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About the Institute
The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

copy submitted by [illegible] in October 1914

Photography of

Smooth Cayenne

Paper mulch

Fertilizing with iron

THE PINEAPPLE

It is interesting to reflect that the pineapple (Ananas comosus) is commercially the most important fruit native to the Americas. The reasons for this are several - delicious flavor, productiveness, suitability for shipment and processing, and so on. From one angle, it is still more interesting to recall the horticultural history of pineapples: In Brazil and adjacent regions, they were developed to a high state of perfection by the pre-Columbian inhabitants. These people had not learned that it was possible, through the art of grafting, to perpetuate superior seedlings which occur in the wild. True enough, they had made some progress through the use of stem cuttings, and through mass selection of seedlings - the avocado is a good example - but this was slow work. The pineapple was almost unique in that it was easy to perpetuate superior varieties by vegetative means. All that had to be done was to take suckers or "slips" from a plant. You set them in the ground and they produced fruits, true to the parent in all respects, in a matter of months. It seems quite probable that the pineapples thus developed by the aborigenes were just about as good as those we have at the present day.

The genus name, Ananas, comes from the Tupi language of southern Brazil, where this fruit was called nana; it first appeared in Jean de Lery's "Histoire d'un voyage fait au Bresil," a work published in 1578, where the author speaks of " ananas, plus excellent fruit de l'Amerique." Gonzalo Fernandez de Oviedo, in his classic "Sumario de la natural historia de las Indias," published in 1526, describes briefly the "piña," which he says is one of the "finest fruits in the world," and in his later and more complete work he relates that the Spaniards gave it this name because it looks like a large pine cone,

and that it grows not only in the Islands but also on "Tierra Firme" - the mainland. The excellent illustration he presents leaves no doubt as to the identity of the fruit about which he was writing.

Due to the ability of the plant to survive long voyages at sea it reached India as early as 1548. Since modern commercial development of pineapple culture is based to such a large extent on processing, it is worthy of note that the first attempts along this line seem to have been made in Florida, about 1871; the fruits used, however, were not grown locally, but imported. The project was short-lived. Hawaii started canning locally-grown pineapples in 1892, Singapore in 1895. The tremendous modern production of canned pineapples and pineapple juice is well known to everyone. In recent years the industry has extended to numerous tropical countries, while fresh pineapples for export have become a source of income in many regions - though not approaching in volume the processed products.

In spite of being the original home of this delicious and commercially valuable fruit, it is only in recent years that it has redeived much attention at the hands of horticultural scientists in tropical America. Research on pineapple growing in Hawaii, which produces more pineapples than all the rest of the world put together, has been intensive; much has been done in Malaya, in South Africa, and in Australia. Workers in Puerto Rico deserve much credit for the research which has been conducted in that island, the results of which have been usefully treated in the "Revista de Agricultura de Puerto Rico," Vol. XLIV, No. 1, 1956. A large part of the material included in this chapter is based on that publication. Early experience in Florida, where attention was devoted to pineapple growing in the early years of this century, developed many facts of basic interest as well as familiarity with the characteristics of a considerable number of varities. There was a time when it was thought that pineapple production in Florida had a bright future. Attention was even devoted to the

breeding of new varieties, without, however, important results.

Varieties

The 3 principal pineapples--Red Spanish, Smooth Cayenne, and Natal Queen--are often considered as the type varieties of 3 groups or races. Several less important varieties can be placed in each of these groups, but at the present time there seems to be no classification which includes all cultivated forms. In part this may be the result of natural crossing between groups, but more probably it is due to insufficient pomological study of many local varieties. Sometimes, too, a well-known variety is not recognized because it is grown under a local name.

Red Spanish is characterized by vigorous plants with strong, stiff leaves. The fruits are reddish-yellow when ripe, somewhat barrel-shaped, weighing from 2 to 4 lbs. Quality is not the best, but the fruits ship well. In the West Indies, the normal season of maturity is early June to July. Slips are usually produced in abundance, while suckers are few. A mutant with smooth leaves, Singapore Spanish, is the chief canning variety in Malaya.

A related variety is the Cabezona, a triploid with fruits weighing 8 to 12 lbs. It is grown on a small commercial scale in Puerto Rico. Pernambuco, Abacaxi, or Eleuthera may also belong in this group. Quality is good, because of the small amount of fiber and low acidity. The fruit varies from 2 to 3 lbs., in weight, is yellow when ripe; most of the crop matures in July. Slips are many and suckers few.

Smooth Cayenne is by far the most important pineapple in the world. The plant is vigorous, with long, broad leaves lacking marginal spines. The fruit is normally from 4 to 8 lbs. in weight, cylindrical in form but tapering slightly toward the apex, the rind yellow on the ripe fruit. The somewhat coarse flesh is pale yellow in color and of

good quality. This variety does not ship very well. It is chiefly grown for canning. Both slips and suckers usually are few. Several related varieties have been grown by greenhouse fanciers, but none commercially. The Esmeralda variety of Mexico may be a white-fleshed mutant of Smooth Cayenne.

Natal Queen is a variety of the old Queen group which was selected in South Africa; the Australian Macgregor Queen is very similar. These varieties are much less vigorous than the ones described above, and the fruit size is small, from 1½ to 2½ lbs.; the rind is yellow. The flesh is golden yellow, with little fiber and of good quality. Queenssmature with Red Spanish and produce many suckers but few slips.

Abakka(Abachi, Abaca) is another variety of the Queen group sometimes grown commercially in Florida and Puerto Rico on a small scale. Like other Queen types, the plants are rather short and compact; fruit size is 3 to 4 lbs., rind and flesh color are like other Queens, but slips are produced more abundantly than suckers. Quality is good, but the fruit does not ship very well.

In recent years commercial production of Smooth Cayenne has become important in the state of Veracruz, Mexico, mainly for canned and other processed products, and in the state of Yaracuy, Venezuela, for sale as fresh fruit or for processing. In the 1920's extensive plantings of Smooth Cayenne from Hawaii were made on the Pacific coast of Guatemala, but the project was a failure because the rich soils of that area produced a fruit of coarse texture and unsatisfactory canning quality. In this same region, however, though at somewhat higher elevations, Smooth Cayenne is grown satisfactorily for fresh use locally; while around Palin, on the slopes of Volcan de Agua at about 4,000 feet, another pineapple is grown, also for local use. This is a small-fruited variety, white-fleshed and delicious, which has not been identified and may or may not be known elsewhere.

The varieties which have commonly been grown in El Salvador, for local use only, are few and of rather indifferent quality, as is true also of a variety grown around San Pedro Sula, Honduras. This appears to be the same as the popular Montufar variety of the lower Motagua valley in Guatemala, a variety of unknown affinity to commercial varieties elsewhere.

The region of Turrialba, Costa Rica, is famous for its pineapples, which are of good size, white-fleshed, and of excellent quality as fresh fruits; but attempts to develop an export trade based on this variety were not successful. The plantings were made near Siquirres, in a very wet region. In part because of climatic conditions, and perhaps in part because an unsuitable variety was chosen, the fruit did not hold up well when shipped to the United States in fresh form, nor did it make a satisfactory canned product. In Panama the Sugarloaf variety grown on Taboga Island is sweet and of excellent quality. It is highly esteemed locally as a fresh fruit.

The Cambray pineapple of the Cauca valley in Colombia is a local favorite as is true also of a variety commonly grown in the region of Milagro, near Guayaquil, Ecuador. It is impossible at present to identify all these local forms or state their affinities. It is to be assumed that most of them have not been found to have the qualities required by the large companies which produce canned pineapples. Nor is it possible to say how much of their popularity is due to inherent qualities and how much to peculiarly favorable environment.

In Puerto Rico, Smooth Cayenne and Red Spanish dominate commercial production, with practically all of the Smooth Cayenne and one-third of the Red Spanish going into cans. The remaining Red Spanish is largely exported fresh.

Climate and Soil

The pineapple is a tropical plant, easily injured by frost. There

is no growth below 65 degrees F. or above 100 degrees F. A temperature range of 70-80 degrees F. is considered ideal. Cool weather causes developing fruits to be smaller, with more acid and less sugars; high temperatures (above 90 degrees F.) produce fruits high in sugars but low in acid, hence rather insipid.

Pineapples are grown commercially with annual precipitation ranging from 25 to 80 inches. While the plants are well adapted to conditions of low rainfall, they do not yield good crops in dry regions unless irrigated. Application of 1 in. of water every 2 weeks during dry periods is recommended. Under high rainfall conditions fruit is excellent in eating quality but does not ship well.

