intermediate marking posts can then be added. Wire, marked at appropriate intervals (2 ft. or 1 ft.), is used to indicate to the planter where to put the individual plants.

The planting material, which will have been treated and graded as described earlier, is then dropped along the lines of the rows. The usual method of planting is for one man to move along the line of the rows making the planting holes with a pointed stick. He is followed by the planter, who puts the slips or suckers (previously dropped) into the holes and presses the soil firmly round the plant with his feet (Plate IIIa).

When planting, it is important to ensure that:—

(i) the holes are not made too deep. This may result in a hole being left beneath the base of the plant, which will consequently grow poorly;

(ii) the soil is pressed firmly round the base of the plant; and

(iii) no soil gets into the heart.

An adapation of a tool (Fig. XI) from Hawaii can also be used (Plate IIIb). This implement has a flat, slightly pointed steel blade which is 8 in. long, $1\frac{1}{2}$ in. wide at the base and $2\frac{1}{2}$ to 3 in. wide at the head. The blade is $\frac{1}{4}$ in. thick and has a handle 6 in. long. It is said that one man can plant 5,000 to 7,000 plants a day using this tool in Hawaii (2). Much lower figures have been obtained in Malaya, but if the soil is fairly well consolidated and there is little timber, this implement could speed up planting.

When using this implement, the planter plunges the blade into the soil at an angle and, by drawing the handle forward, makes a hole behind the blade into which he puts the slip. The blade is then withdrawn and the soil pressed round the plant with the feet as the next hole is being made. It is most tiring work.

Weeding

Following planting, the area must be kept clean-weeded. If weed growth is found to be excessive and includes such damp-loving plants as *Fimbristylis* spp. (Malay: *misai-kuli*) the drainage should be improved. As the pineapple is shallow-rooted, care must be taken when weeding around the plants not to remove the soil and expose the roots. Trials of controlling weeds with machines and by the use of herbicides have been carried out, but no economic recommendations can yet be made. Hand-weeding with a tajak is most suitable. Lalang (*Imperata cylindrica*) should not present any problem, but if it is found the roots should be pulled out, and for this an Assam fork is useful. Well grown pineapple plants at the recommended spacing should require little weeding after the first six to eight months.

Flowering Control

In Malaya, pineapples which are allowed to flower naturally will produce a major harvest during the period from May to July and a secondary harvest at the end of the year. In any one area the fruit will ripen over a period of two to three months. This results in considerable seasonal demand for labour and also means that for part of the year the canneries are over-worked and for much of the rest of the year they receive little fruit.

Chemicals can be applied to the plant to induce it to flower. Such substances; when applied in an area where planting material of even size has been used and where the growing plants have been brought along evenly, can be used to concentrate the harvest in that area over a period of a week or two. This obviates the necessity of having continually to send in labour for harvesting over a long period. These chemicals are applied in solution and such solutions can also help to level off the harvesting peaks. Trials on the delaying of maturation, which would also help to level the peaks and increase fruit size, are now in progress.

It is important when using these chemicals that only plants of sufficient size are treated, that is, healthy plants with about 35 leaves. Smaller plants can be induced to flower, but the resultant fruits are small, and few, if any, slips and suckers are produced.

The recommended treatments are set out below.

ALPHA-NAPHTHALENEACETIC ACID

The most widely used substance is alpha-naphthaleneacetic acid. This is sold in a number of forms under trade names such as Planofix (in solution form), Aperdex (in tablets) and Hortomone A (in powder form). The manufacturers' instructions should be followed to prepare a five or ten parts per million solution. Fifty cubic centimetres (50 c.c.) of this solution is then poured into the heart of the plant. The bottom of an ordinary cigarette tin, with a depth of $\frac{5}{8}$ in., will contain 50 c.c. (Fig. XI). It is important that the correct amount and strength of the solution be applied, for excess of either of these may delay flowering or cause distortion. One application of the solution is sufficient.

Treatment with alpha-naphthaleneacetic acid is recommended for the varieties Singapore Spanish, Selangor Green and Mauritius.

CALCIUM CARBIDE

Calcium carbide also can be used for control of flowering, but labour costs are greater than for alpha-naphthaleneacetic acid because two or three applications are required. There is some evidence, however, that treatment with calcium carbide is more suitable for the Sarawak variety. It may also be more convenient for smallholders to use on the other varieties.

The methods of applying calcium carbide are described in the paragraphs which follow.

Dry Method

A quantity of calcium carbide should be allowed to stand in the air for 24 hours and then be ground to a powder. A pinch of this powder taken

between the finger and thumb is placed in the heart of each plant. The treatment is repeated after three days.

Wet Method

A stout vessel, such as a carboy or steel drum, should be two-thirds filled with water. Calcium carbide is added at a rate of 1 lb. per 12 to 16 gallons of water and the vessel is closed. Great care must be taken to ensure that the vessel has not been cracked or weakened and that the correct proportions of calcium carbide and water are used. If these precautions are not taken, there is danger of an explosion. When all the gas has been given off, the solution should be shaken thoroughly and allowed to stand for 15 to 30 minutes. The vessel is then opened with as little disturbance as possible; 50 c.c. of the solution should be poured into the heart of each plant. This treatment, also, has to be repeated after three days. Preparation of the calcium carbide solution in an open vessel has led to variable results in Malaya.

De-Crowning and De-Slipping

The crown slip and basal slips of the pineapple begin to develop shortly after the numerous purple flowers have died off.

It is the practice in Malaya to remove the crown. In countries overseas the crown is left on either because the fruit is required for the fresh fruit market or because its removal would result in severe sun-scorch of the fruit. Neither of these considerations applies in Malaya, but there is some evidence that the removal of the crown increases the amount of broken core disease. However, removal of the crown increases fruit size and possibly improves fruit shape.

The crown should be removed, either by hand or with a knife, when it is 2 to 3 in. high. When broken off by hand, the crown should be left in position so that when it withers and falls the scar will have dried and the risk of the entry of disease organisms is reduced. Cutting the crown off at an angle with a knife leaves no 'cup' for the collection of water and possible entry of disease, but if done carelessly may damage the young fruit.

Removal of slips at the time of de-crowning will also increase fruit size. All the slips of plants with undesirable characters should be removed. The number left on the other plants will depend on the grower's need for planting material. The slips are removed by hand or with a forked stick.

Harvesting

To produce a good quality canned product it is essential that the fruit should be picked fully ripe, transported carefully to the factory and canned as quickly as possible after picking. With the fruit from the less accessible smallholding areas, several days may elapse between harvesting and canning and well ripened fruit may be rotten before it reaches the factory. However, growers should regard the minimum degree of ripeness for harvesting to be when the bottom two to three rows of eyes have turned yellow.

