

**HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII**

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

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BANANA CULTURE IN HAWAII

BY

W. T. POPE, Horticulturist



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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[Under the supervision of the Office of Experiment Stations, United States Department
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Banana culture in the Hawaiian Islands has received much attention since the establishment of the Hawaii Experiment Station in 1901, and especially since the close of the World War, when interest in the crop increased. Banana production now ranks third in importance of the local agricultural industries, and the fruit surpasses all other food crops in yield per acre. The Territory has a dozen banana varieties of commercial value, four of which are known to export trade, and several others have commercial possibilities.

This bulletin directs attention to the comparatively easy culture of the banana in Hawaii, where large areas can be brought into fruit production in a short time. The plant has few enemies such as insect pests and diseases and is seldom damaged by the wind, and demand for the fruit is growing on the markets of the mainland. Local demands for fruit of a higher grade also are increasing. The banana is, for these reasons, deserving of greater scientific study than it has yet received.

HISTORY AND DISTRIBUTION

The origin of the banana and the story of its development through the centuries is of considerable importance to modern agricultural science. The plant is believed to be indigenous to the warm, moist regions of southern Asia, and was found in cultivation in vast areas in the valley of the Indus as early as 327 B. C. by the army of Alexander the Great. Bas-reliefs on the monuments of ancient Assyria and Egypt indicate its early culture, and recent investigations regarding its early history and morphological development show that it was one of the first foods of man and also one of the earliest plants to be cultivated by him. Fraser (*12*)¹ states that

¹ Reference is made by number (*italic*) to Literature cited, p. 47.

early inhabitants of the East believed that the banana plant was the source of good and evil and that the serpent which tempted Eve hid in a bunch of the fruit. Undoubtedly this legend influenced the early classifiers who designated two species of the plant as *Musa paradisiaca* (Fruit of Paradise) and *M. sapientum* (Fruit of Knowledge).

The banana is widely scattered over the tropical world and is most successfully cultivated in a hot, damp climate. In many countries it is as important to the inhabitants as are grain plants to those living in cooler regions. The northern limit of cultivation, usually of the Cavendish variety, is reached in Florida south of 29° latitude, in the Canary Islands, and in Egypt; the southern limit in South Brazil, Natal, East Africa, and in the southern part of Queensland, Australia.

The term "Hawaiian bananas" includes a number of varieties in use by the natives when the islands became known to Europeans following the discovery by Captain Cook in 1778. As a result of the study of the people and flora of the Hawaiian Islands it is thought that the banana was dispersed among the Pacific Islands by the Polynesians in their migrations, as the bulblike rhizomes, when partly dry, prove admirably adapted to long distance transportation, and varieties found growing in these islands exist in other island groups of the tropical Pacific. The Maoli group of bananas, for example, is in many respects very similar to that known by the same name in other islands of the south and central Pacific. There are also related varieties of both the Hawaiian Iholena and Popoulu groups. The Maia hapai banana of Hawaii has the unusual habit of maturing its fruit within the trunk (13, p. 53), which is characteristic of a variety in Java. The Hawaiian varieties are practically all of the starchy plantainlike kind—most palatable when they are cooked—and their botanical characters are more like those of varieties of the species *sapientum* than of the species *paradisiaca*, to which the plantain is usually assigned.

The Polynesians fully appreciate the importance of establishing these seedless food plants where neither drought nor flood can exterminate them. The corms are planted in the higher mountain gorges where they are insured against lack of moisture, and freshets aid in distributing certain of the rootstocks and suckers throughout the valleys below. The response which most of these varieties make to cultivation gives evidence that they are highly developed fruit plants which once were adapted to cultivation, but in recent times have passed into a semiwild condition.

NOMENCLATURE

The common name "banana" was adopted from the language of an African Kongo tribe, and first came into use during the sixteenth century. Prior to that time the fruit was called "apple of Paradise" and "Adam's fig." The name "banana" seems to have been borne for a long period by the fruit which was eaten raw. The term "plantain" was given to a variety which, though closely related to the banana, is edible only after being cooked. Both these fruits belong to the genus *Musa* of the Musaceæ or Banana family, natural order Scitaminaceæ. The botanist Linnæus (1707-1778) gave the

generic name *Musa* to the banana group in honor of Antonius Musa, a learned physician of the early Roman Empire.

Notwithstanding the fact that the banana was an important agricultural crop even before the time of written records, its specific and varietal relations have never been well defined. About 1750 an attempt was made to establish several of the leading species. The name *sapientum* (affording wisdom) was given to the banana and that of *paradisiaca* (pertaining to Paradise) to the plantain to differentiate the species of the genus *Musa*. Later, the name *cavendishii* was given to another species of the banana. Other species have since been added and hundreds of so-called varieties brought into cultivation, but few have been completely described. Quiesumbing (15, p. 10) states that 77 species have been described. In the work of Baker (6, p. 205) three subdivisions of the genus *Musa* were made: *Eumusa*, *Rhodochlamys*, and *Physocaulis*. The subdivisions are based on well differentiated characters, mainly pertaining to the floral parts, and are described in detail by Fawcett (11, p. 263), and in the Kew Bulletin for 1894 (1).

What determines the difference between bananas and plantains is a problem under the present method of classification. Some botanists are of the opinion that the species *sapientum* and *paradisiaca* are the same, with very marked variations, whereas others believe that the former is a subspecies of the latter. Schumann (18, p. 19) places *sapientum* as a subspecies of *paradisiaca*. The proper use of the terms "plantain" and "banana," or the specific names *sapientum* and *paradisiaca* is uncertain, because of the lack of uniform nomenclature for the different forms. A variety has a different name in almost every country where it is grown, the standard commercial varieties of American trade proving no exception. The most widely grown commercial variety, for example, is known in different places as Martinique, Jamaica, Gros Michel, and Bluefields. The leading commercial banana of Hawaii is also known by such names as Cavendish, Dwarf, Governor, and Chinese. The native varieties also often have different names in different parts of the same island. In most banana-growing countries a variety may be known by different names in the same locality. Some varieties make a much greater vegetative growth in one locality than in another, and may derive their names from the nature of their growth.

In Hawaii several other genera of plants which are closely related to the genus *Musa* include the *Canna*, *Ravenala*, *Strelitzia*, and *Heliconia*.

CHARACTERS

A thorough knowledge of the characters of the banana plant is essential to those seriously attempting its culture. The seedless varieties, by reason of their easy culture, high food value, and immense yields, have become well established, whereas the function of the flower and the possibility of creating new varieties through seed production have not received the attention they deserve.

HABITS OF GROWTH

The banana plant, as commonly understood, is a tropical herbaceous perennial which assumes treelike proportions, some of the larger species often reaching 30 or more feet high. The parts of the plant,

though somewhat fibrous, are coarse in structure and often contain as much as 85 per cent water (16, p. 17). The trunk and large leaves present an ornamental appearance and the flowers and fruit particularly are interesting botanically.

ROOTS

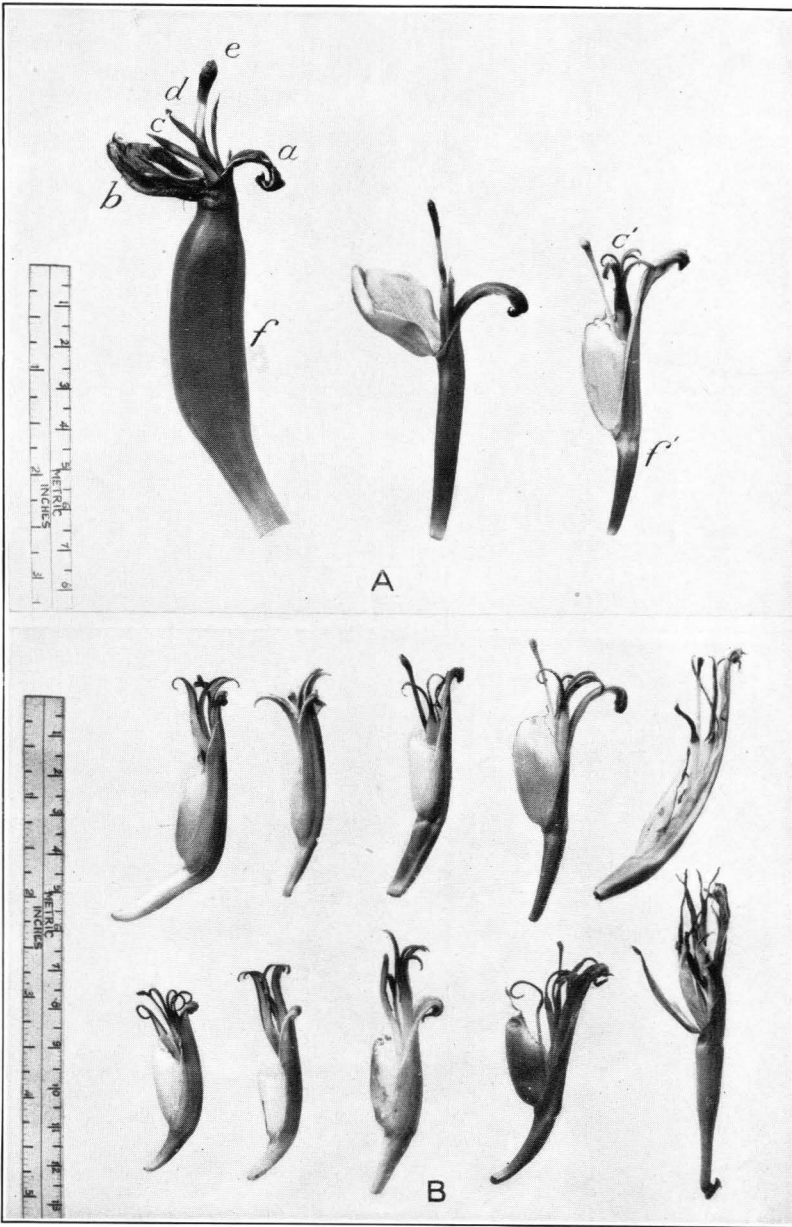
The root system consists of two sets of roots, the horizontal and the vertical; the former, which is the superior, radiates from around the bulb, whereas the latter extends downward from the base. The main roots are tough and cordlike and of nearly uniform thickness throughout, possessing numerous short, threadlike secondary roots or rootlets growing out at right angles. Both main and secondary roots bear numerous root hairs, or feeders, which absorb liquid plant food from the soil. The food passes along the fibrovascular system of cells of the roots, bulb, and stems, to the leaves. Investigation shows that the banana roots, unlike those of many other plants, can not adapt themselves to adverse conditions, such as sour or heavy soil. The distance to which they extend depends largely upon the nature of the soil. Under favorable conditions the horizontal roots may be found at a depth of 6 inches to 2 feet, and the vertical roots 6 inches to 6 feet, both growing at the rate of 2 feet per month.