The only important soil characteristic, is good drainage. Sand, loam, and clay, soils are all used for commercial production if they are well drained. Soil for pineapples should be more or less acid. Sandy soils need pH 4.5 to 6.0, while clay soils may run pH 5.5 to 7.0

Plant Structure and Functions

A pineapple plant in its first year in the field consists of a short, thick stem bearing many long, sword-shaped leaves. As the stem increases in length, new leaves are formed at the apex, and starch is stored abundantly in the stem. The leaves are adapted to keep transpiration at a low value, and are V-shaped, so that rain or dew falling on them is conducted to the stem and runs down it to the roots. Usually the leaves have heavy marginal spines, but some varieties are spineless or smooth-margined by mutation. The root system is rather sparse, most of the roots being within a foot of the stem, extending downward about six inches from the surface. In well aerated soil, vigorous plants have short, thick, fleshy roots with a dense coating of roothairs. In poorly aerated soil, roots are long, slender, and tough, with few roothairs. New roots develop from initials already

present in the stem tissues at intervals during the active life of the stem, but eventually they die when the leaf at the base of which they arose dies and ceases to supply them with food. If new vegetative bfanches of the stem arise and are in contact with the soil, a new root system develops for this branch.

After 10 to 15 months, depending on climate and the kind of propagating material, the growing point of the stem ceases to develop new leaves and begins to form a terminal inflorescence or spike, utilizing the starch previously stored in the stem. After 75 to 150 flowers have formed, the growing point once more begins to produce leaves. Development of red color in the youngest stem leaves marks the end of flower differentiation, and the beginning of elongation of the inflorescence stem, lifing the inflorescence several inches above the leafy nest. No more new leaves can develop from the old stem, but it may now form a few lateral branches whose growing points form a succession of leaves in turn.

The uplifted flower spike opens its blue petals from its base upward in the course of a month or so, and then the flower bases develop into a composite fruit consisting of carpels, fused sepal bases, the bases of the bracts subtending the flowers, and the fleshy axis of the spike. Flowers are self-incompatible (do not set seeds from their own pollen), with the result that in fields planted to a single variety the fruits are seedless. Pollen of one variety will produce seeds on another variety in most cases, however, hence in mixed plantings fruits may be somewhat seedy. Needless to say, the presence of seeds lowers the value of the fruit. In some varieties the inner portion of the fruit axis is fibrous and not palatable, but in others the whole diameter of the fruit may be eaten except the "rind," formed from the outer lining of the calyx and the bract tips, which constitutes a protective covering for the fruit.

From the time when the growing point starts developing a flower spike instead of leaves, to the time when it has finished with flower beginnings and returns to forming terminal leaves, is about 5 weeks. There is a period of some 6 weeks more to the first open flower on the spike, and about 4 weeks from the first to the last flower. Then it takes about 3½ or 4 months for the fruit to reach maturity - even longer during cool weather. The mature fruit bears at its top a crown of leaves, always very much smaller than the leaves on the vegetative stem.

Forcing the Bloom

Scientists have not yet discovered exactly what causes the growing point of the stem to cease forming leaves and initiate flowers. Both cool nights (around 60 degrees F. or below) and short days have been advanced as causes, but while these may account for November differentiation of flower buds in Hawaii or Puerto Rico, differentiation also occure at this season normally near Singapore, where there is no variation in day length during the year and termperatures do not go below 70 degrees F.

Horticulturists have long known, however, that certain treatments would bring about differentiation at any time of year. Around 1900 it was found that smoke from burning damp grass would do this. About 1932 the effective agent in smoke was shown to be ethylene gas, and acetylene works just as well and is easier to use. Then in 1942 the well-known growth-regulating chemical naphthalene acetic acid (NAA) was found to be highly effective for causing pineapple plants to bloom at will. However, plants must attain sufficient size before they are able to produce large fruits and there is little point in trying to cause fruiting at an earlier age than normal. But there are two situations in which forcing the bloom is advantageous. Very commonly only 75% of the plants in a field bloom at the normal time, and

treatment can make this 100%. Then again, the ratoon crop from branches of the original plants is likely to mature very unevenly because of the varying ages of the branches, and treatment can bring uniform maturity so that harvesting is much less expensive. It should be noted that inducing bloom with NAA tends to prevent formation of slips.

In most areas where it is desired to force bloom, NAA is preferred because of its ease of application if spray machinery is available. Using the very soluble sodium salt, a solution containing 5 ppm is made by dissolving 2 g. of the salt in 100 gal. of water. This solution is sprayed on the mature plants so that each receives about 50 ml. (1½ oz.), which means that 100 gal. is put on 7,200 plants. For a small number of plants, one can drop a few small crystals of calcium carbide (about 1/16 tsp.) in the heart of each plant, depending on dew or rain to dissolve the crystals and generate acetylene in place. (Often this injures the leaves.) For large scale use of acetylene, a saturated solution should be prepared by placing 12 oz. of calcium carbide in a 55-gal. steel drum with 36 gal. of water, and rotating the closed drum until the solid is all dissolved. The solution is allowed to flow by gravity into the heart of each plant, allowing about 40 ml. per plant. The gas is easily inflammable. The colder the water the more gas it can hold. A second application a few days after the first assures a high percentage of flower induction.

Propagation

As mentioned previously, seeds are often produced when varieties are mixed in a planting, but these seeds are of value only for developing new varieties, and it takes 4 years, often longer, for a seedling to produce its first fruit. Commercially, vegetative propagation is employed, resulting in plants true to type which mature fruit

in 2 years or less. Three types of propagating material are commonly used--slips, suckers, and crowns; it is also possible to use sections of the plant stem.

Slips are branches of the inflorescence, arising either just below the fruit (basal slips) or just above it (crown slips). In Hawaii, slips are also found sometimes half way up the fruit stalk (hapas). All slips are considered to be aborted fruits, represented by the bulbous base, and a leafy crown very much smaller than develops above true fruits. Basal slips are usual propagating material for most varieties; they should be selected from plants where they have developed far enough below the fruit so that they are not attached to it at all. In Hawaii, from the usual autumn planting of basal slips to harvest is generally 20 to 22 months.

Suckers are branches of the vegetative stem, arising from buds in leaf axils. They may come from buds well above the soil (aerial suckers or suckers proper), or from buds on the stem at or below the soil surface (ground suckers or ratoons). The only difference is that ratoons readily develop roots, if left in place, thus continuing the life of the planting, while suckers must be broken off and planted independently. Being much larger than slips, suckers bear fruit sooner, usually in 16 to 18 months from planting if removed from the parent set out in the spring. Some varieties produce more suckers than slips.

Crowns are the leafy stems on top of fruits, and while they are entirely satisfactory for propagation, they are not often used because they are harvested with the fruits. If desired, both slips and suckers can be left on the plant for months, increasing steadily in size. In spite of being larger than slips, crowns usually need a couple of months longer from planting to harvesting.

If starch-filled vegetative stems are cut before differentiation

of the inflorescence, and the leaves stripped off, they can be used for propagation. A 12-in. stem cut crosswise into discs about ½ in. thick may eventually produce 80-100 small plants, but it may take a year to get all of them started. If the same stem is cut lengthwise into 8 triangular segments, somewhat fewer plants will arise, but the maximum number will develop within 3 months. In either case, the new plants will take a year longer to fruit than slips. The only value of stem sections is in cases where a single plant of a new variety must be multiplied as rapidly as possible.

Planting

In preparation for planting the soil should, if practicable, have large amounts of organic matter turned under, and this should be done sufficiently in advance so that the organic matter becomes well decomposed. If the soil is well drained, and rain water cannot stand on the ground even at the height of the rainy season, the field may be planted in beds at ground level. Otherwise, it is necessary to plant on raised beds with drainage furrows between them. Preferably, level or nearly level ground is used for pineapples.

Soil nematodes and fungi are often serious handicaps. They may be controlled by fumigation before planting with dichloropropane-dichloropropene (DD). This is injected 6 in. deep at the rate of 30-40 gal. per acre about 2 weeks before planting. Even better results may follow 2 applications, 4 weeks and 2 weeks before planting, using 20-30 gal. per acre. Sometimes white grubs in the soil attack the plants, especially when the land has been covered with grass. These are readily controlled with aldrin, using 150 gal. per acre of a solution containing 3 lbs. aldrin per 100 gal. of water. This is applied as a surface spray, followed by disking, and may be done when the ground is being made ready for planting. Ants are also killed by this treatment.

For planting in level beds, double rows are usually preferred, since the rows get some mutual support and the plants are all well exposed to light. The rows are commonly 24 in. apart with plants 12 in. apart in each row but staggered so that a plant in one row is halfway between 2 plants in the other row. The double-row beds are separated by working aisles 3 to 4 ft. wide, depending on variety; more vigorous varieties need wider aisles. From 13,000 to 16,000 plants will be required per acre for double-row planting.