Losses, through fruits which were overlooked during one picking being rotten before the next harvesting, are reduced to a minimum if this degree of ripeness is adopted and harvesters are sent into the area every five to seven days.

The harvester should move slowly and systematically up and down the rows of the area collecting the ripe fruit in a basket which is worn on the back and is large enough for 20 to 30 fruits (Fig. XII). The fruit is piled carefully by the roadside for collection by lorry or is sent to the loading point along a light railway. Where harvesting paths have been cleared, small tractors, such as the Ransomes M.G.6, with trailers or sledges can be used to take out the fruit. Such trailers, carrying 1,000 lb. of fruit, are in use on the Department of Agriculture's stations, but larger trailers might well be tried.

It is essential that at all times the fruit should be handled as gently as possible. The pineapple bruises easily and bruises spoil it for canning and also facilitate the entry of diseases.

The recommended maximum depth for stacking pineapples in a lorry is 14 in. Full loading of the lorry can be achieved by the use of platforms or by using boxes. A suitable box would be one made of meranti timber (*Shorea* spp.) in the form of a crate with the following internal dimensions:—14 in. deep, 12 in. wide and 22 in. long. The ends and bottom should each consist of two boards and the sides of three boards. The gaps in the ends should be $\frac{3}{4}$ in. wide and those in the sides and bottom of the crate should be $\frac{5}{8}$ in. wide.

Over-ripe fruit should not be sent to the factory as it has a fermented flavour and the amount of trimming required is excessive. Immature fruit should not be used because it gives an unsatisfactory canned product.

It is advantageous to have fruit graded before reaching the cannery. At present, grading is done by weight, but grading by size might prove a more satisfactory basis of payment for smallholders' fruit.

The cannery should be sited as close to the growing area as possible and would be ideally situated in the plantation so that the fruit could be processed immediately after harvesting.

Operations after Harvesting

The general practice in Malaya today is continuous cropping as opposed to replanting after the first or second ratoon harvest. This being so, greater care must be taken with the ratoon crops.

After the fruit has been removed from the mother plant, the suckers and slips continue to draw nutrients from the plant. Two to three months after harvest the upper part of the old plant will have died back and should be cut off. The suckers should be checked at the same time and those which are not firmly rooted should be taken off; the suckers which measure 18 to 24 in. can be planted in any empty spaces in the rows. Larger suckers, on being replanted, tend to come into flower immediately and produce very small fruits and no slips or suckers. Poorly rooted suckers which are replanted only after they fall over under the weight of the developing flowers or fruit are apt to produce fruit with broken core disease. It is therefore important that at the time the mother plant is cut back the suckers should be checked and replanted where necessary.

Old plants, together with suckers and slips of plants showing undesirable characters, should be split lengthwise (to prevent regeneration) and be chopped up to form a mulch between the rows.

Use of Fertilisers

Smallholders have grown pineapples on deep peat for many years without using fertilisers. It is now known, however, that by using fertilisers a considerable increase in yield can be obtained and that the fruit size and quality are improved.

MAJOR ELEMENTS

In common with other plants, the three nutrients required in the greatest quantity by the pineapple are nitrogen, phosphate and potash. When the soil is unable to supply these to the plant in sufficient quantity, the grower has to make up the balance by the application of organic manure or inorganic fertilisers. For pineapples, only inorganic fertilisers have so far been proved to be of economic benefit.

Nitrogen

Nitrogen is required for vigorous vegetative growth including sukering. It does not, however, play the dominant role in Malayan pineapple fertiliser programmes that it does overseas. Nevertheless, with the increase in the initial population planted and the use of hormones to advance flowering, the need for applying a nitrogenous fertiliser is increasing.

Nitrogenous fertiliser should not be applied near the time of flowering. If it is applied within two to three months of natural flowering or within one to two months of the application of a flower-including substance it will tend to encourage vegetative growth at the expense of the flowering.

Nitrogenous fertilizers can be applied at any time up to the ninth month to plants which are expected to bloom either artificially or naturally when 12 months old; they should not be applied after the eleventh month to plants expected to bloom when 14 months old. The encouragement of vigorous growth of the mother plant will ensure the production of a good sized fruit which can be harvested when the plant is 17 to 19 months old.

If a nitrogenous fertilizer is applied when the fruit is just beginning to develop, a poor quality fruit will be produced; if it is applied about two months before harvest, however, the growth of the suckers for the ratoon crop will be encouraged and the quality of the fruit will not be adversely affected.

Fasciated crowns are thought to be the result of the presence of excessive nitrogen.

Sulphate of ammonia (21 per cent nitrogen) has in the past been generally accepted as the best source of nitrogen. Urea (44 to 46 per cent nitrogen) is also now available. In South Africa, urea was found to be less efficient than an equivalent amount of sulphate of ammonia (8). No comparison of the two substances has yet been made in Malaya, but it is thought that under Malayan conditions the two substances would be of equal value and it is suggested that the choice be made according to availability and comparative price per unit of nitrogen. The higher percentage of nitrogen in urea means that less bulk has to be carried.

Phosphate

Little is known of the phosphate requirements of the pineapples grown in Malaya. It has been found that added phosphate increases the uptake of

potash, but several trials have so far failed to show any increases in yield or quality of fruit from the application of phosphate fertiliser.

Phosphate is however essential for the plant at about the the time of flowering. The need for balanced fertilising is now becoming clear and is discussed later.

The use of rock phosphate from either Christmas Island (36 to 33 per cent P_2O_5) or North Africa (30 per cent P_2O_5) is recommended. Christmas Island rock phosphate is cheaper per unit of P_2O_5 but may not always be available.

Potash

Potash is the nutrient required in greatest quantity for pineapples in Malaya. A lack of potash will result in poor plant growth. In the early stages of growth this deficiency is made obvious by the slow growth of the plant and the thinness and lack of body of the leaves, which are also of poor colour. A serious deficiency will almost completely check growth. The leaves turn a mottled red-yellow and show die-back of the leaf-tips. Few suckers or fruit are produced.

The judicious application of potash fertilisers encourages vigorous growth of the mother plant and its suckers and ensures production of fruit of good size. The application of potash has also been shown to improve fruit quality by raising the percentages of total sugars and total acidity.

Experiments have shown that there is no advantage to be gained from the use of sulphate of potash (43 per cent K_2O). The cheaper and less bulky muriate of potash (60 per cent K_2O), is therefore recommended.

BALANCED FERTILISER (MAJOR ELEMENTS)

It is known that the application of phosphate increases the uptake of potash but that excess phosphate reduces the uptake of nitrogen. The uptake of nitrogen is said to be dependent on the presence of potash. Again, it is known that the application of nitrogen or phosphate alone can have a detrimental effect on the growth of pineapple.