STEM

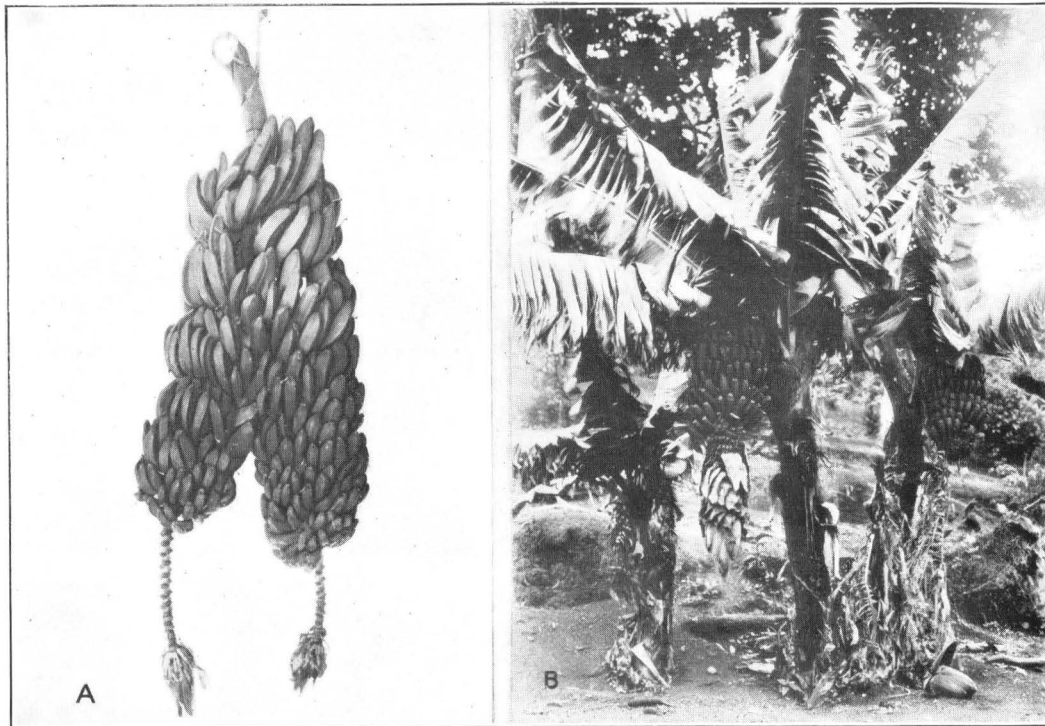
The true stem is the underground "bulb," morphologically known as a tuberous rhizome, wherein is stored the starchy plant food used in connection with the central bud, root, and sucker-bud-producing tissue. The suckers rise from this tissue as additional trunks of the plant group. The trunk consists of a cylinder composed of coarsely constructed concentric layers, each of which is the base of a leaf-stalk. Combined, these layers protect the younger leaves and the flowering stalk. The plant food is used chiefly in the production of suckers and the growth of the fruit. The production of too many suckers results in poorly developed fruit. A sucker may be considered a plant when it has developed to a size with sufficient roots to maintain its own growth fully.

LEAVES

The leaves of the banana plant, consisting of leafstalk and blade, vary in number from 8 to 20 or more, depending upon the vigor of the plant. Normally, they are 8 to 12 feet long and 2 feet or more wide. Prior to expanding, the young leaf is cylindrically rolled on itself, being closed at the tip, possibly to prevent water from entering the center of the trunk where the blossom bud is forming. The exposed portion of the petiole or leafstalk, which varies from one to several feet long, is almost cylindrical, its raised edges forming a distinct trough above. The leaves are so arranged as to adapt themselves to weather conditions. When the sun's rays are perpendicular and too intense, the blade collapses, the under surfaces containing the pores (stomata) coming together and thus protecting the plant against too great evaporation. In wet and moderately cool weather when growing conditions are very favorable the edges of the blade curve upward, permitting increased evaporation, which is necessary



A.—The flowers of the Chamaluco variety are typical in form of parts of those of most varieties of seedless bananas. (1) Pistillate flower: *a*, perianth, *b*, petal of corolla, *c*, rudimentary stamens, *d*, style of pistil, *e*, stigma, *f*, ovary which becomes fruit; (2) neutral flower; (3) staminate flower: *c'*, Stamen with anther, *f'*, rudimentary ovary
 B.—The characters of the flowers of different varieties of bananas are of importance in their identification. Staminate flowers, reading from left to right: Top row, 'Apple, Abaca, Brazilian, Chamaluco, and Borabora; lower row, Father Leone, Hamakua, Iholena, Largo, and Dwarf Plantain



A.—The fruiting stem of the Mahoe variety is divided about midway of the bunch. When the stem divides below the formation of the flower cluster, giving two distinct bunches, it is called Palua
B.—A clump of Cavendish bananas (*Musa cavendishii*). The large bunch shows the heart and numerous bracts on the rachis. The persistency of these bracts is a specific character of this species

for rapid growth. The crude plant food which has been absorbed by the roots and carried up the stem is transformed in the leaf, whence it is distributed where needed to build plant tissue.

FLOWERS

The following is a brief description of the floral parts:

The ovary, or basal part of the pistillate flower, later becomes the fruit. The ovaries of neutral and staminate flowers remain rudimentary and perish. The perianth, corresponding to the calyx of any typical, complete flower, is the protective covering of the more delicate, essential organs known as stamens and pistils. The corolla is much modified in the banana flower, usually being represented by a single free petal, with sometimes three petals, as in the Ice Cream variety and the common plantain. The petal usually holds the nectar surrounding the base of the style. Normally, there are six stamens, but in most seedless varieties only five, the sixth being very rudimentary, or wanting. The anthers, the extreme portions of normal stamens, contain the pollen. On reaching maturity they split lengthwise along the margin, exposing the inner surfaces and releasing pollen grains. The exposed surfaces gradually turn dark in a few hours after the flowers open. The portion of the pistil extending from the apex of the ovary consists of a slim style surmounted by a more or less globular stigma, the surface showing evidence of several lobes, usually six in number.

The inflorescence of the banana, which undoubtedly has undergone many modifications since it first became known to man, is of much interest and importance. Its variations are numerous but of a constancy permitting their use as a most reliable basis for systematically distinguishing the varieties.² The flowering stalk grows up through the center of the trunk, appearing under normal conditions at the top in the form of a large bud when the trunk is about 9 or 10 months old. The flower bud develops rapidly, and, as it increases in size its weight causes it to hang pendant from the plant.³ Botanically, the inflorescence is of the monoecious type, the flowers in most species and varieties being pistillate, neutral, or staminate, the last two kinds closely resembling one another (pl. 1, A).

The flowers are spirally arranged on the flower stalk in consecutive clusters extending from the base to the apex. One or two of the clusters open at a time. Usually the pistillate flowers open in four to seven days. Each developing cluster, consisting of two transverse rows having few to 20 or more flowers, depending upon the variety and conditions of growth, is completely protected by a thick, close-fitting, leaflike bract varying in shape and color with the different species and varieties. In color the outward surface of the bracts may be purple, claret, or reddish-brown, powdered with a frostlike bloom, and the inner surface may be red, pink, purple, vio-

² Flowers should be chosen for study when they have reached a certain definite point of growth. Pistillate flowers, for example, should be examined about the time the last cluster is opening; a day or two later the neutral flowers may be seen; and two days later still the staminate flowers will have developed.

³ In the Kusaie and Fei varieties the scape with inflorescence remains erect. A strain of the Cavendish banana produces two or more flowering stalks within a single trunk, whereas the native Hawaiian variety Mahoe produces a single flower stalk which divides midway of the cluster and bears twin bunches of fruit (pl. 2, A).

let, yellow, orange, brown, or a blend of several of these colors, which are well displayed when the bract is raised as it rolls back at the top. About this time the flowers beneath the bracts may be visited by insects in search of nectar. After completing its work of protecting and displaying the flowers, each bract falls. In the Chinese or Cavendish variety the bracts covering the staminate flowers are persistent (pl. 2, B).

The pistillate flowers are the most important of the several kinds forming the inflorescence, particularly the ovaries, which eventually become the fruit. The number of clusters under favorable conditions varies from six to nine or even more, some varieties producing a greater number than others. The ovary is about two-thirds the length of the pistillate flower, and has three seed compartments with many well-distributed ovules, which in the seedless banana remain small and imperfect. The apex of the ovary supports the other floral parts, including the central style, which is surmounted with a plump, six-lobed stigma and surrounded by a whorl of five short, imperfect stamens.⁴

The floral envelope is considerably modified. The outer and longer portion is the perianth, and is said to consist of three sepals and two rudimentary petals all united, but indicated by the five lobes at the end. The third and separate petal representing the corolla is short, wide, deeply cupped on the inner side, and lipped at the edges. In color these floral parts may be pale cream, yellow, red, or streaked, depending upon the variety. The cups of the petals of the three kinds of flowers secrete a clear, viscid nectar of sweet, pleasant flavor. In the Iholena group the nectar has the consistency of jelly, which was a delicacy eagerly sought by the early Hawaiians.

In the neutral flowers the stamens and pistils are usually undeveloped, and the ovary is half the length of the flower. Fertile pollen grains are rarely found in the stamens, and only few varieties in Hawaii, such as the Bluefields and Lady Finger, have neutral flowered ovaries developing into fruits.

The male or staminate flowers are arranged in clusters more at the end of the inflorescence. Each flower normally possesses five prominent stamens, usually extending beyond the other parts (pl. 1, B). The anthers, or pollen sacks, are long and marked in color, but in most varieties possess no pollen. However, abundance of pollen was found by the writer in the anthers of staminate flowers of the varieties Bluefields, Popoulu, Iholena, Lele, Kapua, abaca, Borabora, and Maia Oa. Pollen grains collected from well-developed stamens of pistillate flowers of the last three-mentioned varieties and examined under a compound microscope were found to be spherical in shape and white or yellowish in color. The grains are connected in chains until fairly mature, when they split apart. The pistil is short and undeveloped. The ovary is only about one-third the length of the flower. Usually the perianth and the corolla petal are more highly colored than other parts of the flower, and, like the same organs in the pistillate flower, have colors peculiar to the variety.

⁴ In some species the stamens are perfect, and occasionally a sixth stamen is present.