When raised beds must be used, fewer plants can be set per acre and even so, the rows must be closer. On a bed 9 ft. wide, with 6 ft. for water furrow, 5 rows may be planted with 21 in. between rows, and the plants 17 in. apart in the rows. Probably better, when deeper drainage furrows restrict the level top of the bed to 8 ft. in each 15 ft. unit, is to plant 2 double rows 18 in. apart, with a 3-ft. aisle between them, spacing plants 14 in. apart in the rows. Either method gives 10,000 plants per acre.

Whether slips, suckers, or crowns are to be planted, the basal leaves should be removed so as to expose ½ in. or more of the stem and thus permit easy emergence of roots. The freshly stripped stem ends should be exposed to sunlight for a few days before planting to allow callusing of wounds. It is worthwhile to protect plants from later attack by mealybugs and mites by dipping the propagating material in a dispersion of 1 tsp. of demeton(Systox) per gal. of water. (Demeton is very poisonous.) This treatment will keep plants free of the above pests for many months. Then the propagating pieces are pushed into the soil far enough to stand erect when the soil is firmed around their bases. If the soil is fine sand, it may be blown by wind into the top of slips and pack tightly around the bud, stunting growth. To prevent this, put a teaspoonful of castor pomace or cotton-seed meal in the top of each slip immediately after planting

them.

Fertilizing

Pineapples need fairly high levels of available nitrogen and potassium, but only low levels of phosphorus. Indeed, high levels of phosphorus retard intake of nitrogen, delay blooming, and lower fruit quality. Many of the soils used for pineapples are low in potassium, and require this element (as potash) in amounts equal to nitrogen. Some loams and clays may have good amounts of potassium available, and so need only half as much potash as nitrogen. But the phosphoric acid content of pineapple fertilizers is usually only 1/5 the nitrogen content.

In most areas dry fertilizer mixtures are used, and are either applied on the ground close to the plants or placed in the axils of the lower leaves. This latter practice assures maximum utilization of the nutrients, but is likely to cause injury if fertilizers are high-analysis ones with high concentration of soluble salts. Such fertilizer mixtures should be diluted with an equal weight of finely ground organic matter before being put in the leaf axils.

The source of nitrogen most often used for pineapples is sulfate of ammonia, as it is one of the cheapest and gives good results. Cottonseed meal and castor pomace also give good results but are expensive and bulky. Sulfate of potash is the preferred source of potassium, and superphosphate the usual source of phosphorus. On soils which are low in magnesium, half as much magnesia as potash should be included in the mixture, 15-3-15-7 instead of 15-3-15.

A good practice is to place fertilizer in the beds just before planting in a band 2 in. wide or in a shallow furrow between the rows of the 2-row beds. Five hundred lbs. per acre of 15-15-15 (or 750 lbs. of 10-10-10) should be laid down, and no further phosphorus need be applied thereafter. If planting is done in the rainy season,

so that much of this application may be leached away before it can be taken in by the plants, then the first application had better be delayed for 2 or 3 months until some roots have formed. This application can be 500 lbs. per acre of 15-3-15, placed close to the plant bases. As a rough guide, 1 pint of fertilizer weighs about 1 lb., and at the above rate it should be divided among 30 plants (or 1 level tablespoon/per plant).

The second application may be made about 8 months after planting and at the same rate, using 15-0-15 if the first application was 15-15-15, and 15-3-15 if this was used previously. The fertilizer may be applied on the ground near the plants or part of it thrown into the axils of the lower leaves.

The third application should follow in another 8 months, or about 16 months after planting, when flowering is commencing. The same analysis should be used as at 8 months, but the rate may be increased to 650 lbs. This application can be broadcast on the beds.

Immediately after harvest, and again 4 months later, fertilizer should be applied in the same ratio and at the same rate as in the second application above, to bring the ratoon crop to maturity. If the field is continued in production for several years, these two applications should be made annually.

Fertilizer can be applied very successfully in liquid form, either from spray tanks or through overhead irrigation. Urea is better than sulfate of ammonia for this use because it can be applied in more concentrated form without injury. Fifty lbs. of urea and 50 lbs. of sulfate of potash should be dissolved in 500 gal. of water for application to each acre, with applications at intervals of 6 weeks. An initial soil application, (under the row before planting) of 500 lbs. per acre of superphosphate will supply this nutrient need.

The above recommendations are for plantings where soil pests

have been kept under control by pre-planting treatments. Research in Puerto Rico has proved that only half as much fertilizer is needed as is commonly applied if pineapple plants do not suffer from nematodes, soil fungi, white grubs, etc. If these pests are not prevented from attacking the plants, then the fertilizer schedule should be changed to make applications every 4 months instead of every 8 months.

Weed Control

Pineapple plants are very sensitive to weed competition, hence control is essential. Traditionally this has been done by means of the scuffle hoe, the blade of which slides back and forth on the soil surface. Heavy mulching with organic material such as dry grass is very helpful. Chemical herbicides are available which greatly decrease the amount of hand labor needed, but the chemicals are not very cheap. Dalapon is excellent for application before planting to kill grasses and sedges, so that in the first few months the pineapple plants can start growth without competition. When weeds appear in the beds, diuron is one of the safest and most effective spray materials. Monuron is also much used. New chemicals are likely to become available from time to time. Spray dosage is 3 to 5 lbs. in 100 gal. of water, applied every 3 months as a very fine spray, directed as low as possible so that the pineapple leaves receive little.

Harvesting

Pineapples increase in sugar content so long as they remain on the plant and receive sugar from the leaves. A fruit which has not begun to show any yellow color may have 5% sugar; the same fruit if harvested when half of the "eyes" are yellow may have 10% sugar; while fruit harvested at full yellow color may have 12% sugar. Fruits ripen from the base upward, since the oldest flowers were at the bottom of the spike, but there is only a difference of 2 or 3 days between ripening at bottom and top. Fruit harvested at full color can hold

up well for at least a week if cooled at once and shipped cool. If facilities are not available for this, fruit should be harvested when the eyes on the lower half have colored. Such fruit may be held (or shipped) at 48 degrees F. for up to 3 weeks in good condition. Fruit harvested green will never have good quality.

Pineapples for local use of canning can be broken from the fruit stem, but fruit for shipping to a distant market should be cut. Decay fungi will invade the stem-end during shipment and cause internal breakdown unless the stem wound is treated, and the jagged surface left by breaking is very difficult to disinfect properly. The smooth surface left by cutting is easily sterilized by brushing on it a solution of salicylic acid (1g. in 100 ml. of 20% alcohol). Crowns are usually left on the fruits in shipping; if they are cut off to conserve shipping space, the exposed surface should also be treated as above.

Ratoon Crops

The first crop obtained from a new planting is called the "plant crop." The original plant stems can never bear again, but long before the plant crop matures, branches will have arisen on the stems. Usually aerial branches develop before branches arise near or below the soil surface, and about a year after the plant crop matures, fruits should mature on these branches,- the first ratoon crop. New branches continue to develop each year; fields have sometimes continued in production without replanting for 25 years. The fruit size decreases in successive ratoon crops, and with it the yield per acre. The problem is to determine when diminishing yield makes it economically unwise to take further ratoon crops instead of replanting. In most pineapple-growing areas, 2 ratoon crops are considered worthwhile; but in Puerto Rico only 1 is recommended while South Africa 4 may be taken. As an example may be considered data from Australia with

Smooth Cayenne. If 2 ratoon crops are harvested, the average annual yield over the 5 years that the field is in pineapples is 9 tons per acre. If only 1 ratoon crop is harvested, with a 4-year planting cycle, the annual yield is 8 3/4 tons. In this case the second ratoon crop is worth while. In Hawaii the reverse is true.

When it is considered that no further ratoon crops are economical, the field should be plowed right after harvest. The old stems add many tons of organic matter to the soil, which decomposes slowly during a year of fallow. Then the field is prepared again for planting. The cycle of 4 years includes 2 years from planting to plant crop, 1 year of ratoon crop, and 1 year of fallow.

Many animal pests need control, but few fungi attack pineapples. Soil-borne fungi are controlled by soil fumigation before planting, and the fruit-rotting fungi by disinfecting the cut peduncles as previously described.

Mealybugs are probably the most serious insect pests. They crawl down behind the leaf bases and suck juice from the stem, injecting a poison as they feed which causes the leaves to wilt. Heavily infested plants have stunted leaves, reddish-yellow instead of dark green, with dead or dying tips. Some of the lower leaves must usually be pulled off before the insects can readily be detected. While malathion sprays will give control, it is better to prevent development of the pest by dipping in demeton before planting. For field spraying, apply 500 gal. per acre of a dispersion of 3 lbs. of the 25% wettable malathion powder per 100 gal. of water. Ants often help spread mealybugs, hence the desirability of eliminating ants before planting.