It is clear that it is most important not only to apply the three major elements but also to ensure that they are applied in the correct proportions. The Department of Agriculture, by means of field trials and leaf analyses, is seeking to determine what these proportions should be. The interim programme set out in Table I is suggested for the guidance of growers of the Singapore Spanish variety.

Table I

Recommended Fertiliser Programme.

(Singapore Spanish variety at an original population of 7,250 plants per acre).

Nutrient	Fertiliser	Period after Planting			
		2 months	8-9 months	2nd years	3rd and later years
		Application Rate (lb. per acre)			
Nitrogen	Sulphate of ammonia	100	100	145	215
	or				
	Urea	50	50	70	105
Phosphate	C.I.R.P. *	60	60	70	100
	or				
	N.A.R.P. †	75	75	80	120
Potash	Muriate of potash	50	90	170	250

* Christmas Island rock phosphate. † North African rock phosphate.

Method of Application

The fertilisers should be weighed out carefully and then mixed thoroughly.

Application of the fertiliser by hand is still recommended. The fertiliser should be placed within 9 to 12 in. of the base of the mature plant. The roots of the pineapple are not extensive and fertiliser placed farther away than this will be lost to the plant. For the first application to the young crop, the fertiliser should be placed nearer than 9 in., as the roots are not yet fully developed. Care must be taken that the fertiliser does not enter the axils of the young leaves or they may be severely scorched by the muriate of potash.

In the second and subsequent years the fertiliser can be applied in two six-monthly applications, the first one being given one to two months before the main harvest.

Application of fertiliser by means of leaf spraying is under trial but no recommendation can yet be made.

TRACE ELEMENTS

Of the trace elements—that is, those substances required by the plant in only very small amounts—it has proved necessary to supply only additional copper, although a lack of zinc has been suspected. The symptoms of deficiency of these two substances are noted in the section "Pests and Diseases" under the names Green Die-Back (copper) and Crook-Neck (zinc).

As a general practice, growers are advised to make regular applications of copper. This can be done either by adding copper sulphate powder to the fertiliser mixture or by a foliar spray application of Bordeaux mixture. Lime must be added to the copper sulphate solution or severe leaf scorching will result. The method of preparing the Bordeaux mixture is given earlier in the section "Preparation of Planting Material". The solution should be checked for neutrality before use. If blue litmus paper turns red when it is dipped in the solution, or if a deposit of copper is left on a clean steel surface dipped into

it, insufficient lime has been used. The spray solution should be carefully filtered before being poured into the sprayer. Knapsack sprayers are in almost general use and a number of makes which will give a suitable fine spray are now available at prices from $35 upwards.

Annual or semi-annual spray applications to supply 5 to 10 lb. of copper sulphate per acre will be sufficient.

Mulching

A mulching trial, including the use of mulch paper, is now (1957) in progress on one of the experiment stations of the Department of Agriculture. No recommendation can yet be made, but there is no evidence so far to show that mulching with material other than the cutup parent plants would be of economic benefit.

Shade

A shading trial is still in progress but there has been no evidence to suggest that growing pineapples require shade.

Pests and Diseases

MEALYBUGS

With the Singapore Spanish varieties, the early sign of an attack by mealybugs (*Dysmicoccus brevipes* [Ckll.]) is a change of colour (to red) of the apical ends of four to six of the leaves of the second and third whorls from the top of the plant. Later, this coloration moves down the leaves, the ends of which turn yellow and later wither. Later still, other leaves may be affected and bumps or warts be produced on the lower leaves. Another early symptom of attack is a marginal yellow mottling, often variegated with pink.

The Selangor Green variety cannot produce the red pigment and the symptoms of attack by mealybug are marginal mottling and, later, a change of leaf colour to a pale yellow green.

A diagnostic test, which requires some experience, is to remove a thin strip of the discoloured epidermis. In plants attacked by mealybugs the underlying tissue will be white or yellowish white; in all other cases it will be green.

A plant on which the symptoms of attack are very marked may be found free from mealybugs; the pests will have moved to the next plant *along* the row.

Mealybugs are usually found in the lower leaf axils or on the roots, though they may occasionally be seen clustered round the base of a fruit nearing maturity. Pineapples are not the only hosts of this pest.

The Sarawak variety appears to be less susceptible to attack than the Singapore Spanish.

Control measures have not yet been found necessary in Malaya. However, it is suggested that large quantities of material could be fumigated with methyl bromide; effective control could be achieved for small quantities of material by dipping in "Besudin 20E" (1:800) for five seconds and then stacking upright for 24 hours. These measures are expensive to undertake and if they are contemplated it is suggested that growers should seek the advice of the Department of Agriculture beforehand.

OTHER PESTS

Other pests which eat either the fruit or the young leaves of pineapples are monkeys, musang (civet), pigs and rats. Growers who have difficulty in controlling these pests should contact the local Agricultural Officer for advice.

RED WILT

The leaves of some varieties of pineapples will, under adverse conditions, turn red due to the production of the pigment anthocyanin. Such varieties are Singapore Spanish and Sarawak, though not Selangor Green. This condition is often referred to as 'red wilt' and it is widely but erroneously believed to be a specific disease.

The most common causes of this coloration are:—

(a) bad drainage. It is essential to ensure that the drainage of an area is satisfactory before the pineapples are planted. Subsequently, drains must be maintained.

(b) soil in the heart of the young plant. This can be prevented by careful planting and weeding.

(c) a lack of consolidation of the soil round the base of the plant. This can be prevented by following the advice given in the section 'Planting' and in the section 'Action After Harvest'.

(d) an attack on the plant by termites. These insects can be killed with a solution of dieldrin.

(e) an attack on the plant by mealybugs. Though mealybugs are found throughout the pineapple-growing areas of Malaya, they are not yet a serious pest. Good drainage and careful cultivation and manuring appear to prevent their attacks having serious consequences.

FRUIT COLLAPSE (GHOST FRUIT, FRUIT ROT)

Fruit collapse is one of the most serious diseases of pineapples in Malaya and has resulted in the loss of 30 per cent of the fruit grown in some areas. It appears to affect the plant crop particularly. The bacterium causing the disease is a specialised strain of *Erwinia carotovora*.

The symptoms are a very rapid rotting and liquifying of the tissues of fruit just approaching maturity. The internal tissues are affected by a very soft rot and assume a dull, water-soaked greenish colour. Gas is produced and there is copious exudation of juice. Affected fruits have a characteristic sour smell. The outer tissues remain relatively firm, but the skin of the fruit assumes a dull yellow-green colour.