Like a number of other fruits of commercial importance, the seedless banana is distinctly parthenocarpic and does not require the stimulus of pollination to insure the setting of fruit (8, p. 293). However, 15 of the 27 species of the subgenus *Eumusa* produce fruit containing seeds (11, p. 263). A number of well-established varieties of seedless bananas, including Gros Michel (Bluefields) and Apple, have been successfully pollinated by hand and caused to produce seed (11, preface, p. 8). The Ice Cream variety of Hawaii when growing near abaca plants is occasionally naturally pollinated and produces seed. W. J. MacNeil, Oahu College, Honolulu, reports that in 1909 he succeeded in crossing flowers of the Ice Cream variety with pollen from seed-producing banana, presumably abaca. More than one bunch produced seeds, some fruits having 1 to 15. Ten of the seeds, collected at random when dry, weighed 0.6 gram, and were 0.8 by 0.6 by 0.4 to 0.6 by 0.5 by 0.4 centimeter in dimensions. Of 50 seeds planted on two different occasions none germinated.

In nearly all commercial varieties the pistillate flowers with imperfect stamens are open and their stigmas past the receptive stage for pollen before either the neutral or the staminate flowers are released by the opening of the bracts (pl. 3, A). This fact indicates the need of cross pollination to produce seed. Insects, which are attracted to the flowers by the nectar, might possibly be the occasion of cross pollination, but since seeds are rarely produced, the pollen of most of the commercial varieties either does not develop, or it is infertile.

It is believed that the original wild banana bore perfect flowers; that is, having both stamens and pistils, as is still represented in some of the local varieties, and that pollination of flowers of the same cluster was aided by external agencies, such as the wind and insects. In isolated specimens of the local Borabora (pl. 3, B), Maia Oa, and abaca varieties, it was observed that the flowers becoming seed-bearing fruits were pollinated before the staminate flowers, located farther along the rachis, were released from under the bracts. It is also probable that there once were species, if not varieties, whose floral parts were modified, requiring cross pollination to fertilize the ovules and produce seeds capable of germination, just as is now the case with most of the Hawaiian commercial varieties, which usually are parthenocarpic. Examination of a number of these varieties failed to show the presence of pollen on their flowers. Several varieties, such as the Ice Cream and Chamaluco, had some pollen, the surface of whose grains was found to be collapsed, however, suggesting infertility. S. C. Harland, of Trinidad, British West Indies, reports crossing successfully the Gros Michel, resulting in the production of seeds which germinated, giving in one instance a hybrid of highly desirable qualities. Some varieties are known to be bud sports; for example, the Green Red banana of Panama, which O. A. Reinking, pathologist of the United Fruit Co., states is a bud sport of the well-known Red variety, is also a bud sport of some yellow variety. A bunch of the fruit of the Green Red banana was found to contain 150 seeds scattered throughout the fingers, only about half a dozen of which were perfect. Doctor Reinking calls attention to

the Burrow Apple plantain as a variety of the species *paradisica* producing seed, a portion of which have been germinated and successfully grown.

FRUIT

The fruit of the banana is borne in a bunch consisting of a number of clusters called "hands," which are further developments of the floral panicle. The hands, bearing 5 to 20 or more bananas arranged in two rows, commonly called "fingers," grow separately in spiral arrangement on the axis of the rachis, called the stem. The bunch is the commercial unit where bananas are sold wholesale, and is classed as ranging from 6 to 9 hands. Smaller bunches are not readily marketed. Standard bunches have 9 hands and weigh from 50 to 80 pounds, varying with the variety and conditions under which produced. Cavendish bananas given good culture may average 85 pounds in weight, and rarely 100 pounds per bunch. Large bunches of Bluefields often weigh 100 pounds or more, and occasionally bunches weighing 150 pounds, with 20 or more hands and over 300 fruits, have been exhibited. One bunch shown at the Territorial Fair of Hawaii, 1924, weighed over 170 pounds. The favorite variety of the Hawaiians, Moa, which grows wild in the deep mountain valleys, often has less than a dozen fruits to the entire bunch. Given special care, however, this variety can be made to produce a larger number. In Cochin China, the "Lubang" variety (*Musa corniculata*) produces only one fruit which has the appearance of a large cucumber. The Lady Finger, a commercial banana of the West Indies and now under trial at the station, produces as many as 300 to 400 fruits to the bunch. The Guindy, said to be the best banana of India, often has 1,000 fruits to the bunch (11, p. 181). The King of Thousands, a variety of banana of the Malay Archipelago, is said to produce bunches of great size. A bunch measuring 7 feet long and bearing 2,000 fruits was produced in a Singapore garden in 1911 (2, p. 452).

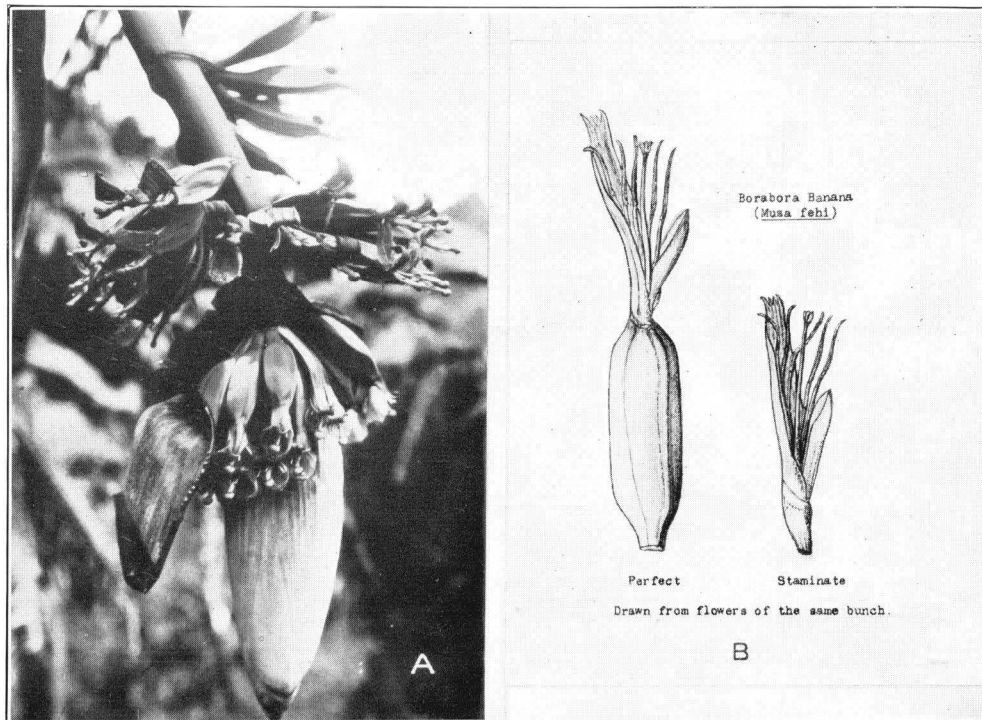
The fruit develops in 60 to 80 days after the inflorescence has pushed out of the crown of the trunk. Fruit development, like the growth of the rest of the plant, may be greatly retarded by adverse conditions. Individual fruits of the edible banana vary greatly in size, shape, color, and flavor, according to the variety and cultural conditions.

The general description of the fruit of the seedless banana is as follows: Weight, 2 to 16 ounces; length, 1 to 18 inches; shape, elongated, cylindrical, sometimes angular, somewhat curved; skin, thin and tender to tough and leathery; color of skin, yellow or red at maturity, and in some varieties, green when ripe; pulp, yellow, pink, salmon, or white in color, soft to firm in consistency; flavor, usually pleasing when the fruit is ripe.⁵

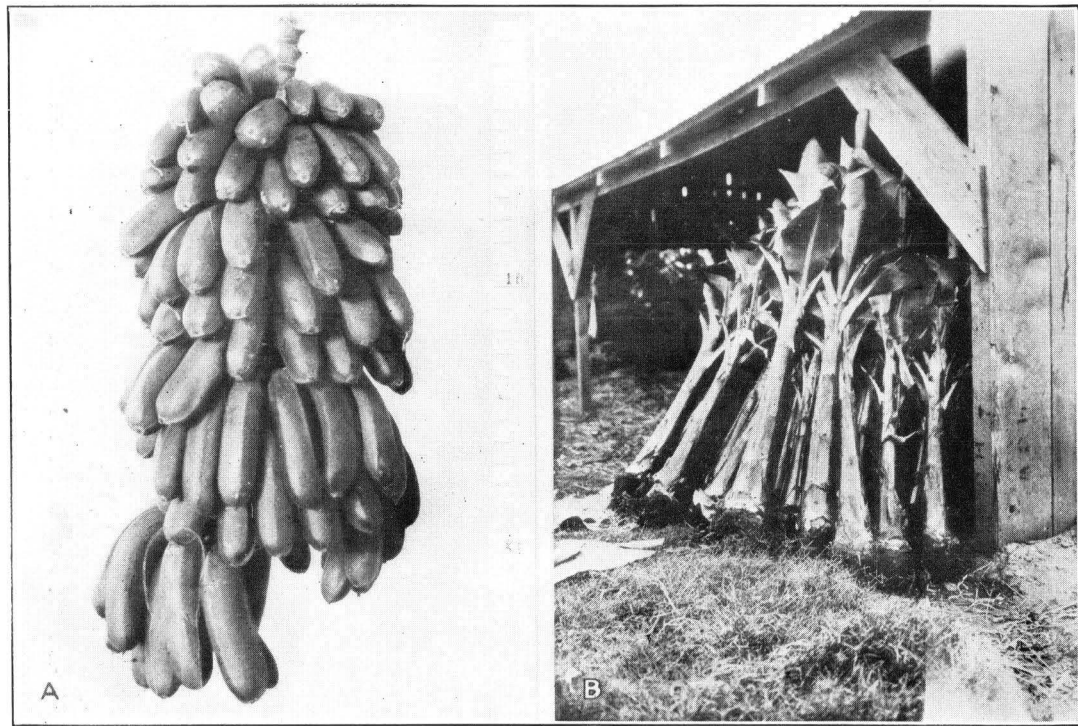
COMPOSITION AND FOOD VALUE

The composition and food value of the banana are of interest to the grower and to the consumer. From the composition the grower

⁵ The fruit should be studied first while it is green but at full size, and later when it fully ripens.



- A.—The flower cluster of the Largo variety. The pistillate flowers are all past the receptive stage for pollen before the staminate or pollen-producing flowers appear. The stamens of the pistillate flowers are rudimentary, being entirely without anthers.
- B.—Borabora banana flowers. The pistillate flowers are perfect, and some of their anthers release pollen in abundance at the time the stigma of the pistil is ripe. This variety sometimes produces seeds.



A.—Maïamaoli, the leading Hawaiian cooking banana, is high in carbohydrates
B.—Well-developed suckers

learns the importance of his crop as a food, and the demands the plant makes upon the soil medium he is to provide; the consumer learns the food value of the fruit, and the dietitian its proper place in the dietary.