Nematodes, especially the rootknot species, are serious pests but easily avoided by fumigation with DD before planting. New land

is usually free of these pests.

The pineapple mite often kills young plants and seriously stunts older ones by its feeding on the leaves. Here, again, prevention by dipping slips in demeton is better than later attempts to cure.

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The genus name, Ananas, comes from the Tupi language of southern Brazil, where this fruit was called nana; it first appeared in Jean de Lery's "Histoire d'un voyage fait au Bresil,", a work published in 1578, where the author speaks of "ananas, plus excellent fruit de l'Amerique". Gonzalo Fernandez de Oviedo, in his classic "Sumario de la natural historia de las Indias", published in 1526, describes briefly the "piña", which he says is one of the "finest fruits in the world", and in his later and more complete work he relates that the Spaniards gave it this name because it looks like a large pine cone, and that it grows not only in the Islands but also on "Tierra Firme" - the mainland. The excellent illustration he presents leaves no doubt as to the identity of the fruit about which he was writing.

Due to the ability of the plant to survive long voyages at sea it reached India as early as 1548. Since modern commercial development of pineapple culture is based to such a large extent on processing, it is worthy of note that the first attempts along this line seem to have been made in Florida, about 1871; the fruits used, however, were not grown locally, but imported. The project was short-lived. Hawaii started canning locally-grown pineapples in 1892, Singapore in 1895. The tremendous modern production of canned pineapples and pineapple juice is well known to everyone. In recent years the industry has extended to numerous tropical countries, while fresh pineapples for export have become a source of income in many regions - though not approaching in volume the processed products.

In spite of being the original home of this delicious and commercially valuable fruit, it is only in recent years that it has received much attention at the hands of horticultural scientists in tropical America. Research on pineapple growing in Hawaii, which produces more pineapples than all the rest of the world put together, has been intensive; much has been done in Malaya, in South Africa, and in Australia. Workers in Puerto Rico deserve much credit for the research which has been conducted in that island, the results of which have been usefully treated in the "Revista de Agricultura de Puerto Rico", Vol, XLIV, No. 1, 1956. A large part of the material included in this chapter is based on that publication. Early experience in Florida, where attention was devoted to pineapple growing in the early years of this century, developed many facts of basic interest as well as familiarity with the characteristics of a considerable number of varieties. There was a time when it was thought that pineapple production in Florida had a bright future. Attention was even devoted to the breeding of new varieties, without, however, important results.

commercial production has been conducted in recent years. Research on pineapple growing has also been extensive in Hawaii, which produces more pineapples than all the rest of the world together, and in other important producers such as Malaya, South Africa, and Australia. Some of these research findings have been incorporated in this discussion, as well as Florida experience, where it seems applicable to tropical American conditions.

Varieties

The 3 principal varieties--Red Spanish, Smooth Cayenne, and Natal Queen--are often considered as the type varieties of 3 groups or races of pineapple. Several less important varieties can be placed in each of these groups, but it is not possible to allocate all varieties thus. In part this may be the result of natural crossing between groups, but more commonly it is due to insufficient pomological study of many local varieties. Sometimes, too, a well-known variety is not recognized because it is grown under a local name.

Red Spanish is characterized by vigorous plants with strong, stiff leaves. The fruits are reddish-yellow when ripe, somewhat barrel-shaped, weighing from 2 to 4 lbs, and white-fleshed. Quality is not very high, but the fruit ships well. The normal season of maturity in the West Indies is early June to July. Slips are usually produced in abundance, while suckers are few. A mutant with smooth leaves, Singapore Spanish, is the chief canning variety in Malaya.

A related variety is the Cabezona, a triploid with fruits weighing 8 to 12 lbs. It is grown on a small commercial scale in Puerto Rico. Pernambuco, Abacaxi, or Eleuthera probably belongs in this group, too, as it has white flesh. Quality is good, because of the small amount of fiber and low acidity. Fruit runs from 2 to 3 lbs., is yellow when ripe, and matures mostly in July. Slips are many and suckers few.

Smooth Cayenne is by far the most important pineapple ~~variety~~ in the world. The plant is vigorous, with long, broad leaves lacking marginal spines. The fruit is normally from 4 to 8 lbs. in weight, ~~with~~ cylindrical, form tapering toward the apex, the rind yellow on the ripe fruit. The somewhat coarse flesh is ~~light~~ yellow in color and of good quality. The variety is chiefly grown for canning, ~~and~~ does not ship very well. ~~The fruit matures chiefly in July and August.~~ Both slips and suckers are usually few. ~~A few~~ related varieties have been grown by greenhouse fanciers, but none commercially. The Esmeralda variety of Mexico ~~seems to~~ be a white-fleshed mutant of Smooth Cayenne.

Natal Queen is a variety of the old Queen group which was selected in South Africa; the Australian Macgregor Queen is very similar. These varieties are much less vigorous than the ones described above, and the fruit size is small, from $1\frac{1}{2}$ to $2\frac{1}{2}$ lbs.; ~~with~~ yellow, ~~rind~~. The flesh is golden yellow, with little fiber and of good quality. Queens mature with Red Spanish and produce ~~very~~ many suckers but few slips.

Abakka (Abachi, Abaca) is another variety of the Queen group sometimes grown commercially in Florida and Puerto Rico on a small scale. Like other Queen types, the plants are rather short and compact; ~~but~~ fruit size is 3 to 4 lbs. Rind and flesh color are like other Queens, but slips are produced more than suckers. Quality is good, but the fruit does not ship very well. ~~The season of maturity is mostly July.~~

In recent years commercial production of Smooth Cayenne has become important in the state of Veracruz, Mexico, mainly for canned and other processed products, and in the state of Yaracuy, Venezuela, for ~~both~~ fresh and ~~produced~~ uses. In the 1920's extensive plantings were made on the Pacific coast of Guatemala ~~of~~ Smooth Cayenne from Hawaii, but the project was a failure because the rich soils of that area produced a fruit of coarse texture and unsatisfactory canning

quality. In this same region, however, though at somewhat higher elevations, Smooth Cayenne ~~this variety~~ is grown satisfactorily for fresh use locally; while around Palin, on the slopes of Volcan de Agua at about 4,000 feet ~~of elevation~~, another pineapple is grown, also for local use. This is a small-fruited variety, white-fleshed and delicious, which has not been identified ~~yet~~ and may or may not be known elsewhere.

The varieties which have commonly been grown in El Salvador, for local use only, are few and of rather indifferent quality, as is true also of a variety grown around San Pedro Sula, Honduras. This appears to be the same as the ~~locally~~ popular Montufar variety of the lower Motagua valley in Guatemala, a variety of ~~uncertain~~ unknown affinity to commercial varieties elsewhere.

The region of Turrialba, Costa Rica, is famous for its pineapples, which are of ~~rather large~~ good size, white-fleshed, and of excellent quality as fresh fruits; but attempts to develop an export trade based on this variety were not successful. The plantings were made near Siquirres, in a ~~hot and~~ very wet region. In part because of climatic conditions, and perhaps in part because an unsuitable variety was chosen, the fruit did not hold up well when shipped in fresh form to the United States, nor did it make a satisfactory canned product. In Panama the Sugarloaf variety grown on Taboga Island is sweet and of excellent quality, and esteemed locally, It is highly as a fresh fruit.

The Cambray pineapple of the Cauca valley in Colombia is ~~highly regarded for fresh use locally~~ a local favorite, as is true also of a variety commonly grown in the region of Milagro, near Guayaquil, Ecuador. ~~Like the varieties mentioned above,~~ It is impossible at present to identify all these local forms or state their affinities. It is to be assumed that most of ~~these varieties of local popularity~~ them have not been found to have the qualities required by the large companies which produce canned

pineapples. Nor is it possible to say how much of their popularity is due to inherent qualities and how much to peculiarly favorable environment.

Commercial production in Florida is not large although it has been carried on for nearly a century. Red Spanish, Natal Queen, Smooth Cayenne, Eleuthera, and Abakka are all grown to some extent for fresh use. In Puerto Rico, Smooth Cayenne and Red Spanish dominate commercial production, with practically all of the Smooth Cayenne and one-third of the Red Spanish going into cans. The remaining Red Spanish is largely exported fresh.

Climate and Soil

The pineapple is a tropical plant, easily injured by frost. There is no growth below 65°F or above 100°F, and a temperature range of 70-80°F is considered would be ideal. Cool weather causes developing fruits to be smaller, with more acid and less sugars; and more subject to physiological breakdown on ripening. High temperatures (above 90°F) produce make fruits high in sugars but low in acid, hence rather insipid. On the equator the most favorable conditions are likely to be found at altitudes of 3,000 to 5,000 ft., whereas at 20° latitude temperatures near sea level are usually favorable.