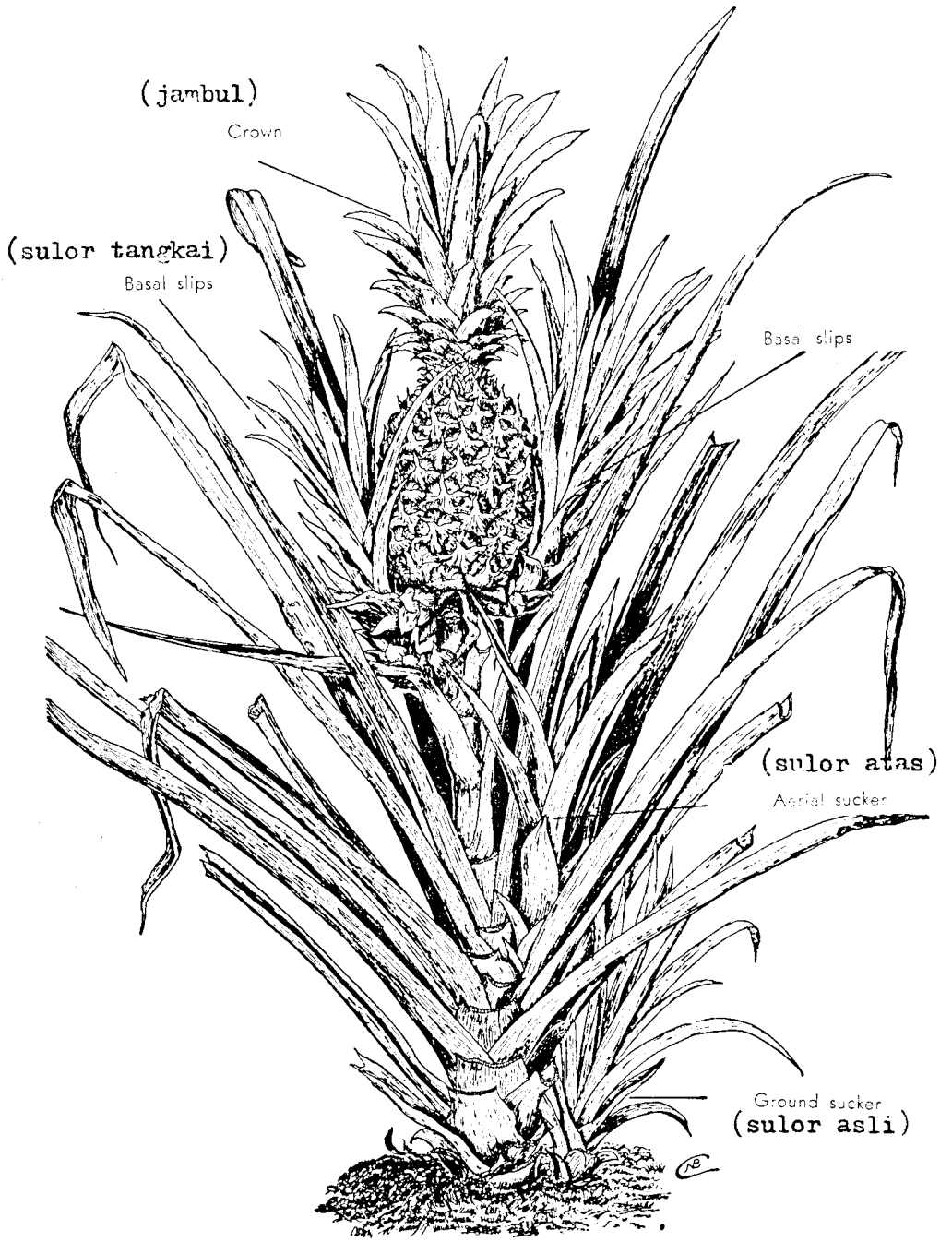
No cure is possible and methods of prevention are still under trial. Rigid sanitation should be adopted; where it is possible, affected plants should be buried to prevent the spread of the infection from them.

HEART ROT

Heart rot can also be serious, particularly in newly planted areas. The causal organism is the same as that for fruit collapse, a strain of the bacterium *Erwinia carotovora* (7).

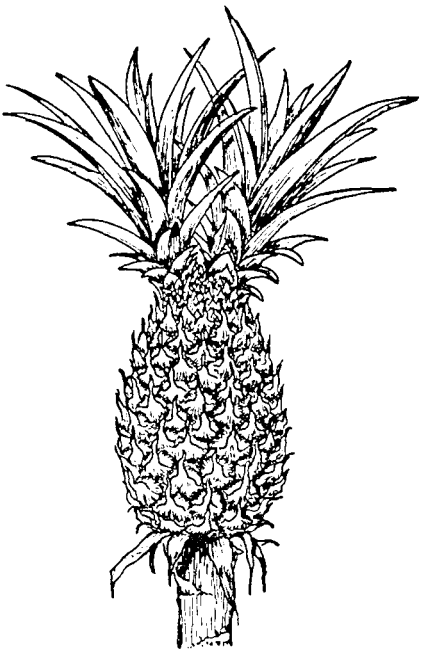
Plants can be affected from the age of three months to the time of flowering and the first symptom is a basal soft rot of the youngest leaves. This later spreads until the growing point and the bases of the first and second whorls of leaves are affected. A distinctive sour smell is noticeable.

FIG. 1



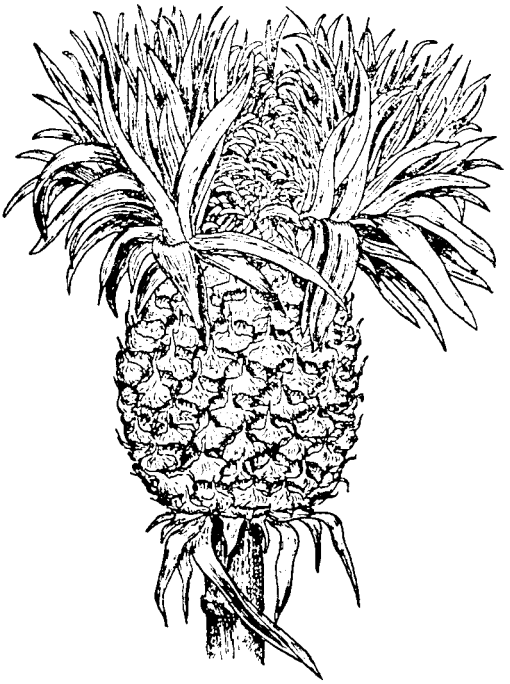
Planting materials of the pineapple.
Beneh2 daripada pokok nenas