Analyses of a number of locally grown bananas, made with a slight modification of the method recommended by the Association of Official Agricultural Chemists (20, p. 77) and published by the station in 1914 (19, p. 66), indicate little difference in composition between them and bananas grown elsewhere. Bananas have a high and variable sugar content, the highest being in the Hawaiian cooking, or so-called native, bananas (pl. 4, A). The green fruit of any variety of bananas, such as that used for dehydration in the manufacture of flour, has a starch content of about 12 per cent, most of which disappears during ripening, along with the tannic or organic acids. Doherty (9, p. 187) reports 6 per cent of starch remaining in some ripe fruit, and other observers have found less. A test for tannin on cross sections of both the green and ripe fruit showed tannin to be arranged in a narrow line around the outer margin of the fruit and along the three divisions of the core radiating from the center. Ricciardi (17, p. 554) explains that tannin, together with organic acids, like much of the starch, disappears during the process of ripening. Thoroughly ripened fresh fruit is for this reason more easily digested than unripe fruit. The proteins, consisting of albumen and gluten, are small in amount, constituting little over 1 per cent of the edible portion of the ripe fruit. Acidity averages about 0.329 per cent, but runs unusually high (over 0.4 per cent) in the Apple and Brazilian varieties. A similar variation is noted in the different varieties in fat content, in which the cooking banana is unusually high. Table 1 gives the results of analyses of different kinds of bananas.

TABLE 1.—Composition of different kinds of banana fruits

| Kind | Edible portion | Waste | Water | Protein | Fat | Acids as H ₂ SO ₄ | Carbohydrates | | Ash |
|------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|---|-----------------|-----------------|-----------------|
| | | | | | | | Sugar | Crude fiber | |
| | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> |
| Chinese..... | 70.00 | 30.00 | 78.72 | 1.788 | 0.180 | 0.245 | 16.66 | 0.253 | 0.955 |
| Apple..... | 74.49 | 25.51 | 68.48 | 1.238 | .223 | .417 | 24.15 | .351 | .964 |
| Brazilian..... | 68.25 | 31.75 | 72.22 | 1.775 | .201 | .406 | 19.68 | .305 | .924 |
| Baking (Hawaiian)..... | 75.72 | 24.28 | 67.78 | 1.350 | .518 | .397 | 26.20 | .333 | .750 |
| Fehi..... | 64.29 | 35.71 | 72.13 | 1.069 | .046 | .230 | 14.49 | .594 | |

¹ Determined by copper reduction method.

The banana leads all other raw fruits in food value and surpasses most of the vegetables in energy value and tissue-building elements. According to S. C. Prescott, of the Massachusetts Institute of Technology, it provides more actual food for the same cost than any other fresh fruit or vegetable, fish, meat, milk, or eggs (16, p. 53). Table 2 compares the nutritive value of the banana with that of some other commonly used Hawaiian fruits.

TABLE 2.—Comparison of composition of bananas and other fruits

| Kind | Edible portion | Waste | Water | Protein | Fat | Acids as H ₂ SO ₄ | Carbohydrates | | Ash |
|----------------------------|----------------|----------|----------|----------|----------|---|---------------|-------------|----------|
| | | | | | | | Sugar | Crude fiber | |
| | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent |
| Banana (Chinese)..... | 70.00 | 30.00 | 78.73 | 1.788 | 0.180 | 0.245 | 16.66 | 0.253 | 0.955 |
| Mango (Pirie)..... | 60.00 | 40.00 | 79.48 | .456 | .032 | .221 | 14.78 | .508 | .343 |
| Avocado (Esbank)..... | | | 81.76 | .950 | 12.620 | | 2.84 | 1.030 | .800 |
| Breadfruit (Hawaiian)..... | 77.75 | 22.25 | 58.18 | 1.575 | .190 | .049 | 9.49 | 1.204 | .952 |
| Papaya (No. 4610)..... | | | 83.73 | .548 | .148 | .140 | 13.76 | .827 | .687 |
| Orange (Kona)..... | 72.13 | 27.87 | 87.85 | .681 | .387 | .882 | 5.90 | .575 | .453 |
| Pineapple..... | | | | .375 | | .660 | 10.70 | | |
| Apple..... | | | 84.60 | .400 | .500 | | 14.20 | | .300 |

The world's leading food crops, including wheat, rice, corn, and potatoes, have become great staples because of their large yields of energy-producing food in concentrated and palatable form. In a comparative study of these foods, the banana has been found to lead in total production per acre and in fuel value per acre. Table 3 compares the acre yield and fuel value of a fair crop of Chinese bananas and the other staple crops.

TABLE 3.—Yield and food value of bananas and other crops¹

| Kind of crop | Fair yield per acre | Fuel value per pound | Fuel value per acre |
|---------------------|---------------------|----------------------|---------------------|
| | Pounds | Calories | Calories |
| Bananas..... | 32,000 | 260 | 8,320,000 |
| Wheat..... | 1,620 | 1,650 | 2,673,000 |
| Rice..... | 3,000 | 1,620 | 4,860,000 |
| Corn..... | 2,240 | 1,635 | 3,662,000 |
| White potatoes..... | 10,170 | 295 | 3,000,150 |
| Sweet potatoes..... | 14,000 | 440 | 6,160,000 |

Hawaii Exp. Sta. Ext. Bul. 6 (1917), p. 4.

The yields of bananas, rice, and sweet potatoes given in the table are, as explained by Higgins, based upon the experience of a number of growers in Hawaii, and the estimate of fair yields of the other crops was arrived at by increasing by 50 per cent the average yields of plants in the areas of the United States where they are grown extensively. Average yields can not be considered fair yields, but increasing them by 50 per cent would seem to be fair to these crops when comparing them with bananas. The estimated yield for rice includes the two crops which are harvested each year in Hawaii. Locally grown sugar will probably exceed the other crops in caloric value, but it can be used only in limited quantity in the diet. Bananas as fresh fruit are too bulky to form a satisfactory ration, for one must consume 1,400 grams, or approximately 50 ounces, of the fruit to obtain 300 grams of carbohydrate.

Reduced to a concentrated form, as by drying or converting into flour, the banana can be used in very large quantities and in times of necessity could replace much of the wheat, corn, potatoes, and similar imports. In these prepared forms the banana is adapted to a much wider use, and its nutritive value compares more favorably with the manufactured products of the cereals and dehydrated fruits.

BANANA FLOUR

Both the banana and the plantain form a far more important article of food in some other countries than they do in Hawaii or in any of the United States. Fawcett (11, p. 119) states that they take the place of wheat, rye, barley, and potatoes for an immense portion of the human race. Flour is the most concentrated form to which the banana can be reduced, and is manufactured from fully grown green specimens which have not begun to ripen. In the West Indies the fruit is cut from the bunches and placed in water at about 176° F. for four or five minutes so that the green skin may the more easily be removed. The pulp is then split in halves with a wooden, bone, or silver blade. After the banana has been thus prepared, drying, either by sun or artificial heat, takes place rapidly. When the moisture has been reduced to 15 per cent or less, the dried fruit is ground and run through sieves having 120 meshes to the inch. The freshly prepared product has an odor characteristic of the fresh article, and an agreeable and somewhat sweet taste. It may be stored in boxes or barrels lined with paper.

Some difficulty has been encountered in making bread with banana flour alone, but when mixed with wheat flour or with oatmeal it proves satisfactory. Good bread has been made from banana flour paste which had been subjected to the action of steam under pressure. Table 4 compares the nutritive value of banana flour and other foods.

TABLE 4.—Comparative nutritive value of banana and other foods¹

| Kind of food | Moisture | Protein | Fat | Carbo- hydrates | Ash | Food value per pound |
|------------------------|-----------------|-----------------|-----------------|--------------------|-----------------|----------------------------|
| | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Calories</i> |
| Banana (fresh)..... | 75.3 | 1.3 | 0.6 | 22.0 | 0.8 | 460 |
| Banana flour..... | 9.7 | 3.1 | .5 | 84.1 | 2.6 | 1,610 |
| Wheat flour..... | 12.0 | 11.4 | 1.0 | 75.1 | .5 | 1,650 |
| Cornmeal (bolled)..... | 12.5 | 9.2 | 1.9 | 75.4 | 1.0 | 1,655 |
| Potato (white)..... | 78.3 | 2.2 | .1 | 18.4 | 1.0 | 385 |

¹ Hawaii Exp. Sta. Ext. Bul. 6 (1917), p. 7.

DRIED BANANAS

Bananas may be preserved in a concentrated form known as banana "figs," which are simply the dried ripe fruit. Drying as a means of preserving the banana is commonly practiced in the West Indies and many other countries. Trials of different methods of processing by the station indicate that drying is applicable to Hawaiian-grown varieties, and fig making from the banana seems possible. The following is a simple method of preserving the banana:

The firm, ripe fruit, peeled and split lengthwise in halves or fourths, is placed on trays and dried, either in the sun or with artificial heat. Various kinds of driers, including evaporators and vacuum driers, are used. The drying process is complete when the dried product resembles dried figs, prunes, or dates. In drying, the fruit becomes covered with a white, sugary powder formed from its own juice. In the ripe fruit the starch turns to sugar, which in the drying process acts as a preservative and enables the fruit to keep

for a considerable time. That the dried fruit compares favorably with other dried fruits is shown in Table 5.

TABLE 5.—Average composition of dried bananas and other dried fruits¹

| Kind of fruit | Refuse | Water | Protein | Fat | Carbo- hydrates | Ash | Fuel value per pound |
|---------------|-----------------|-----------------|-----------------|-----------------|--------------------|-----------------|----------------------------|
| | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Per cent</i> | <i>Calories</i> |
| Bananas..... | | 29.2 | 5.3 | 2.3 | 57.9 | 5.3 | 1,240 |
| Dates..... | 10.0 | 15.4 | 2.1 | 2.8 | 78.4 | 1.3 | 1,615 |
| Figs..... | | 18.8 | 4.3 | .3 | 74.2 | 2.4 | 1,475 |
| Raisins..... | 10.0 | 14.6 | 2.6 | 3.3 | 76.1 | 3.4 | 1,605 |
| Apples..... | | 26.1 | 1.6 | 2.2 | 68.1 | 2.0 | 1,350 |
| Apricots..... | | 29.4 | 4.7 | 1.0 | 62.5 | 2.4 | 1,290 |

¹ U. S. Dept. Agr. Farmers' Bul. 293, p. 14.