Pineapples are grown commercially with annual precipitation rainfalls ranging from 25 to 80 inches. While the plants are well adapted to conditions of low rainfall, they do not yield good crops in dry regions unless irrigated. Application of 1 in. of water every 2 weeks during dry periods is recommended. Under high rainfall conditions fruit is excellent in eating quality but does not ship well.

The only important soil characteristic, except that it should be neither saline nor alkaline, is good drainage. Sand, loam, clay, and muck soils are all used for commercial production if they are well drained. Soil for pineapples should be more or less acid. Sandy soils need pH 4.5 to 6.0, while clay soils may run pH 5.5 to 7.0.

Plant Structure and Functions

A pineapple plant in its first year in the field consists of a short, thick stem bearing many long, sword-shaped leaves. As the stem increases in length, new leaves are formed at the apex, and starch is stored abundantly in the stem. The leaves are adapted to keep transpiration at a low value, and are V-shaped, so that rain or dew falling anywhere over the leaf area is conducted to the stem and runs down it to the roots. Usually the leaves have heavy marginal spines, but some varieties are spineless or smooth-margined by mutation. The root system is rather sparse, most of the roots being within a foot of the stem, and in the top 6 inches of soil. In well aerated soil, vigorous plants have short, thick, fleshy roots with a dense coating of roothairs. In poorly aerated soil, roots are long, slender, and tough, with few roothairs. New roots develop from initials already present in the stem tissues at intervals during the active life of the stem, but eventually roots die when the leaf at the base of which they arose dies and ceases to supply them with food. If new vegetative branches of the stem arise and are in contact with the soil, a new root system develops for this branch.

After 10 to 14 months, depending on the size of the plant set out, the growing point of the stem ceases to develop new leaves and begins to form a terminal inflorescence or spike, utilizing the starch previously stored in the stem. After 75 to 150 flowers have formed, the growing point once more begins to produce leaves. Development of red color in the youngest stem leaves marks the end of flower differentiation and the beginning of elongation of the inflorescence stem, lifting the inflorescence several inches above the leafy nest. No more new leaves can develop from the old stem, but it may now form a few lateral branches whose growing points form a succession of leaves in turn.

The uplifted flower spike opens its blue petals from its base upward in the course of a month or so, and then the flower bases develop into a composite fruit consisting of ovaries, fused sepal bases, the bases of the bracts subtending the flowers, and the fleshy axis of the spike. Flowers are self-incompatible

(do not set seeds from their own pollen), ~~and so~~ with the result that in fields planted to a single variety, the fruits are seedless. Pollen of one variety will produce seeds on another variety in most cases, however, hence in mixed plantings fruits may be somewhat seedy. Needless to say, the presence of seeds lowers the value of the fruit. In some varieties the inner portion of the fruit axis is fibrous and not palatable, but in others the whole diameter of the fruit may be eaten except the ~~outer covering. This~~ "rind," formed from the outer lining of the calyx and the bract tips, ~~forms~~ which constitutes a protective covering for the fruit.

From the time when the growing point starts developing a flower spike instead of leaves, to the time when it has finished with flower beginnings and returns to forming terminal leaves, ~~again~~ is about 5 weeks. There is a period of some 6 weeks more to the first open flower on the spike, and about 4 weeks from the first to the last flower. Then it takes about $3\frac{1}{2}$ or 4 months for the fruit to reach ~~development to~~ maturity, ~~or~~ even longer during cool weather. The mature fruit bears at its top a crown of leaves, always very much smaller than the leaves on the vegetative stem.

Forcing the Bloom

Scientists have not yet discovered exactly what causes the growing point of the stem to cease forming leaves and initiate flowers. Both cool nights (around 60°F or below) and short days have been advanced as causes, but while these may account for November differentiation of flower buds in Hawaii or Puerto Rico, differentiation also occurs at this season normally near Singapore, where there is no variation in daylength during the year and temperatures do not go below 70°F.

Horticulturists have long known, however, that certain treatments would bring about differentiation at any time of year. Around 1900 it was found that smoke from burning damp grass would do this. About 1932 the effective agent in smoke was shown to be ethylene gas, and acetylene works just as well and is easier to use. Then in 1942 the well-known growth-regulating chemical naphthalene

acetic acid (NAA) was found to be highly effective for causing pineapple plants to bloom at will. However, plants must attain sufficient size before they are able to produce large fruits and there is little point in trying to cause fruiting at an earlier age than normal. But there are two situations in which forcing the bloom has ~~real~~ advantages. Very commonly only 75% of the plants in a field bloom at the normal time, and treatment can make this 100%. Then again, the ratoon crop from branches of the original plants is likely to mature very unevenly because of the varying ages of the branches, and treatment can bring uniform maturity so that harvesting is much less expensive. It should be noted that inducing bloom with NAA tends to prevent formation of slips.

In most areas where it is desired to force bloom, NAA is preferred because of its ease of application if spray machinery is available. Using the very soluble sodium salt, a solution containing 5 ppm is made by dissolving 2 g. of the salt in 100 gal. of water. This solution is sprayed on the mature plants so that each receives about 50 ml. (1½ oz.), which means that ~~the~~ 100 gal. is put on 7,200 plants. For a small number of plants, one can drop a few small crystals of calcium carbide (about 1/16 tsp.) in the heart of each plant, depending on dew or rain to dissolve the crystals and generate acetylene in place. (Often this injures the leaves.) For large scale use of acetylene, a saturated solution should be prepared, ~~e.g.,~~ by placing 12 oz. of calcium carbide in a 55-gal. steel drum with 36 gal. of water, and rotating the closed drum until the solid is all dissolved. The solution is allowed to flow by gravity into the heart of each plant, allowing about 40 ml. per plant. The gas is easily inflammable. The colder the water the more gas it can hold. A second application a few days after the first assures a high percentage of flower induction.

Propagation

As ~~explained~~ mentioned previously, seeds are often produced when varieties are mixed in a planting, but these seeds are of value only for developing new varieties, and it takes 4 years, often longer, for a seedling to produce its first fruit.

Furthermore, it takes a minimum of 4 years for a seedling to mature a fruit. Hence vegetative propagation is used exclusively, resulting in plants true to type and maturing fruit in 2 years or less. Three types of propagating material are commonly used--slips, suckers, and crowns; it is also possible to use sections of the plant stem.

Slips are branches of the inflorescence, arising either just below the fruit (basal slips) or just above it (crown slips). In Hawaii, slips are also found sometimes half way up the fruit stalk (hapas). All slips are considered to be aborted fruits, represented by the bulbous base, and a leafy crown very much smaller than develops above true fruits. Basal slips are the most common propagating material for most varieties; and should be selected from plants where they developed far enough below the fruit so that they are not attached to it at all. From the time of planting basal slips to harvest is usually 20 to 22 months, for the usual autumn planting.

Suckers are branches of the vegetative stem, arising from buds in leaf axils. They may arise from buds well above the soil (aerial suckers or suckers proper), or from buds on the stem at or below the soil surface (ground suckers or ratoons). The only difference is that ratoons readily develop roots in place, and continue the life of the planting, while suckers must be broken off and planted to develop roots. Being much larger than slips, suckers bear fruit sooner, usually in 16 to 18 months from planting if set out in the spring. Some varieties produce more suckers than slips.

Crowns are the leafy stems on top of fruits, and while they are entirely satisfactory for propagation, they are not often used because they are harvested with the fruits. It is rarely desirable to plant right after harvest, and both slips and suckers can be left on the plant for months, increasing steadily in size. In spite of being larger than slips, crowns usually need a couple of months longer from planting to harvesting.

If the starch-filled vegetative stems are cut before differentiation of the inflorescence, and the leaves stripped off, the ~~starch-filled stems~~ can be used for propagation. A 12-in. stem cut crosswise into discs about 1/4 in. thick may eventually produce 80 to 100 small plants, but it may take a year to get all of them started. If the same stem is cut lengthwise into 8 triangular segments, somewhat fewer plants will arise, but the maximum number will develop within 3 months. In either case, the new plants will take a year longer to fruit than slips require. The only value of stem sections is in cases where a single plant of a new variety must be multiplied as rapidly as possible.