FIG. II



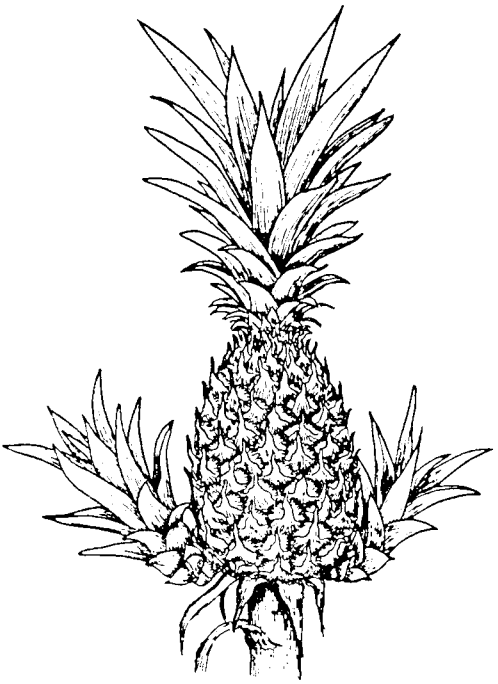
Multiple crown.
Jambul berchabang

FIG. III



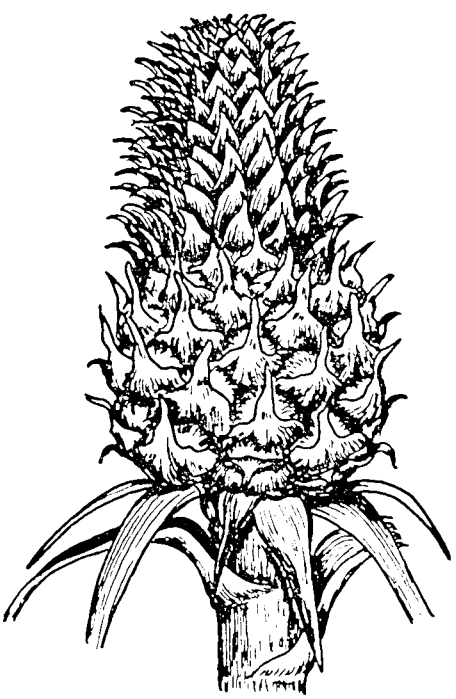
Fasciated crown.
Sisir ganjil

FIG. IV



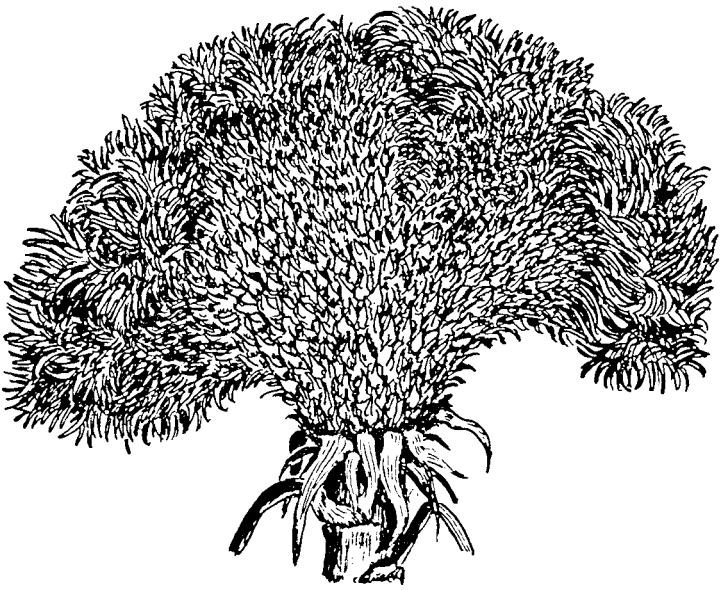
Collar of slips.
Buah Bertunas

FIG. V



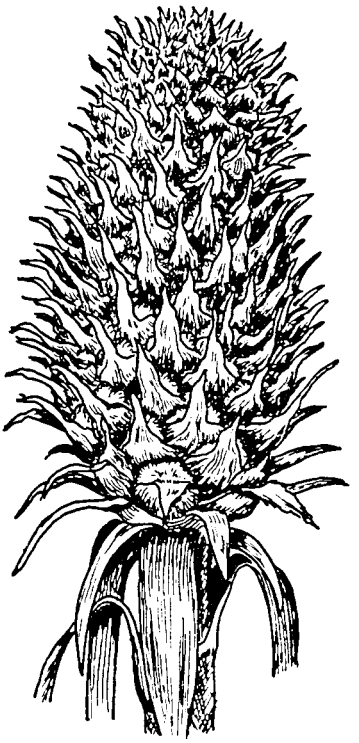
Bottle neck.
Buah tergenchat

FIG. VI



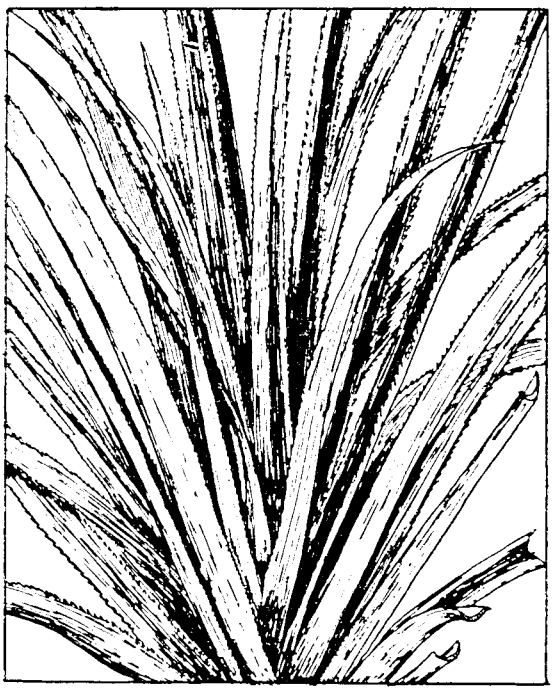
Fasciated fruit.
Buah berkedua

FIG. VII



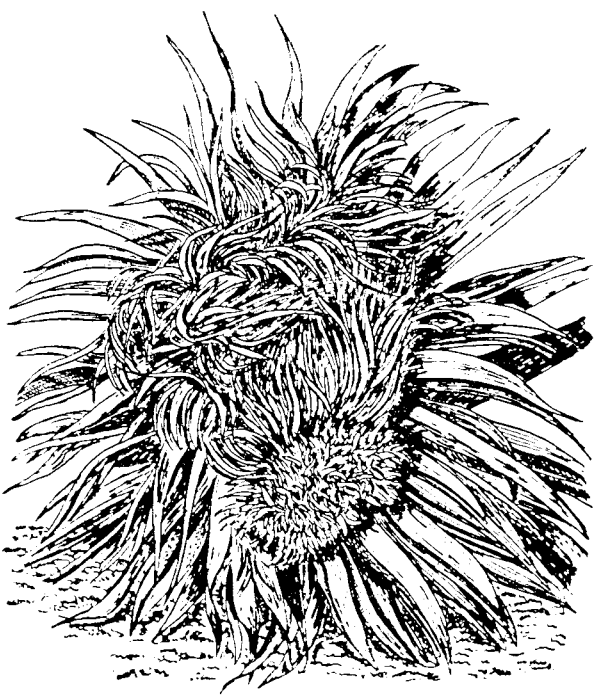