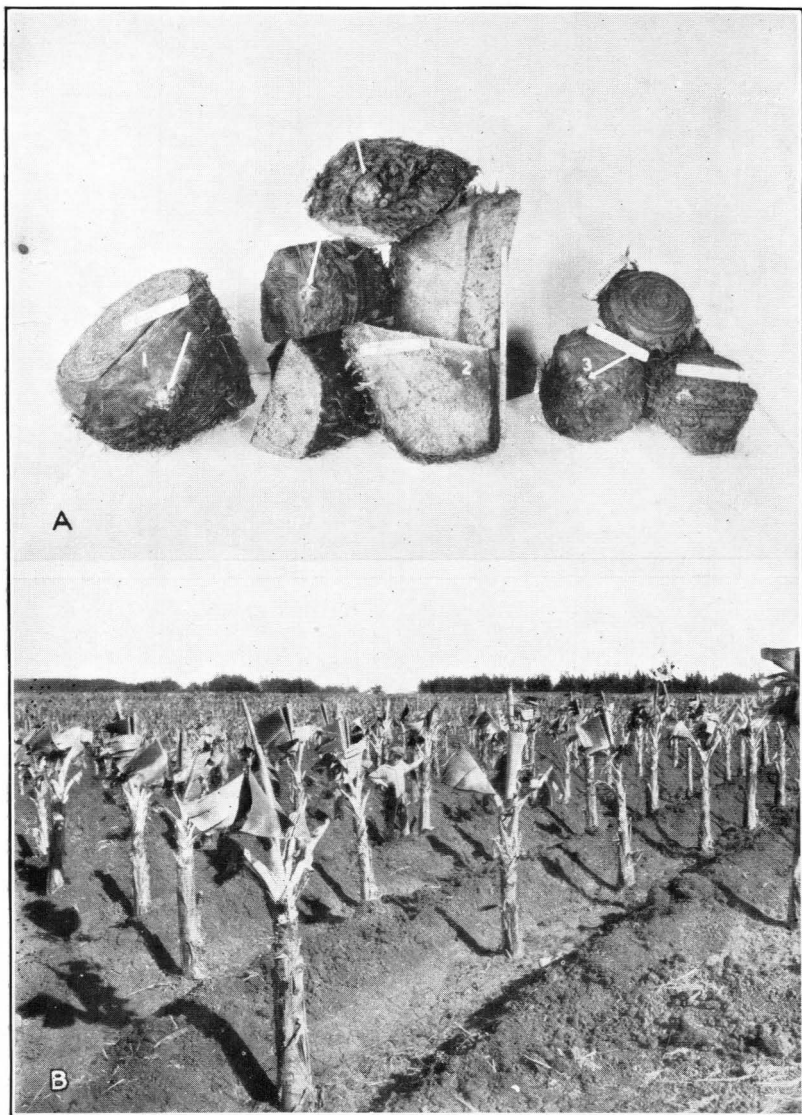
PROPAGATION

Seedless bananas are propagated by asexual methods, three different parts of the stem being used: (1) Large suckers, 4 to 6 months old, having well-developed basal bulbs (pl. 4, B); (2) small suckers, a few weeks to 2 or 3 months old and 8 to 30 inches high; and (3) old stumps of plants that have fruited (pl. 5, A).

Large suckers, 4 or 5 feet high, are the forms most commonly used to propagate the banana in Hawaii. The bulbs contain a large supply of concentrated food, have tissue ready for root development, and have started to take on the characters of adult foliage. Care should be taken, however, to see that the flower cluster has not yet begun to form in the trunk. Large suckers should be carefully removed from the plant after the fully developed bunches of fruit have been severed. All fibrous roots should be removed, the expanded leaves cut back to prevent excessive transpiration, and the suckers allowed to dry for several days to heal the cut surfaces before planting. Some growers place the suckers in heaps 8 to 10 deep, cover them with trash to protect them from the rays of the sun, and allow them to remain for about a month. Large suckers have been found to be very satisfactory in local commercial plantings of the Cavendish and Brazilian varieties and to produce earlier and more desirable bunches of fruit than smaller suckers or heads. In some countries the large suckers are cut back to within a few inches of the solid corm or bulb, the central or heart bud is cut out, and all surface buds are removed, excepting one which then takes its strength from the parent bulb. When the heart bulb is not destroyed, a new bulb forms on the top of the old one, producing a plant which may be the more easily blown over.

"Peepers," or small suckers less than two or three months old, should be handled with great care to guard against bruising, and should be allowed to dry for several days prior to planting, as a precaution against decay. Small suckers may not prove wholly satisfactory, but can be used in time of scarcity of propagating material.

Old banana stumps are sometimes dug up and cut back to heads. They may be planted whole or in longitudinal sections, each of which should have one good bud (pl. 5, A). After the cut surfaces have



A.—Propagating material of banana plants. (1) A medium-sized rhizome “head”; (2) a large head cut into sections, each having at least one evident bud; (3) small rhizomes which are used entire. The white arrow indicates the bud which develops into the sucker
 B.—Field of suckers of the Cavendish or Chinese variety set in the customary way for growing at lower levels where irrigation is necessary. The suckers were set in September, 1924, and photographed two weeks later. Note the arrangement of the trenches

healed the stumps should be planted at least 8 inches deep, with the bud in an upright position. Stumps are said to be used in other countries where commercial varieties are grown on a large scale.

CULTURAL REQUIREMENTS

SOIL

Practically all the agricultural soils of Hawaii may be made suitable for banana growing. At the lower elevations, where most of the commercial varieties are grown, the soils are conglomerate deposits formed from various decomposed lavas.⁶ Productivity of these soils depends more upon their physical character than upon their chemical composition, although the latter must be given careful consideration. At elevations of 1,000 feet and higher, where the rainfall is sufficient for the production of natural forest growth, the soils consist of decomposed lavas with an abundance of humus. Such soils have excellent drainage on account of the porous nature of the lavas directly underlying them. Except for the clearing necessary, these forest lands are more easily brought into use, but, owing to their altitude, require a longer time to produce crops than the low-lying lands. They produce commercial bananas of excellent quality, and are well adapted to growing most of the native bananas.

The virgin forest loam, where the rainfall is adequate, is the ideal soil for banana culture, but a great variety of soils may be successfully used if their physical and chemical properties are improved by proper tillage, liberal applications of organic matter, and irrigation. Water-holding capacity and good drainage are among the essential requirements for banana growing. Moisture must be abundant at all times to insure good crop yields. It is estimated that the banana plant requires about 600 pounds of water for every pound of dry matter produced.

PREPARATION

Land at the lower elevations, where usually the forest growth is sparse, should first be cleared of all vegetation and stones. This may require some expense, but partial clearing preceding breaking the land is a doubtful economy. A well-cleared field means cheaper and better tillage. The banana lands at the lower elevations are largely sedimentary in formation, and rather firmly packed, requiring deep and thorough plowing. After weathering by exposure to air and sunshine the roughly plowed field should be harrowed and staked off for planting. The fields customarily are laid out with regularity in small areas of 5 or 10 acre blocks for conveniently carrying on the various necessary operations. The rows are laid out in ditches 1½ to 2 feet deep with high ridges between (pl. 5, B). The ditches are made by running a plow several times through each row, after which the loosened soil is thrown to the sides. If the subsoil is hard it should be broken up with a subsoil plow and the soil should be reduced to a fine state of tilth to furnish a suit-

⁶ In some localities the lavas are mixed with calcareous material consisting either of coral sand brought in from the seashore by the agency of the wind or partly decomposed coral reefs that have arisen out of the sea.

able bed for the plants. Loosening the soil gives better drainage and a greater feeding area for the roots, which then become deeply established and enable the plant to withstand heavy winds. Thoroughly preparing the land also greatly increases nitrification and other chemical processes releasing plant food in the soil.

IMPROVING THE SOIL

In addition to deep plowing and good drainage, banana soils often need some kind of fertilizer. Fertilizing materials include barnyard manures, green manures, lime, and chemical or commercial fertilizers. The soils usually have most of the necessary elements. Nitrogen, potassium, phosphorus, and calcium are the elements most likely to become exhausted and to require replacement by the use of fertilizers. Numerous experiments with fertilizers for bananas have been made by private growers, fertilizer concerns, and by the station, alone and in cooperation with growers. Barnyard manure has been found to be very beneficial, especially at the central station in Honolulu.

In using fertilizers the grower must be guided not only by his general knowledge of the needs of the plant but also by close study of its growth, including its composition and the action of the soil under treatment. Considerable experience is required to determine the kind of fertilizer necessary and the best method of applying it. Sufficient nitrogen is shown in a vigorous growth of rich green foliage, whereas nitrogen deficiency is generally indicated by poor growth of foliage of yellowish color. Nitrogen deficiency is often corrected by the application of barnyard manure and the incorporation of an abundance of humus in the soil, with more moisture. Green manures also assist in maintaining humus, which aids in nitrification. Nitrogen deficiency may be temporarily overcome by using nitrate of soda, sulphate of ammonia, or dried blood. Potash also often improves the fruiting quality of banana plants. Both Higgins and Fawcett state that where vigorous plants produce bunches of fruit of inferior size and quality the condition may often be corrected by using potash in some form, such as sulphate or muriate of potash. The need of phosphoric acid is probably not so easily determined, but the fact that phosphorus is present in practically every plant cell indicates its importance. Applied as superphosphate, which is phosphate rock treated with sulphuric acid, phosphoric acid is often believed to be the correcting element for stunted growth. Lime in excess of that already present in the soil may sometimes be required as a soil amendment, or, what is known as an indirect fertilizer, rendering the potash more available to the plant. It aids nitrification and may also correct soil acidity, resulting in an improved physical condition. (For fuller discussion of the use of fertilizers, see *II*, p. 69.)

PLANTING DISTANCES

The distance between the rows and the plants in the row varies somewhat with the character of the soil, the amount of moisture available, and the variety to be planted. Different distances are used in setting the Chinese banana, the leading commercial variety

in Hawaii. Success may be obtained by planting 6 by 6, 6 by 7, 7 by 7, 7 by 8, 8 by 9, and 8 by 10 feet; and greater distances are required for large plants, such as the Bluefields and Brazilian varieties. Large plants should be set at least 14 by 14 feet on land that is not very fertile, some growers preferring 15 by 15 and 16 by 16 feet. The greater distances permit the growing of a larger number of suckers and fruiting trunks in each clump at the same time. With the greater distances between plants the suckers should be set in large holes, the size of which will depend upon the preparation previously given the soil. In poorly prepared soil the holes must be made very large, being at least 4 feet across and 1½ or 2 feet deep, depending upon the character of the subsoil. When the land has been thoroughly plowed and harrowed the holes can be made with a small amount of hand labor. Large suckers of the Chinese variety are set locally at selected distances in holes made in the bottom of the ditch with 5 or 6 inches of soil firmed around each plant. In dry weather the plantings should be watered as soon as the areas of acre-blocks are set. Table 6 gives the planting distances and number of plants per acre.

TABLE 6.—Planting distances and number of plants per acre¹

| Distances (feet) | Plants (number) | Distances (feet) | Plants (number) |
|------------------|-----------------|------------------|-----------------|
| 6 by 6..... | 1,210 | 8 by 10..... | 544 |
| 6 by 7..... | 1,037 | 14 by 14..... | 222 |
| 7 by 7..... | 888 | 15 by 15..... | 194 |
| 7 by 8..... | 777 | 16 by 16..... | 170 |
| 8 by 9..... | 605 | | |

¹ "To find the number of plants required to set an acre, multiply together two distances, in feet, at which the trees stand apart, and divide 43,560 by the product; the quotient will be the number of plants required." (6, pp. 117-119).