Planting

In preparation for planting the soil should, if practicable, have large amounts of organic matter turned under, and this should be done sufficiently in advance so that the organic matter becomes well decomposed. If the soil is well drained, and rain water cannot stand on the ground even at the height of the rainy season, the field may be planted in beds at ground level. Otherwise, it is necessary to plant on raised beds with drainage furrows between them. Preferably, Usually, level or nearly level ground is used for pineapples. Soil nematodes and fungi are often serious handicaps. They may be controlled by fumigation before planting with dichloropropane-dichloropropene (DD). This is injected 6 in. deep at the rate of 30-40 gal. per acre about 2 weeks before planting. Even better results may follow 2 applications, 4 weeks and 2 weeks before planting, using 20-30 gal. per acre. Sometimes white grubs in the soil attack the plants, especially when the land has been covered with grass. These They are readily controlled by with aldrin, using 150 gal. per acre of a solution containing 3 lbs. aldrin per 100 gal. of water. This is applied as a surface spray, followed by disking, and may be done when the ground is being made ready for planting. Ants are also killed by this treatment.

For planting in level beds, double rows are usually preferred, since the rows get some mutual support and the plants are all well exposed to light. The rows are

commonly 24 in. apart, with plants 12 in. apart in each row but staggered so that a plant in one row is halfway between 2 plants in the other row. The double-row beds are separated by working aisles 3 to 4 ft. wide, depending on variety; more vigorous varieties need wider aisles. From 13,000 to 16,000 plants will be required per acre for double-row planting.

When raised beds must be used, fewer plants can be set per acre and even so, the rows must be closer. On a bed 9 ft. wide, with 6 ft. for water furrow, 5 rows may be planted with 21 in. between rows, and the plants 17 in. apart in the rows. Probably better, when deeper drainage furrows restrict the level top of the bed to 8 ft. in each 15 ft. unit, is to plant 2 double rows 18 in. apart, with a 3-ft. aisle between them, and spacing plants 14 in. apart in the rows. Either method gives 10,000 plants per acre.

Whether slips, suckers, or crowns are to be planted, the basal leaves should be removed so as to expose 1/2 in. or more of the stem and thus permit easy emergence of roots. The freshly stripped stem ends should be exposed to sunlight for a few days before planting to allow callusing of wounds. It is worthwhile to protect plants from later attack by mealybugs and mites by dipping the propagating material in a dispersion of 1 tsp. of demeton (Systox) per gal. of water. (Demeton is very poisonous.) This treatment will keep plants free of the above pests for many months. Then the propagating pieces are pushed into the soil far enough to stand erect when the soil is firmed around their bases. If the soil is fine sand, it may be blown by wind into the top of slips and pack tightly around the bud, stunting growth. To prevent this, put a teaspoonful of castor pomace or cotton-seed meal in the top of each slip immediately after planting them.

Fertilizing

Pineapples need fairly high levels of available nitrogen and potassium, but only low levels of phosphorus. Indeed, high levels of phosphorus retard intake of nitrogen, delay blooming, and lower fruit quality. Many of the soils used for pineapples are low in potassium, and require this element (as potash) in amounts

equal to nitrogen. Some loams and clays may have good amounts of potassium available, and so need only half as much potash as nitrogen. But the phosphoric acid content of pineapple fertilizers is usually only 1/5 the nitrogen content.

In most areas dry fertilizer mixtures are used, and are either applied on the ground close to the plants or placed in the axils of the lower leaves. This latter practice assures maximum utilization of the nutrients by the plants, but is likely to cause injury if fertilizers are high-analysis ones with high concentration of soluble salts. Such fertilizer mixtures should be diluted with an equal weight of finely ground organic matter before being put in the leaf axils.

The source of nitrogen most often used for pineapples is sulfate of ammonia, as it is one of the cheapest and gives good results. Cottonseed meal and castor pomace also give good results but are expensive and bulky. Sulfate of potash is the preferred source of potassium, and superphosphate the usual source of phosphorus. On soils which are low in magnesium, half as much magnesia as potash should be included in the mixture, e.g., 15-3-15-7 instead of 15-3-15.

A good practice is to place fertilizer in the beds just before planting in a band 2 in. wide or in a shallow furrow between the rows of the 2-row beds. Five hundred lbs. per acre of 15-15-15 (or 750 lbs. of 10-10-10) should be laid down, and no further phosphorus need be applied thereafter. If planting is done in the rainy season, so that much of this application may be leached away before it can be taken in by the plants, then the first application had better be delayed for 2 or 3 months until some roots have been formed. This application can be 500 lbs. per acre of 15-3-15, placed close to the plant bases. As a rough guide, 1 pint of fertilizer weighs about 1 lb., and at the above rate it should be divided among 30 plants (or 1 level tablespoon per plant).

The second application may be made about 8 months after planting and at the same rate, using 15-0-15 if the first application was 15-15-15, and 15-3-15 if this was used previously. The fertilizer may be applied on the ground near the plants or thrown ~~in part or whole~~ part of it into the axils of the lower leaves.

The third application should follow in another 8 months, or about 16 months after planting, when ~~blooming~~ flowering commencing is ~~beginning~~. The same analysis should be used as at 8 months, but the rate may be increased to 650 lbs. This application can be broadcast on the beds.

Immediately after harvest, and again 4 months later, fertilizer should be applied in the same ratio and at the same rate as in the second application above, to bring the ratoon crop to maturity. If the field is continued in production for several years, these two applications should be made annually.

Fertilizer can be applied very successfully in liquid form, either from spray tanks or through overhead irrigation. Urea is better than sulfate of ammonia for this use because it can be applied in more concentrated form without injury. Fifty lbs. of urea and 50 lbs. of sulfate of potash should be dissolved in 500 gal. of water for application to each acre, ~~and~~ with applications ~~made every~~ at intervals of 6 weeks. An initial soil application, (under the row before planting) of 500 lbs. per acre of superphosphate will supply this nutrient need.

The above recommendations are for plantings where soil pests have been kept under control by pre-planting treatments. Research in Puerto Rico has proved that only half as much fertilizer is needed as is commonly applied if pineapple plants do not suffer from nematodes, soil fungi, white grubs, etc. If these pests are not prevented from attacking the plants, then the fertilizer schedule should be changed to make applications every 4 months instead of every 8 months.

Weed Control

Pineapple plants are very sensitive to weed competition, hence ~~so that weed~~ control is essential. Traditionally this has been done by means of the scuffle hoe, the blade of which slides back and forth on the soil surface. Heavy mulching with organic material such as dry grass ~~hay~~ is very helpful ~~in weed control also.~~ Chemical herbicides are available which greatly decrease the amount of hand labor needed, but ~~although~~ the chemicals are not very cheap. Dalapon is excellent for application before planting to kill grasses and sedges, so that in the first few months the pineapple plants can start growth without competition. When weeds appear in the beds, diuron is one of the safest and most effective materials, ~~to~~ spray ~~on them~~. Monuron is also much used, ~~and other~~ new chemicals are likely to be come available from time to time. Spray dosage is 3 to 5 lbs. in 100 gal. of water, applied every 3 months as a very fine spray, directed as low as possible so that the pineapple leaves receive little.

Harvesting

Pineapples increase in sugar content so long as they remain on the plant and receive sugar from the leaves. A fruit which has not begun to show any yellow color may have 5% sugar; the same fruit if harvested when half of the "eyes" are yellow may have 10% sugar; while fruit harvested at full yellow color may have 12% sugar. Fruits ripen from the base upward, since the oldest flowers were at the bottom of the spike, but there is only a difference of 2 or 3 days between ripening at bottom and top. Fruit harvested at full color can hold up well for at least a week if cooled at once and shipped cool. If facilities are not available for this, fruit should be harvested when the eyes on the lower half have colored. Such fruit may be held (or shipped) at 48°F for up to 3 weeks in good condition. Fruit harvested green will never have good quality.

Pineapples for local use or canning can be broken from the fruit stem, but fruit for shipping to a distant market should be cut. Decay fungi will invade the stem-end during shipment and cause internal breakdown unless the stem wound is treated, and the jagged surface left by breaking is very difficult to disinfect

properly. The smooth surface left by cutting is easily sterilized by brushing on it a solution of salicylic acid (1g. in 100 ml. of 20% alcohol). Crowns are usually left on the fruits in shipping; if they are cut off to conserve shipping space, the exposed surface should also be treated as above.

Ratoon Crops

The first crop obtained from a new planting is called the "plant crop". The original plant stems can never bear again, but long before the plant crop matures, branches will have arisen on the ~~plant~~ stems. Usually aerial branches develop before branches arise near or below the soil surface, and about a year after the plant crop matures, fruits should mature on these branches, the first ratoon crop. New branches continue to develop each year; ~~and~~ fields have sometimes continued in production without replanting for 25 years. The fruit size decreases in successive ratoon crops, and with it the yield per acre. The problem is to determine when diminishing yield makes it economically unwise to take further ratoon crops instead of replanting. In most pineapple-growing areas, 2 ratoon crops are considered worthwhile; but in Puerto Rico only 1 is recommended while in South Africa 4 may be taken. As an example may be considered data from Australia with Smooth Cayenne. If 2 ratoon crops are harvested, the average annual yield over the 5 years that the field is in pineapples is 9 tons per acre. If only 1 ratoon crops is harvested, with a 4-year planting cycle, ~~the annual yield is harvested, with a 4-year planting cycle,~~ the annual yield is 8 3/4 tons. In this case the second ratoon crop is worthwhile. In Hawaii the reverse is true.