Slender fruit.
Buah bujor/kurus

FIG. VIII



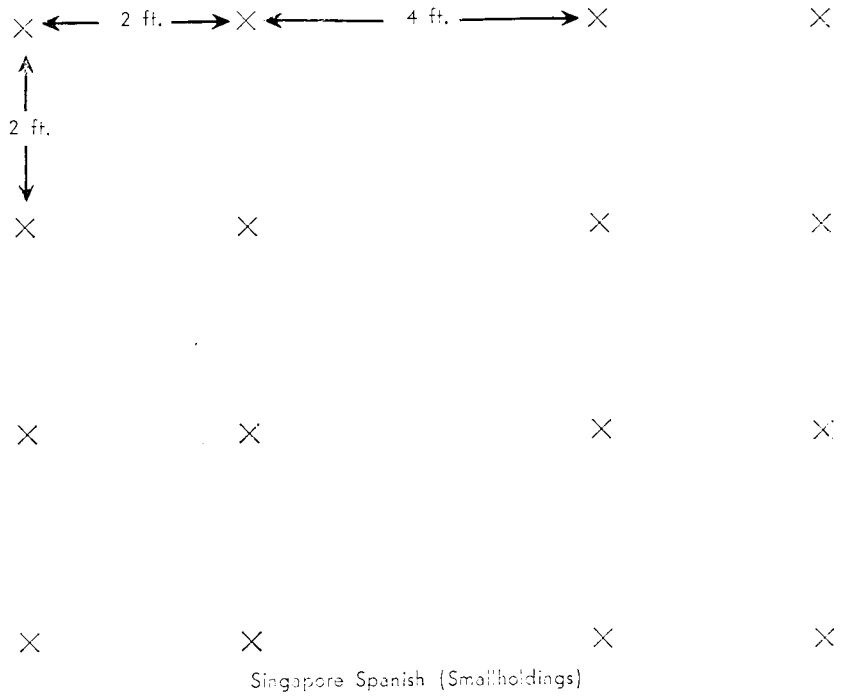
Spiny leaves.
daun berduri

FIG. IX

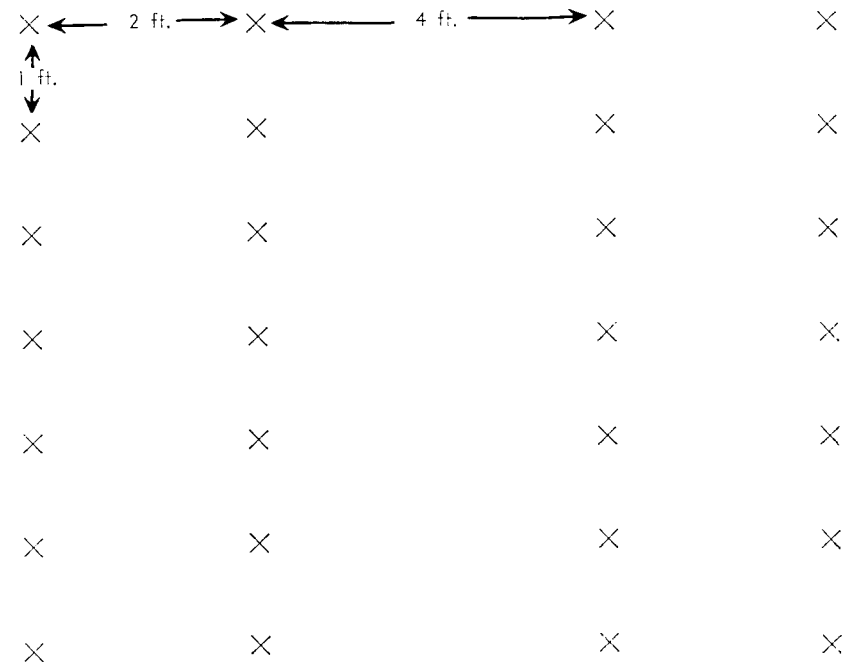


Prolification.
Puchok menyerai

FIG. X



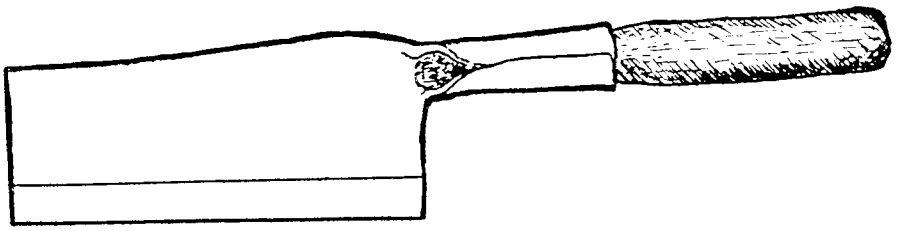
Singapore Spanish (Smallholdings)



Singapore Spanish (Estate) and Sarawak.

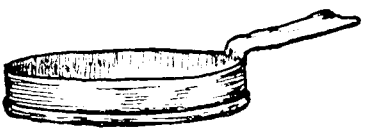
PLANTING DISTANCES

FIG. XI

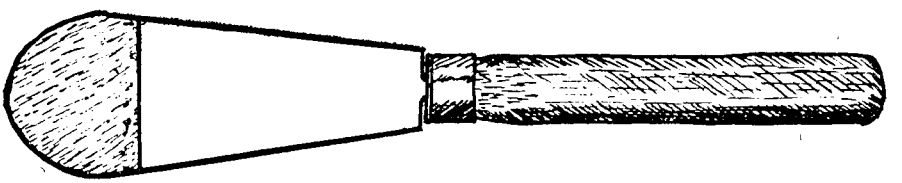


Short parang.

Harvesting knife.