CULTIVATION

Tillage is one of the most important factors entering into the production of good bananas, and success depends to a considerable extent upon the thoroughness of preparation given the soil before planting.

Most of the typical banana lands of Hawaii are kept free of weeds by some sort of shallow tillage which is maintained until the plants are large enough to shade the ground completely. The implement best suited to shallow tillage is an animal-drawn, double-shovel cultivator which loosens the soil to a depth of 2 to 3 inches. Some growers prefer using a 6-inch stirring plow, which effectively loosens the soil to a depth of 4 to 6 inches. In cases where cultivators and plows can not well be used the work may be started with a spading fork and finished by hoeing. Cultivation is sometimes given after each rain or irrigation, and in other instances once in six or eight weeks. Only one cultivation a year is necessary after the plants become well established.

In parts of the West Indies cover crops are grown during the wet season. A cover crop prevents surface washing, and when turned under, enriches the soil and improves its texture. The Jerusalem pea (*Phaseolus trinervis*) is most commonly used, as it makes a fairly dense growth in the shade of the banana plants.

Green manure crops greatly benefit Hawaiian soils, many of which are lacking in organic matter.

Some planters consider root cutting, such as is done by the plow, of value particularly during certain seasons. The roots of the banana plant usually grow out horizontally with little branching. If they are severed several feet from the plant the cut ends will send out a number of feeders, which spread in all directions. Root cutting should be done before the plants begin to fruit.

In certain parts of Central America where the Gros Michel (Bluefields), and other tall-growing varieties are cultivated, banana plantations are located on forest-covered areas. The locality is first selected, consideration being given such important factors as climate, rainfall, drainage, likelihood of damage by flood and wind, and the feasibility of obtaining labor and supplying transportation. After surveys, trails, roadways, and main drainage ditches are completed, the underbrush is cut sufficiently to permit systematic lining and staking, after which the planting material is set at intervals of 12 to 18 feet each way, or otherwise, as the grower decides best. As the banana plants develop the land is kept cleared of undergrowth, and the remaining trees are removed until finally the forest is replaced by the field. The clumps of banana plants will have increased sufficiently in size and number by the end of the year to cover the fields with vegetation maintaining a condition of temperature and moisture not greatly unlike that formerly existing in the virgin forest. (For detailed information on the development of banana plantations, see *16*, p. 21.)

The above outlined method, with some modification, might be applicable to vast areas of Hawaiian subforest lands at elevations of 500 to 2,000 feet. The excellent underdrainage of the geologically new lava soils would greatly lessen the extensive preparation and cultivation necessary on the lower lands where the Chinese variety is most commonly grown.

A survey of the banana-growing possibilities on the island of Hawaii at elevations of 500 to 2,100 feet was made by the writer in 1924. Bluefields, Chinese, and several other varieties of the native cooking banana of the Maoli type were found in cultivation in clearings at elevations up to 2,100 feet. The plants were free from insect pests and disease and were making luxuriant growth, producing large bunches of fruit, specimens of which on ripening proved to be of excellent quality. Although banana culture at the higher elevations requires a longer time to mature the fruit than it does at the lower levels, cost of production is considerably reduced by the simple methods of culture used, and by the natural rainfall, which makes irrigation unnecessary. It was also found that enough clean, healthy propagating material of the varieties could be assembled and multiplied rapidly to start a plantation of no small consequence, and that all the stock needed could be obtained in the Territory, thus precluding the introduction of disease and insect pests from other countries against which quarantine regulations now exist.

IRRIGATION AND DRAINAGE

Where irrigation is to be practiced, the ditches should be laid out on contours enabling the water to cover every portion of each division

of the field without washing the soil. Drainage ditches should also be provided to prevent the water from accumulating. Newly set fields require a light irrigation about once a week. The water should be admitted to ditches made between the rows when the plants are well established. Thus centered the ditches will provide a more substantial feeding system for the roots and lessen the tendency of the plant to produce suckers. After reaching the age of fruitfulness a field of Chinese bananas normally requires a thorough watering about every 15 days during the months of insufficient rain.

Good drainage is absolutely necessary for the production of first-class fruit. It is just as important to maintain adequate drainage as to have efficient irrigation, and more harm is done by having too much water than by not having enough. Too much water causes water-logging and soil acidity. Deep rather than shallow drainage ditches are most satisfactory.

WINDBREAKS

Banana plants grow best in localities having little or no wind. The gentler trade winds are not to be feared, but continuous high winds whip the young leaves into ribbons and prevent normal growth. The plants, especially such as are weighted with fruit, may be blown down by unusually high winds, which, fortunately, seldom occur in these islands. Some varieties like the low and stocky Cavendish withstand heavy wind better than others. Of the taller growing varieties, the Brazilian has been found to be best adapted to windy exposures in the Hawaiian Islands.

The local banana industry has not yet grown to proportions making it necessary to utilize all sheltered lands suitable for banana growing. Only such lands have been used as are naturally protected from the prevailing northeast trade winds. Some of the windy localities probably could be utilized for banana culture by growing windbreaks on the windward side of the field, or on a surrounding area of 5 to 10 acres, as the situation requires. Several rows of the Brazilian banana might be utilized for the purpose. The panax (*Nothopanax guilfoylia*) which grows upright to a height of 15 feet, makes a good windbreak. More permanent windbreaks may be obtained by planting such rapidly growing trees as the ironwood (*Casuarina equisetifolia*) and eucalyptus (*Eucalyptus robusta*) alternately in rows 10 feet apart and of the same distance apart in the row. The mango (*Mangifera indica*) also withstands high winds and, on account of its dense top, makes an excellent windbreak. Grafted mango trees have the additional value of producing good fruit in season.

The windbreak trees may be set in three rows 10 feet apart in alternate form with the same distance between trees in the row. The row nearest to the prevailing wind should consist of eucalyptus trees, which make tall, slim growth; the central row should be made up of two kinds of trees, eucalyptus and grafted mango arranged alternately in the row; and the row adjoining the field of bananas should consist entirely of ironwood. The horizontal roots of these

trees can be prevented from encroaching on the zone occupied by the bananas by maintaining a narrow ditch 3 or 4 feet in depth at a distance of about 4 feet from the row of trees adjoining the field. Good examples of controlling horizontal root growth of windbreaks are to be found in different parts of the Territory. Vigorous and prolific plants can be grown in close proximity to tree windbreaks where the ditch method is used. A windbreak of round, dense-topped trees intermixed with the taller topped forms makes an irregular and more satisfactory shelter than one of uniformly tall, dense trees.

PRUNING

Both vigor and productivity of the banana plant are greatly increased by proper sucker pruning. The plants soon lose their ability to collect and assimilate sufficient plant food to maintain all their suckers when developed to abnormally large fruiting conditions, as is often done for commercial purposes. Fruit of improved size and quality can be had by pruning out the poorer suckers and forcing each clump to produce two to four fruiting trunks. Growers may time their crops to meet market demands. By choosing the right time to start new suckers, it is possible to bring in the greater part of the crop during the season of highest prices.

A thorough knowledge of pruning requires considerable study and practice. The difference between desirable and undesirable small suckers is hard to determine. Undesirable specimens should be removed before attaining a height of 2 feet, for the larger they grow the more food they will take from the parent plant, and the more their young roots will interfere with the root system of the clump. Selected suckers of a size for transplanting should be so carefully removed as not to injure remaining suckers or the core and root system of the parent. The roots of the severed sucker should be removed before transplanting.

Practically all the work in sucker pruning is done with a long-handled, chisellike cutting tool, commonly called a "sucker spud," which is very similar to the Hawaiian "o-o." After removal of some of the soil from around the sucker the spud is forced straight down between the sucker and the corm of the parent plant to make a clean cut without bruising either. In pruning out small, undesirable suckers care must be taken to cut far enough into the hard, white part of the corm to prevent the suckers from sprouting again and necessitating a repetition of the work.

The large terminal bud of the flower stalk may be pruned out when the fruit has set and a few clusters of the staminate flowers have fallen. When the earlier leaves of the plant complete their assimilative function they hang pendant around the trunk, protecting it from the rays of the sun. If they are pruned out, the outer sheathing of the trunk may be injured and the whole plant may suffer. The dead leaves may be pruned out, however, and used for wrapping the fruit for shipment when the plants are set close together and the trunks are well shaded by the foliage. When a bunch of fruit forms about a leaf petiole the leaf should be pruned out to prevent its causing any irregularity of the fruit.

REPLANTING

The number of years in which a banana plantation may be kept in production depends upon depth of plowing, physical condition of the soil, thoroughness of preparation, and nature of cultivation. Growers often find it necessary to remove the old rhizomes and other root material from the soil and to prepare the field thoroughly again after 4, 5, or 8 years, depending upon conditions. One of the most productive local fields of Chinese banana is now (1925) in its ninth year of production from setting of suckers. The soil in this field was deeply plowed and was in excellent condition when thoroughly prepared prior to setting selected suckers and has received the best of care. Fields in certain parts of Central America are said to have continued to produce during 20 years from a single planting.

HARVESTING AND SHIPPING

The banana, like the avocado and some other fruits, ripens best when it is picked green. This fact has greatly helped to develop the banana industry of the Tropics as a source of supply of an all-the-year-round fruit for the numerous markets of the Temperate Zone. The best conditions for proper ripening of the banana rarely exists naturally in those parts of the world where the fruit is extensively grown, or in the still wider range where much of it is consumed. Usually, the jobber receiving the green fruit has the responsibility of ripening it. A careful study of the banana showed the ripening process to be governed by highly important factors such as regulation of temperature, humidity, and fresh-air supply. Only in the carefully regulated ripening room is the high quality of the fruit developed. It is a well-known fact that Hawaiian bananas which are shipped to the markets of the mainland and properly ripened in the ripening rooms are superior to the same kind of fruit cut for local market and ripened in the open air of retail stores.

In regard to range of time of harvesting, the banana is less exacting than are most fruits. If the fruit is to be shipped long distances, it must be cut from the plant earlier than if intended for use nearer the plantation. The fruit should be allowed to get plump before the bunch is severed from the plant, but not to develop to the stage where it will ripen and decay before reaching the consumer. The exact stage of maturity suitable for certain occasions can be determined only by experience. The terms "full," "too full," and the like are commonly used to express stages of maturity. The fruit should be given the greatest care during all the work of harvesting and shipping to avoid bruising.