When it is considered that no further ratoon crops are economical, the field should be plowed right after harvest. The old stems add many tons of organic matter to the soil, which decomposes slowly during ~~the~~ a year of fallow. Then the field is prepared again for planting. The ~~planting~~ cycle of 4 years includes 2 years from planting to plant crop, 1 year of ratoon crop, and 1 year of fallow.

Pests

Many animal pests need control, but few fungi attack pineapples. Soil-borne fungi are controlled by soil fumigation before planting, and the fruit-rotting fungi by disinfecting the cut peduncles as previously described.

Mealybugs are probably the most serious insect pests. They crawl down behind the leaf bases and suck juice from the stem, injecting a poison as they feed which causes the leaves to wilt. Heavily infested plants have stunted leaves, reddish-yellow instead of dark green, with dead or dying tips. Some of the lower leaves must usually be pulled off before the insects can readily be detected. While malathion sprays will give control, it is better to prevent development of the pest by dipping in demeton before planting. For field spraying, apply 500 gal. per acre of a dispersion of 3 lbs. of the 25% wettable malathion powder per 100 gal. of water. Ants often help spread mealybugs, ~~and thus~~ hence the desirability of eliminating ants before planting.

Nematodes, especially the rootknot species, are serious pests but easily avoided by ~~preplanting~~ fumigation with DD before planting. New land is usually free of these pests.

The pineapple mite often kills young plants and seriously stunts older ones by its feeding on the leaves. Here, again, prevention by dipping slips in demeton is better than later attempts to cure.

~~Chapter 3~~ THE PINEAPPLE

~~The Pineapple~~

The pineapple, Ananas comosus (L.) Merr., is commercially the most valuable of the horticultural fruits native to the Americas. It is known only as a cultivated plant, as is true of the orange, but ~~three~~ several closely related wild species are found in ~~southern~~ Brazil ~~and this~~ which almost certainly the country is ~~surely the place~~ in which the pineapple originated. The genus name, Ananas, comes from the Brazilian Tupi Indian name, nana, and first appeared in Jean de Lery's "Histoire d'un voyage fait en Bresil" in 1578: "ananas, plus excellent fruit de l'Amerique." From ~~southern~~ Brazil the pineapple had spread northward, and by 1492 it was before being cultivated in Middle America and the islands of the West Indies. ~~Indeed, already at this time the three principal types or races of pineapple--Spanish, Cayenne, and Queen--were well established.~~

From America the pineapple was early introduced to Europe and Asia by the Spanish and Portuguese, thanks to the ability of the plants to endure the many weeks of travel on sailing vessels, and by 1548 it was in India. The first record of commercial canning seems to have been in Florida in 1871, but this was of imported fruits and did not continue long. Hawaii started canning home-grown pineapples in 1892, and Singapore in 1895, and these industries have continued to grow. Today the production of pineapples for canning far exceeds production for marketing fresh.

The names "pineapple" in English and "piña" in Spanish reflect the similarity of the fruit in external appearance to large pine cones which impressed early European travellers. These are the names by which pine cones were known, and were simply transferred to the strange, new American fruit.

Although native to the area, pineapple culture has had little scientific attention in most tropical American countries. In some of them, however, notably in Puerto Rico, a great deal of valuable research with a view to profitable

THE PINEAPPLE

Today the pineapple, botanically Ananas comosus, is commercially the most valuable of the horticultural fruits native to the Americas, ~~xxxxxxx~~ Like the orange, it is known only as a cultivated plant, but wild forms from which cultivated varieties have ~~xxxxxxxx~~ been developed are abundant in Brazil and adjacent regions. The facility of vegetative propagation by means of suckers and "slips" made it possible for the indigenous inhabitants of pre-Columbian America to perpetuate superior variations or mutations, which was not so simple with food plants which were grown from seed. The art of grafting does not seem to have been known to the ancients. Thus it is that today's pineapples probably are not greatly different from those which had, long before the Discovery, spread from South America into the West Indies and on the mainland perhaps as far north as Southern Mexico.

The genus name, Ananas, comes from the Tupi language of southern Brazil, where this fruit was called nana. It first appeared in Jean de Lery's "Histoire d'un voyage fait au Bresil", an interesting work published in 1578, where the author speaks of "ananas, plus excellent fruit de l'Amerique". Oviedo The name "pineapple" in English and "piña" in Spanish reflect the similarity of the fruit in external appearance to a large pine cone. Due to the ability of the plant to survive long voyages at sea, it reached India as early as 1548. ~~xxxxxxxxxxxxxxxx~~ Since modern commercial development of the pineapple is based to such a large extent on processing, it is worthy of note that ~~xxxxxxxxxxxxxxxx~~ the first attempts along this line seem to have been made in Florida (1871); imported pineapples were used, the fruits were not grown locally but were imported and the project was short-lived. Hawaii started canning locally-grown pineapples in 1892, and Singapore in 1895. The tremendous modern development of canned pineapples and pineapple juice is well known to

everyone. In recent years the production of canned pineapples, juice and other products has extended to numerous tropical countries, while fresh fruit for export has also become a source of income in many regions - though not approaching in volume the processed products.

In spite of being the original home of this delicious and commercially important fruit, it is only in recent years that it has received much attention at the hands of scientists in Tropical America. Research on pineapple growing in Hawaii, which produces more pineapples than all the rest of the world put together, has been intensive; much has been done also in Malaya, South Africa, and Australia.

Workers in Puerto Rico deserve great credit for the research which has been conducted in that Island, the results of which have been usefully treated in the "Revista de Agricultura de Puerto Rico, Vol. XLIV, No. 1 (1956), which has served as the basis of much of the material included in this chapter. A large part is based on that publication. Early experience in Florida, where attention was devoted to the possibilities of pineapple growing in the early years of this century, also developed numerous facts of basic interest, as well as familiarity with the chracteristics of a considerable number of varieties. There was a time when it was thought that pineapple production in Florida had a bright future; and attention was even devoted to the breeding of new varieties, without, however, important results.

Collins, J. L. History, Taxonomy and Culture of the Pineapple. Economic Botany. 3 (1949) 335-

Does he have much to say about varieties and their classification?

Just lists SC, RS, 1 & 2 as 3 most important varieties. Minor = Perhaps Monte Lirio. No classif.

Hilo is a variety or a strain of Smooth Cayenne characterized by an almost complete failure to develop slips, and by a more cylindrical shape which fits into cans better. Size of fruits and plants is a little smaller than in standard Smooth Cayenne, and both sugar and acid are a little lower. The strain seems to have reached Hawaii before 1890, but only attracted attention much later. It now constitutes a ~~considerable~~ small portion of the Hawaiian crop, but is not known to be grown elsewhere.

Hilo was 8% of crop in 1950

In Hawaii the use of asphalt paper mulch has long been standard practice for weed control; ~~but of the other areas of commercial pineapple production, only~~ the Caribbean island of Martinique has also adopted this usage. The paper mulch is especially effective in preventing weed competition when the plants are very small and least able to endure it. In addition the mulch conserves soil moisture, reduces leaching of mineral nutrients, and keeps the soil warmer during the cooler months. It lasts about 15 months and can only be used once. Young plants grow faster under the mulch and a higher percentage fruit than without it. The biggest disadvantage of paper mulch is its relatively high cost. In Hawaii it is estimated to cost about $60 annually per acre, and to give a 20% increase in yield.

Asphalt-impregnated paper is used of 32 in. width, and laid down with soil covering both edges to keep it in place. Holes are made 6 in. from each edge and 12 in. apart in the row, staggered so that they are not opposite each other. The plants are set in place through these holes, the locations of which should be marked on the paper before it is laid; or better, the holes may be made before laying. In the highly mechanized industry of Hawaii, great machines inject soil fumigants and fertilizer, and lay the paper on long flat beds.

On some soils, especially those which are not acid or which have a high manganese content, pineapple plants may have yellow leaves because of deficiency of available iron. This condition is easily corrected by spraying the plants with an 0.5% solution of $FeSO_4$. This may be done every 2 weeks where the condition is chronic, or applied as needed when symptoms only appear irregularly.

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Hilo is a selection from Smooth Cayenne which was made in Hawaii and is planted there to some extent. It differs from the parent variety in forming more suckers but no slips, in slightly smaller plant and fruit size, and in more cylindrical fruit shape--a very desirable canning feature. Hilo fruit has more yellow color when ripe than does Smooth Cayenne, with slightly lower content of both sugars and acid, and more rapid deterioration after reaching full ripeness.