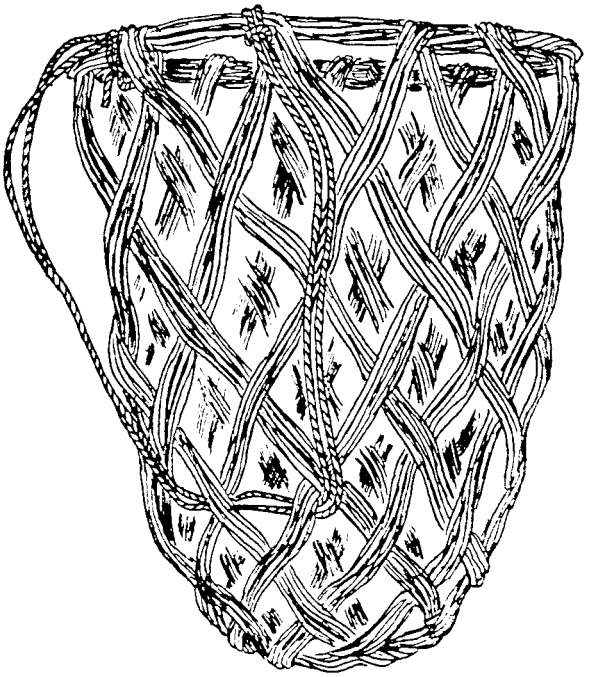


Hormone measure. (50 c.c.)



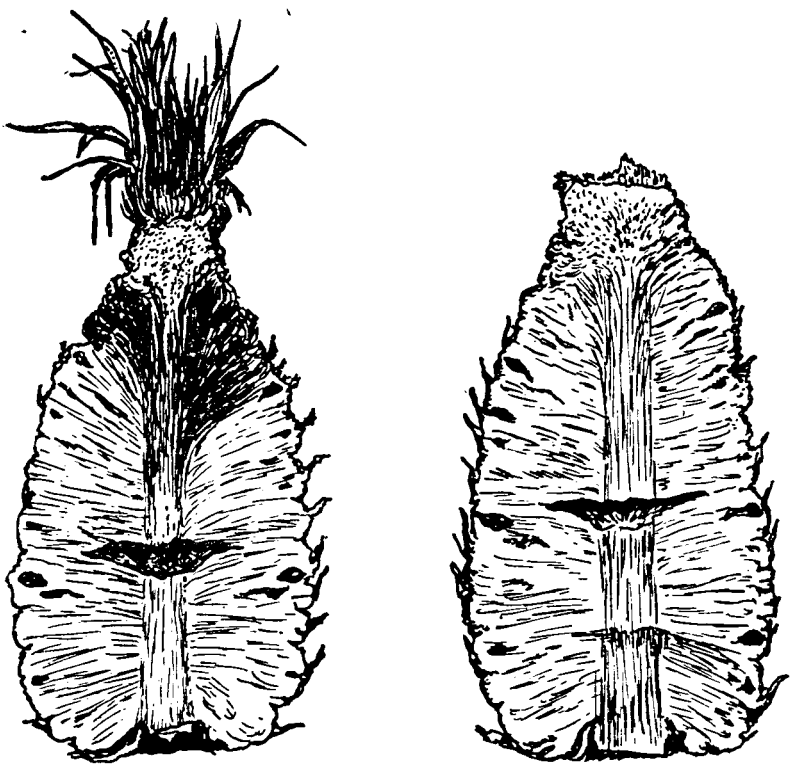
Hawaiian planting tool.

FIG. XII



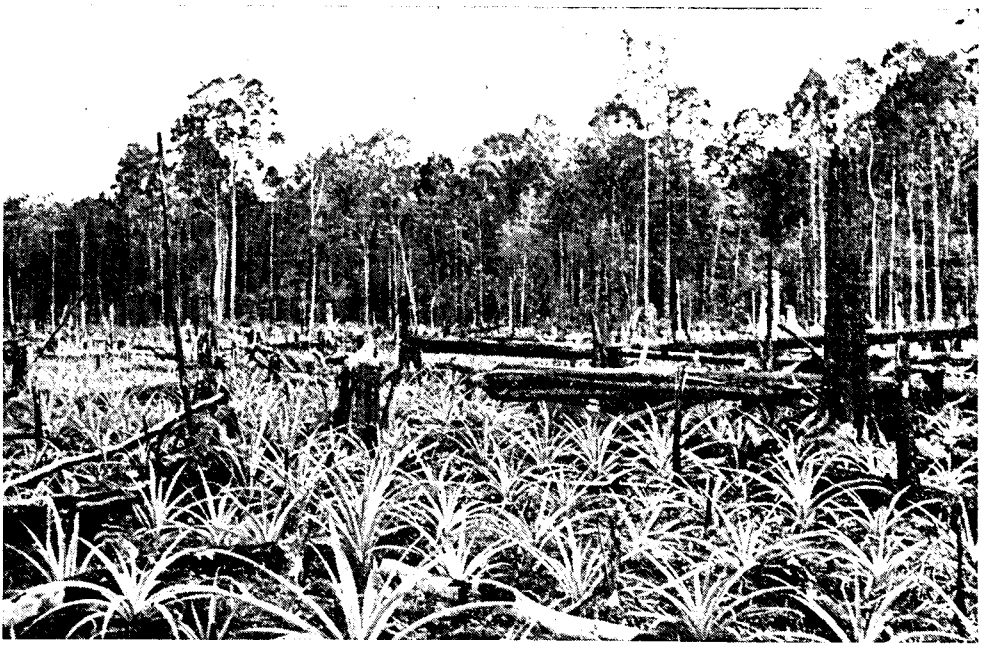
Harvesting basket.

FIG. XIII



Broken core.