The bunches are cut from the plant with $1\frac{1}{2}$ to 2 feet of stem left above the fruit to serve as a convenience in handling it and to aid in keeping it fresh while in transit. Usually three men work together to harvest the fruit of the dwarf varieties, the first man holding the bunch, the second man severing it, and the third man carrying it to the nearest field road. In harvesting the fruit of the higher-growing varieties the cutter hacks the trunk slightly above the middle on the side toward which the bunch is to fall, taking care that it does not fall against or injure any other plant. The top of the plant with its bunch of fruit is gradually lowered to a workman, who holds the

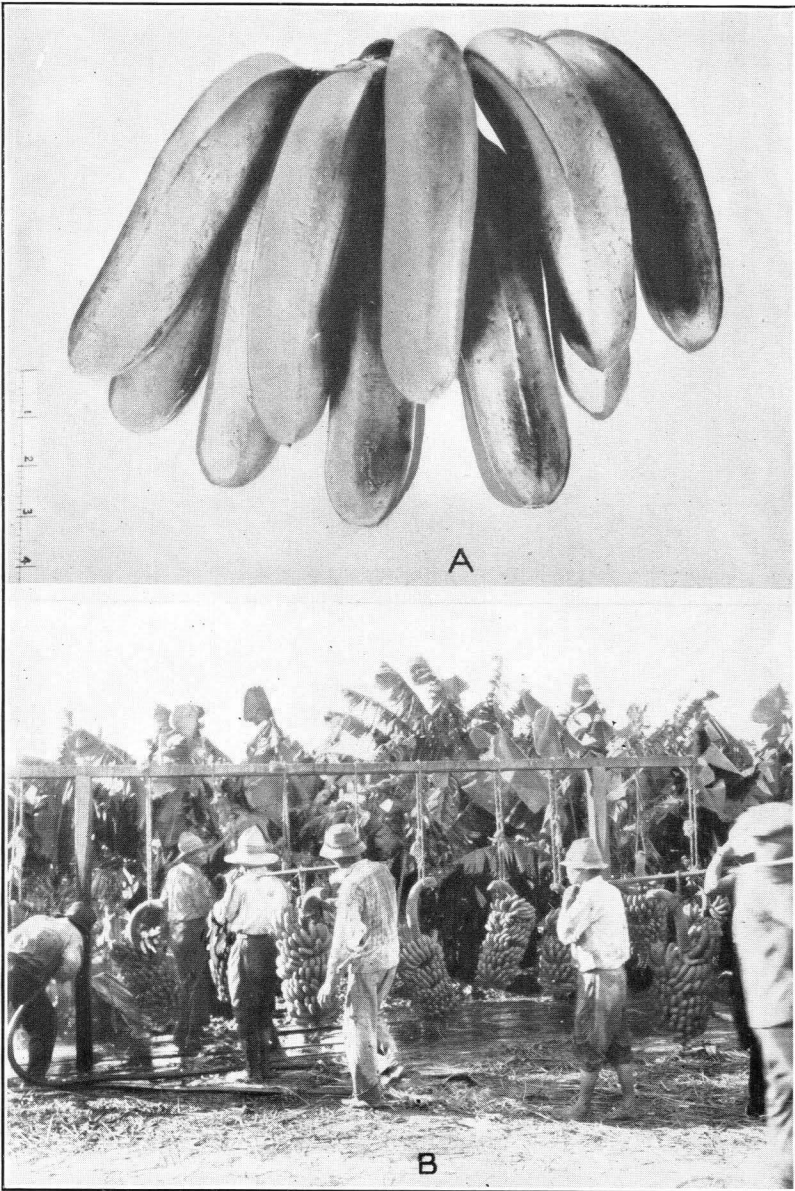
bunch while it is being severed. The bunches are then collected and placed on light autotrucks and taken to the packing shed, where they are set upright on straw.

The packing shed, usually a rectangular structure with corrugated iron roof, has two open sides to permit convenient handling of the fruit. The earthen floor is covered with a liberal supply of straw to protect the fruit from bruising. The dimensions of the structure depend upon the size of the field to be accommodated, a convenient size being 20 to 40 feet, with one packing shed to each 20-acre unit of the plantation. Near the shed is the washing rack, consisting of a long ridgepole supported horizontally at about 7 feet above a slat floor, and from which are suspended ropes looped to support the bunches conveniently. The fruit is carried to the washing rack, where it is hung and then washed to remove dust, trash, and insects (pl. 6, B). The fruit is finally returned to its place in the packing shed for weighing, marking, and grading. Four or five hours later, when the bunches have thoroughly dried, the fruit is inspected in accordance with the plant quarantine regulations of the United States Department of Agriculture and is ready for wrapping.

In Hawaii each standard bunch of bananas used for exportation is wrapped separately in a protective covering consisting of (1) paper, (2) rice straw, and (3) banana leaves. The leaves are long, tough, and very light, and are bound about with cheap cord or the fibrous midrib of the banana leaf. Such wrapping material permits free circulation of fresh air about the fruit, and is deemed very necessary when shipping the fruit without refrigeration. The cost of wrapping is estimated to be about 5 cents per bunch of fruit.

The local banana industry has developed slowly with the steady increase of proper shipping facilities between the islands and the mainland. Commercial production amounts to about 200,000 bunches annually. Table 7 gives the number of bunches and valuation of bananas exported from the islands since 1856, when the first shipment was made.

As the banana industry in Hawaii continues to develop, methods of shipping the fruit will probably improve. The industry can not make rapid growth until shipping facilities are increased, and steamship companies are not likely to increase their special shipping equipment unless they are assured of a steady supply of freight. The interests of the two are mutual. The local banana grower has long been compelled to export his fruit as deck freight, which is not always a satisfactory method. A change of schedule, made regardless of perishable freight, may result in partial or complete spoilage of bananas, the loss of which the grower must stand. Ventilation afforded deck freight may be better than that in the holds of some vessels, but neither the circulation nor the temperature of the air can be regulated as desired. Specially designed steamers having a part of their freighting capacity equipped with the modern cooling system, such as is used in transporting fruit similar distances from Central American ports, would seem adaptable to Hawaiian banana transportation. The cooling system makes it possible to maintain the desirable temperature of 56° F., in moderately warm climates such as occur between Hawaii and Pacific coast ports of the mainland.



A.—Hand of “Hai” bananas, a native variety of the Maoli group. One of the best kinds for cooking. A single fruit weighs a pound
B.—Washing the bunches of fruit to remove dust and any insects lurking among the bananas. The fruit is then placed in the packing shed, where it remains about a day to dry thoroughly. It is then wrapped for shipping

TABLE 7.—Number of bunches and valuation of bunches exported from the Hawaiian Islands¹

| Year | Number of bunches | Valuation | Year | Number of bunches | Valuation |
|------|-------------------|-------------|------|-------------------|--------------|
| 1856 | 93 | | 1891 | 116,660 | \$179,501.00 |
| 1857 | | | 1892 | 105,375 | 104,945.00 |
| 1858 | 150 | | 1893 | 92,909 | 92,020.00 |
| 1859 | | | 1894 | 113,118 | 112,930.75 |
| 1860 | | | 1895 | 98,164 | 97,813.00 |
| 1861 | | | 1896 | 120,659 | 121,273.00 |
| 1862 | 121 | | 1897 | 74,759 | 74,364.50 |
| 1863 | 60 | | 1898 | 79,482 | 65,418.61 |
| 1864 | 1,781 | | 1899 | 88,416 | 83,193.82 |
| 1865 | 1,211 | | 1900 | 9,733 | 9,317.00 |
| 1866 | 1,771 | | 1901 | | 74,414.00 |
| 1867 | 2,913 | | 1902 | | 70,888.00 |
| 1868 | 3,966 | | 1903 | | 66,180.00 |
| 1869 | 6,936 | | 1904 | | 91,338.00 |
| 1870 | 4,007 | | 1905 | | 120,653.00 |
| 1871 | 4,280 | | 1906 | | 131,806.00 |
| 1872 | 4,508 | | 1907 | | 115,771.00 |
| 1873 | 6,492 | | 1908 | | 160,944.00 |
| 1874 | 6,449 | | 1909 | | 209,676.00 |
| 1875 | 10,518 | | 1910 | 87,615 | 51,229.00 |
| 1876 | 14,982 | | 1911 | 183,201 | 108,414.00 |
| 1877 | 15,965 | | 1912 | 226,445 | 140,720.00 |
| 1878 | 18,431 | | 1913 | 223,762 | 143,472.00 |
| 1879 | 12,369 | | 1914 | 200,482 | 126,455.00 |
| 1880 | 19,164 | | 1915 | 280,629 | 189,578.00 |
| 1881 | 20,776 | | 1916 | 244,118 | 166,977.00 |
| 1882 | 18,848 | | 1917 | 243,558 | 170,368.00 |
| 1883 | 44,902 | | 1918 | 119,019 | 90,988.00 |
| 1884 | 58,040 | | 1919 | 115,127 | 102,796.00 |
| 1885 | 60,046 | \$58,803.50 | 1920 | 182,772 | 176,020.00 |
| 1886 | 45,862 | 43,824.25 | 1921 | 154,423 | 151,968.00 |
| 1887 | 58,938 | 54,703.25 | 1922 | 217,722 | 214,255.00 |
| 1888 | 71,335 | 69,208.00 | 1923 | 206,552 | 212,624.00 |
| 1889 | 105,630 | 135,278.00 | 1924 | 222,138 | 211,343.00 |
| 1890 | 97,204 | 176,351.00 | 1925 | 255,641 | |

¹ Compiled from published reports of the Customs House, Honolulu. No records of values are given for the period 1856-1885, and no records of bunches for the period 1901-1910. All data are for the calendar year except for the period 1901-1910, which was for the fiscal year. The valuations of the period 1905-1909, inclusive, include those for shipments of pineapples (fresh fruit), which probably amounted to 50 per cent. The number of bunches inspected for export for the year 1925 was furnished by the Federal Horticultural Board, Honolulu.

Bananas from Central American and West Indian ports are sent long distances in regular steamers, usually having cold-storage capacity for 10,000 to 20,000 bunches, and carrying passengers and general freight as well. Although the banana does not require the low temperature necessary in transporting frozen meat, it does require a complicated cooling apparatus to maintain a constant circulation of fresh air because of the heat which the fruit is constantly generating by respiration. Usually, the ships are equipped with loading and unloading apparatus enabling them to receive and discharge about 2,000 bunches of fruit per hour. The fruit is carried into different parts of the United States by box cars or refrigerator cars, depending upon the season and the distance to be covered. In winter the cars are often heavily lined with paper and the fruit is packed in straw as a protection against the cold. In summer refrigerator cars are used to prevent undue ripening on long journeys.

ENEMIES

Enemies of the banana in Hawaii are mainly insects, fungus diseases, rats, and possibly nematode worms, none of which has given serious trouble. The Japanese beetle (*Adoretus umbrosus*) is oc-

asionally found feeding upon the foliage of the plant. Damage from fungus diseases, the banana freckle disease excepted, is negligible. The cane borer (*Sphenophorus obscurus*) is no longer a pest of the banana plant in Hawaii, having been almost completely exterminated by the tachinid fly *Ceromasia sphenophori*, which was introduced into Hawaii in 1910 by the Sugar Planters' Association Experiment Station to check the ravages of the pest.