Mango

Storage – best 50°F 2-3 weeks; some var. longer (at 50 but injury + decay in others. Below 50 gen. unsuit.

Pests – Brazil has blight + dry rot caused by Ceratocystis fimbriata. Prune + spray with DDT.

Pineapple

Mulch – In Mart. 1966 + Guad. new method is use of black polyethylene on double-row beds. Sheet 70 cm wide extends 15 cm beyond double (70 cm) rows. The poly. protects soil from erosion, keeps down weeds, promotes root growth by raising soil temp; but also favors soil fungi attacking roots injured by nema or soil insects, so must treat soil before planting to kill these. Yields are increased by poly thus. (Enough to make profit?)

In Guiana black poly also very good.

In Virgin Is., no mulching was profitable. Best yields with no mulch + 400 lb/a 10-4-20 after planting before and 7 mo.

In Hawaii, research shows on one important soil type that chief value of mulch is raising soil temp. in winter months of first year, + clear poly. are effective as black poly. Effect on soil moisture was little and usually negative

Storage – best storage for 7-14 days at 45-50°F for mature green fruits.

Fert – In Queensland, preplanting appl. 240 lb/a K and 176 lb/a/yr of N to flowering; 350 lb/a/yr after harvest as urea spray every 5 weeks.

Spacing – In Taiwan, using selected strain of Sm Cay, found highest yield with 16,600 ~~7500~~ plants/a.

Culture in Colombia – 2500 ha (6200 a), mostly on poor, non-irr. soils up to 1500 m. Ave yield 20 tons/ha/yr 8 tons/a/yr

Macadamia

Pest – In Costa Rica, young trees much injured or killed by girdling shoots by the Trigona bee. Spraying not effective Destroy nests.

Prop – In NS Wales, seedlings cleft tip grafted at 6 weeks. Germ. in peat moss + use wedge. 50% succ. To field at 15 mo.

In S. Africa – whip or splice graft was best, using 2-yr. stocks + 2-yr twigs as scions.

In P

Guava

Fruit fly – In Venez., spray with 1% protein hydrolysate + 300 g. malathion or 100 g. diazinon in 250 l. water every 10 days for 2 months beginning at fruit set. Need spray only 1/3rd in N

Prop. – In Puerto Rico. stem cuttings dipped in 200 ppm IBA rooted well under intermittent mist.

Lychee Rambutan

Prop. – In Punjab, 250 ppm IBA in lanolin paste reduced rooting time of marcots from 100 to 70 days. March best month.

In Phil. Is., besides marcots, success with patch buds of dormant May-June (after rains begin).

Cashew — Hardy to drought — grows + fruits well with 20" rainfall up to 70-80" if soil is well drained. Tolerant [illegible] requir.
Insect poll. usually important. From 3-10% of ♂ flowers set. Usually 25% or less of flowers are ☿, mostly ♂.
About 60 days to maturity. Seeds of high sp gr give high germ + greater vigor of seedlings. (Should sink in water.)
(whip-graft recom. in Mozamb.) Veg. prop. by marcotte, grafting (side?), budding (patch), + even cuttings (not always). More expen. but can prop. only high yielders.
Seeds are planted in situ at 2-3" depth, with base up.
Spacing 10-12' if no intercrop, but should thin after trees begin to crowd to 30-40'.
Usually no fert. even in poor soils unless nutr. def. appear. Usually compost or manure in planting hole.
Weeding import. until trees shade ground (2-3 yrs if 10-12' spacing). Intercropping on fairly fertile soil with [illegible].
Harvest fallen fruits or pick ripe apples. Ave yield at 3 yrs = 4-8 lbs, but big tree variation.
Only serious disease in Brazil, India, + E. Afr. = anthracnose (dieback) - Gloeosporium sp. Prune + Cu spray.
Mildew in El Salv. (S spray)
Stem borers major pest; hard to control by spray. Prune + burn infested twigs + destroy eggs, grubs + pupae.
Thrips locally severe.
Brazil, Panama, El Salv. have comm. crop. Very attractive crop for small farmer where too dry for other crops.

Avocado — FSHS 1963 - Popenoe - 3 lbs N/yr, in 2 or 3 appl., was enough for 12 yr old trees in Dade Co.

Lecythis ollaria — In Venez, nuts contain toxic levels of Se. Possibly widespread hazard to health.

~~Pineapple — Fruits 21:229, 1966 New method of culture in Mart. + Guad. = beds covered with black polyethylene 70 cm wide, extending 15 cm beyond double rows of plants. The poly protects soil from erosive rain + keeps down weeds + promotes root growth by higher soil temp. But it favors soil fungi attacking roots injured by nemas + soil insects, so must control nemas before planting.~~

Chirimoya — Large bags use 2% DDT on young fruit to control Bephrata + chlordane for leaf miners.

~~Pineapple — Colombia - 2000 ha., mostly poor, non-irrigated soils up to 1500 m. Av. yield 20 tons/yr. (Etc.?)~~

~~Decid. Fr. — Span 5:121-123, 1963 Blandy: Growing dec. fr. in tropics~~

~~Rambutan — Philippines - besides marcotts, patch budding is very successful if done in rainy season.~~

Patiño, V.M. Plantas cultivadas y animales domesticos en America equinoccial.
Tomo I: Frutales. Cali. Imprenta Departmental, 1963. Wein?

Pineapple — Proc. Soil Sci. Soc. Amer. 31:270, 1967 Black paper poly. in Hawaii ~~[illegible]~~
Considers effect of mulch on soil temp. in winter is chief reason for incr. yield (+ growth).
60% of soil surface is covered. 90 cm. strip is laid on bed 1.525 m. wide. Slips set 15 cm from each edge (60 cm between rows).
Very little effect of mulch on soil moisture — small negative effect even. Clear plastic as good as black(?) [illegible]

Pejibaye

Johannessen, C.L. Pejibayes in commercial production. Tropical Agriculture 16:151– , 1946

Native S. Honduras to Bolivia, from 0–1200 m. elev., the crop decreases above 700 m. Needs high soil moisture and does best in areas of heavy rainfall (over 100") with little dry period. Needs high temp. (>60°F mostly over) in interest of speed. Good alluvial soils along rivers are very satisfactory.

Fruits 2–6 cm. long, round, ellipsoidal, or pyramidal. Color yellow, orange, red, or green-brown and dull. Mealy (waxy) Occasional trees have seedless fruit, highly valued. Fruit high in vit A and starch, also riboflavin and

Racemes may have 300 fruits + weigh up to 25 lb; up to 12 racemes on trunk and may have 2 blooms (crops) a year.

Spines 2–5" long cover trunks of 70–90% of trees. 1½% of trees in CR are spineless, +1–30% have varying degr.

Must have real trunk before determination where spineless or not.

Suckers can be cut off + rooted. Big help to mix Mg. chloride in soil of planting hole to prevent insect infestation

Do not plant deeper than 1" above roots growing from sucker base.

Harvest racemes by cutting free; need cushion of some sort to prevent spine injury when it falls (3–6 m)

[Spines can only be cut from 5–8 ft. of trunk in any one season; over 5 yrs. a 35' trunk could be cleared.]

Fruit saves in 3–4 days unless in cold storage (35–40°F) where keeps 3 weeks. Sept–Dec is main season in CR

Cost of production is only 15% of price usually sold by farmer from middle man.

Only seeds from large, deep colored fruits & good flavor should be planted + preferably from spineless trees.

Citrus

Weed Control -

Florida - Young - diuron 3.2 lb/a 2x/yr or 6.4 lb/a 1x/yr for ann. gr. + bdlf. weeds
Bearing - diuron 6.4 lb/a or simazine 9.6 lb/a (+ dalapon for per. gr. or bromacil 12-20 lb/a 2.0-2.5 lb/a in 3 appl. at 3-day intervals)

Calif. - Young
Bearing - diuron 12-30 lb/a, simazine 30-40, monuron 8-20, dalapon 3-6

Nitrogen - In Fla. on Lakeland sand, 70% of applied N is lost by leaching. Mixture of sol. + insol. sources of N no better than all sol. N.

Citrus thrips - In Barbados, introd. parasites Eretmocerus + Prospaltella (effective in warm-wet climate) control well. (better for mite)

Scales - Guthion controls variety of scales + whitefly, about like parathion

Passiflora - In Colombia, Hawaiian yellow form yielded more than strains from Brazil + Venez. 2 crops/yr at Cali and 6 tons/a/yr yield them.

Akee - Aril toxicity due to hypoglycine.

Avocado - Ripen best at 65°F. Store best at 40°F for cold-hardy varieties (Gx WI), but cold injury at 50°F for some WI.