PLATE I

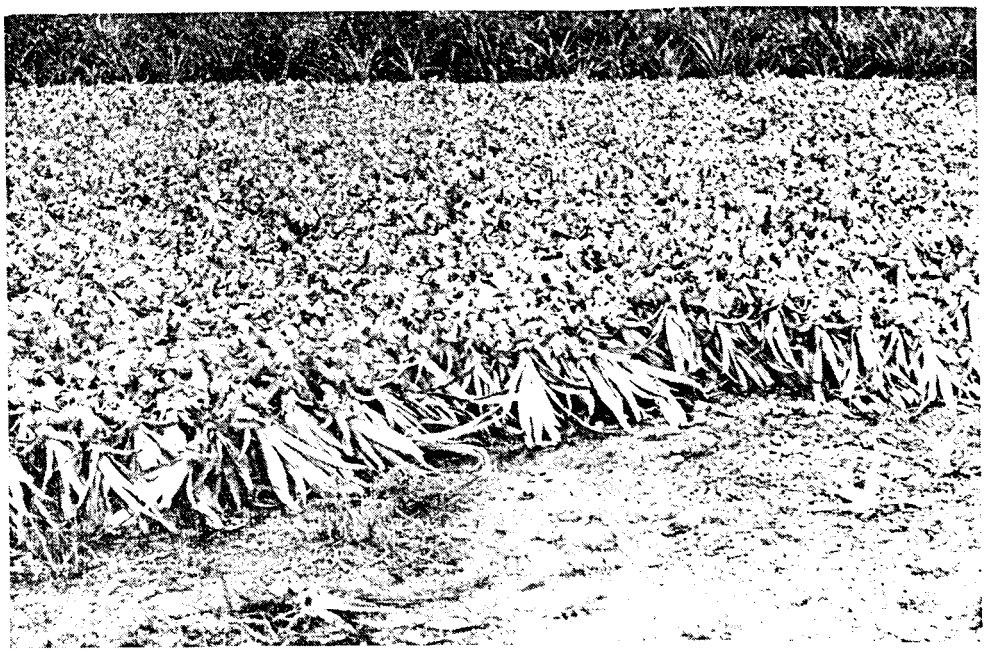


Newly planted area showing timber lie. Smallholding area near Pontian, Johore.

PLATE IIa

Preparation of planting material. The bundle of slips is about to be plunged into the copper-lime mixture so that the mixture enters the heart and leaf axils of each slip.

PLATE IIb



The slips are being sun-dried in an inverted position after dipping.

PLATE IIIa

Traditional method of planting. One man makes the holes along the marked wire while the second puts in the slips (already scattered along the line) and consolidates the soil round the slips with his feet. Note that the land is clean.

PLATE IIIb

Use of the Hawaiian tool in planting. As each slip is planted the soil around the one planted previously is consolidated with the feet. (The marking wire is not shown in the photograph). Note that the land is clean.

Trial methods of control are still in progress, but the methods suggested below are aimed at reducing the chances of infection by simple field practices which can be easily and cheaply carried out:—

(i) Slips should be treated before planting by dipping them in Bordeaux mixture to reduce the danger of early infection. (This is also done to guard against die-back, caused by copper deficiency);

(ii) Care should be taken when planting and subsequently to prevent the entry into the heart of the plant of possibly contaminated soil;

(iii) Badly infected plants which are likely to be completely killed by the disease should be dug up and destroyed by burning or deep burying; and

(iv) Slightly affected plants in which the rot does not extend to the outer leaves often recover by producing lateral shoots. To aid recovery of these plants and to prevent their acting as centres of infection, the central rotted leaves should be pulled out and destroyed and the heart should be sprayed with Bordeaux mixture or some other copper fungicide.

FRUITLET BROWN ROT

No symptoms of fruitlet brown rot are noticeable externally. On the removal of the skin, however, a brown rot is evident just below the floral cavities. These brown patches are well defined, as only individual fruitlets are affected, the tissues of which are rotted and turn brown. The rotted tissues are firm and there is no liquefaction; the rot may extend to the core. If two adjacent fruitlets are both badly affected the rot appears in cross section as a wedge of brown, almost decay, possibly with a red-brown margin. The rot appears to be caused by a bacterium, (*Ericinia* (?) *ananas*) which is often accompanied by a species of the fungus *Penicillium*.

Application of muriate of potash, which will increase the acidity of the fruit juice, may prove beneficial. Fortnightly spraying of fruit with Bordeaux mixture from flowering onwards has been practised in the Phillipines but has not been tried in Malaya.

BROKEN CORE

Broken core is a transverse break in the core of the fruit (Fig. XIII). It results in the upper part of the fruit not developing properly. Affected fruits ripen from the top downwards and may be of poor shape. The portion of fruit above the break is usually a pale colour and less sweet than the lower part. The disease is not parasitic in origin and may be caused by unfavourable water conditions at some time during the growth of the fruit. Core rot may also be present.

CORE ROT

The symptoms of core rot are a fairly well defined brown or greyish rot extending down the core. At first only the core tissues are affected, but later the flesh also may be involved. The diseased tissue remains firm. Though the core may become hollow, liquefaction of the tissue does not take place and the rot remains localised.

The affected tissues appear similar to those infected with fruitlet brown rot and it is possible that it is caused by the same bacterium.

The causal bacterium probably enters through wounds made by de-crowning.

RIPE ROT

Ripe or over-ripe fruit may be affected by a rather soft rot which causes the disintegration of the flesh and makes it appear water-soaked. There is a superficial resemblance to fruit collapse but ripe rot can be distinguished by the fact that:—

(i) only ripe or over-ripe fruits are affected;

(ii) the affected flesh is yellow rather than the greenish colour of the disease fruit collapse;

(iii) the skin of the fruit is orange rather than greenish-yellow;

(iv) affected tissues are populated largely by yeast rather than bacteria.

OTHER DISEASES

Other diseases of pineapples in Malaya which have been noted but are of minor importance are fungal leaf spots (*Asterinella stuhlmanni* and *Curvularia* sp.) and butt rot (*Ceratostomella paradoxa*).

Trace Element Deficiencies

GREEN DIE-BACK

Green die-back is often referred to as green wilt although the affected plant does not wilt. The disease is found in small, scattered places in many pineapple-growing areas. Usually the younger plants are affected, often in groups of only two or three plants.

The leaves of affected plants are brighter green than the leaves of healthy plants, are thin and narrow and are held notably erect. Successive leaves produced by affected plants are shorter and narrower. There is no reddening of the leaves and no wilting of the younger leaf-tips occurs. Affected plants may die if not treated.

The application of copper as suggested in the section "Use of Fertilisers" will control the disease.

CROOK-NECK

In Australia and South Africa a deficiency of zinc is often associated with a lack of copper. The disease is referred to as 'crook-neck'. The symptoms shown by a Cayenne plant suffering from a lack of zinc are said to be a marked thickening and twisting of the leaves, which become brittle. The leaf edges curl upwards and there is a yellowing of the leaf. The symptoms are most marked in young leaves. The name 'crook-neck' arises from the inability of the young leaves to fan out; the whorl of young leaves twists round. Later, necrotic patches occur on the leaves. A diagnostic test is said to be one in which the distribution of chlorophyll is examined. If a leaf appears mottled when it is help up to the sun, indicating an uneven distribution of chlorophyll, the plant is suffering from a lack of zinc.

Growers who find plants showing symptoms of crook-neck are advised to contact an officer of the Department of Agriculture.

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(8) Lewcock, H. K. (1956): "Fertilizers of Pineapple". *Pineapple Grower and Eastern Cape Farmer*, **1**, 12.

For further advice, apply to:—