The mealybug *Pseudococcus bromeliæ* is found in masses between the fruits in some localities during the drier months of the year, and although it does not seriously retard development of the fruit it does make it unclean. The pest may be removed by washing the severed bunches with streams of water from a force pump. *P. bromeliæ* also attacks young suckers and injures them considerably; and it collects under the leaves and the inner side of the outer sheaths where it feeds upon the sap, greatly retarding growth. The pest may be controlled by spraying with an oil emulsion.

Notwithstanding the investigations made since 1910 to determine to what extent the banana in Hawaii is attacked by the Mediterranean fruit fly (*Ceratitis capitata*), no evidence has been obtained indicating that commercial varieties are susceptible to attack by the pest. This fact has failed to receive the publicity to which the banana industry is justly entitled.

When the Mediterranean fruit fly was discovered to be well established in Hawaii, the Bureau of Entomology of the United States Department of Agriculture, at the request of the Federal Horticultural Board, began an investigation covering three years (1912-1915) to learn which fruits should be prohibited from exportation. A summary of the findings (3) in so far as the banana is concerned and a report (4) of the field work done were published later. It is to be regretted that the investigators did not have at the time a clear classification of all the banana varieties growing in Hawaii so that each variety could have been fully tested to determine its susceptibility to fruit-fly attack. The report of the possible infection of two thin-skinned native varieties, the Popoulu and the Moa, when allowed to ripen on the plants, has probably led uninformed persons to believe that all Hawaiian varieties are attacked by the Mediterranean fruit fly. The Popoulu and Moa varieties are rarely eaten raw or shipped from the islands. They are scarce and are strikingly distinct from both ordinary cooking bananas and the commercial varieties.

Examination of approximately 27,000 fruits of the Chinese variety in the Moanalua fields, Oahu, in 1913, showed no evidence of fruit-fly infestation or of egg puncture. Examination of 3,500 bananas of the same variety at Kalauao, Oahu, gave negative results, and 1,000 bananas of this variety which were considered too mature for shipment gave no evidence of fruit-fly infestation when held in the insect hatchery of the laboratory. A lot of 1,044 bananas discarded for similar reasons gave negative results when examined in the laboratory. Fully ripened fruits of the Chinese and Apple varieties growing among many other kinds of fruits showed no evidence of infestation, and some 50 fruits of the Ice Cream variety, cut in 1914 from

the plant as they ripened, were found not to be infested, although growing in the midst of many other species of fruits. Five hundred overripe fruits of Manila hemp or abaca (*Musa textilis*) and 60 ripe fruits of Borabora bananas (*M. fehi*) growing in the mountain gorges at the head of Manoa Valley, Oahu, were found to be free from infestation.

A number of experiments have been conducted in both the field and laboratory to learn why bananas are immune from attack by the Mediterranean fruit fly. It was long thought that the fruit was afforded protection by other plants for which the fly had a preference. Results of experiments failed to confirm this belief, however. When attempts failed to force the female fly to oviposit in bananas that were sufficiently mature to ship, freshly laid eggs were taken from another kind of fruit and placed in incisions made in the banana, each bunch of which was marked. Some of the eggs hatched, but the larvæ died before entering the pulp.

During the 13 years the local representatives of the Federal Department of Agriculture have supervised the inspection of bananas for shipment no fruit fly infestation has been discovered among either green or ripe bananas grown under normal field conditions.

The freckle disease (*Phoma musæ*), the most serious known to local banana growers, was described by Carpenter in 1918 (7, p. 36). The disease attacks almost exclusively the Chinese banana, but has also been observed on the foliage and fruit of the Lady Finger and Father Leonore varieties. The disease does the most damage during the months of greatest moisture. The earlier stages of growth and spore production of the fungus take place in the tissues of the foliage. Later the spores fall upon bunches of fruit which are approaching maturity and cause the skin to blacken in specks or freckles. The freckles usually occur mainly on the fruit of the upper part of the bunch. Damage lies largely in the spotted appearance of the skin and becomes more evident as the fruit ripens and attains full color. The disease is largely controlled by spraying with Bordeaux mixture and by wrapping the bunch of fruit, several weeks before it reaches full size, with newspapers or with a tough paper slip which is manufactured for the purpose. It is important that the wrapper completely cover the upper part of the bunch.

The tree rat (*Mus rattus*), sometimes called the black rat or the blue rat, climbs up on the banana plant and eats part of the maturing fruits. Although it seldom seriously damages commercial fields where the fruit is picked green for shipment, it does considerable injury to bananas growing in gardens or wild in the mountains, where the fruit naturally ripens on the plants. The tree rat is easily identified by its long, slender snout, large ears, and body of dark bluish color; it nests usually in the tree tops and occasionally in hidden places on the ground. The rat feeds upon many kinds of fruits and nuts, and has a particular liking for coconuts, bananas, and algaroba beans. The pest is best controlled by shooting, using light charges of small shot.

DESCRIPTION OF VARIETIES ⁷

According to a manuscript, written in 1870, by G. P. Kalokuokamaile, of Napoopoo, Hawaii, fully 70 varieties of bananas were known to the old Hawaiians of the Kona district, and large areas of the Kona woods were covered with banana plants at one time. It is also known that half a century ago wild bananas covered large areas in East Hawaii, which are now utilized for grazing. Apparently many varieties that were formerly grown there have disappeared. Some so-called native varieties, for instance, which are mentioned in locally published old lists, can not be found, and a number of varieties that were introduced from the West Indies by the station in 1904-1905 no longer grow in the islands.

The varieties described in this bulletin were grown at the central station in Honolulu, or in commercial fields in different parts of the Territory. In a number of instances the Hawaiian or native varieties were examined and photographed growing wild in the forest. The varieties, including some not found by the writer, have been arranged in two divisions, introduced varieties and Hawaiian or native varieties.

The introduced varieties are those brought in since the discovery of the islands by Captain Cook in 1778, and include the Chinese or Cavendish, Bluefields or Gros Michel, Brazilian, Red, Green Red (a bud mutation of the Red variety), Hamakua, Lady Finger, Borabora or Fei, Ice Cream, Eslesno, Apple, Chamaluco, Father Leonore, Largo, Colorado Blanco, Abyssinian, Kusaie, abaca or Manila hemp,⁸ and common and dwarf plantain varieties.

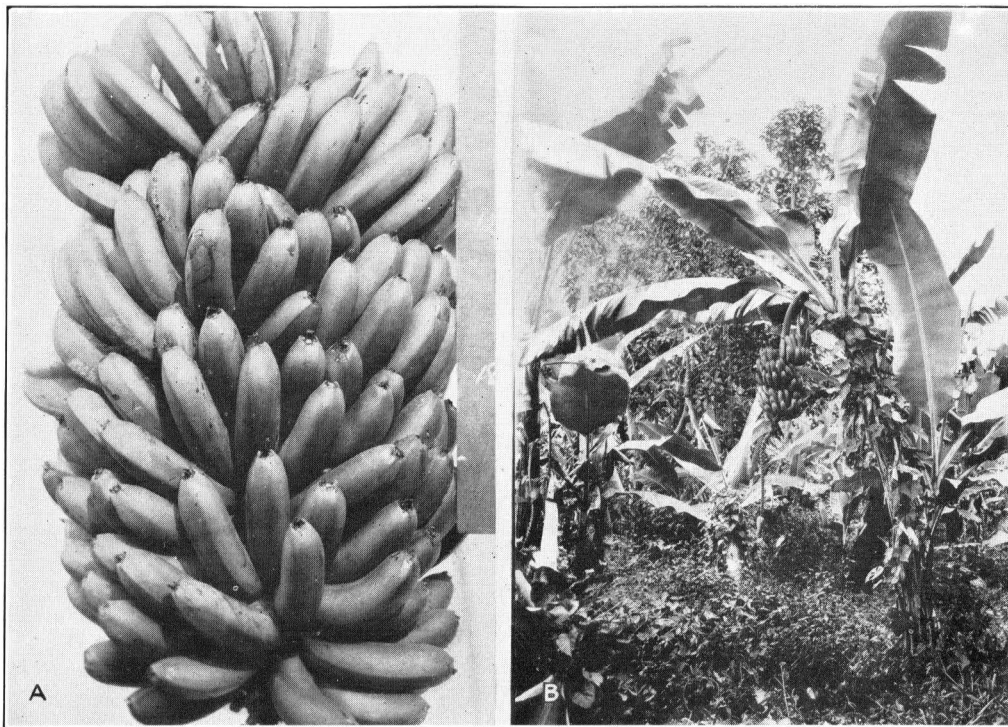
The Kusaie variety, although of Pacific origin, is of rather recent introduction, and has been briefly described by Higgins (*13*, p. 46). Specimens of the plant were not found by the writer, but interested people about Hilo, Hawaii, seem to be familiar with the variety.

The Hawaiian or native varieties are supposedly of Polynesian origin, and fall into three groups, the Maoli, Iholena, and Popoulu, with several additional varieties, the leading characters of which apparently are not related to any of the groups. The Maoli group includes the Maiamaoli, Hai, Haikea (a subvariety of Hai), Manaiula or Malaiula, Kaulau, Eleele, also known as Poni and Hinupuaa, Koae or Aea, Mahoe or Palua, Pui, Eka, Iho-u, and Loha varieties; the Iholena group includes the Iholena or Hilahila, Kapua or Puapuanui, Lele, and Haa or Haahaa varieties; and the Popoulu group includes the Popoulu, Kaio, Moa or Huamoa, Nou, and Lahi varieties. The varieties not falling into any of the three groups are the Maia hapae and Maia Oa.

The Loha, Lahi, Nou, Maia hapai, and Haa varieties were not found by the writer, and are briefly described by Higgins (*13*, pp.

⁷ Spelling of names and grouping of varieties do not agree in all instances with the classification used by Higgins (*13*). The changes were made only after careful investigation and consultation with a number of well-informed persons on the subject, including T. C. White, of Kona; G. P. Wilder and A. J. Campbell, of Honolulu; F. Gay, of Kauai; and T. Kelsey, of Hilo.

⁸ Abaca plants are found growing among banana plants in many parts of the Territory, and ordinarily can not be distinguished from them. The fruit is frequently sent to the station with inquiries as to "why these bananas produce seeds." It is mentioned among the introduced varieties and is described on page 35 in order that growers may readily identify the species, which is of value in cross-pollination work because of its production of abundant pollen.



A.—Fruit of the Cavendish or Chinese variety, which is the leading locally grown banana for export trade
B.—The variety Hamakua, often erroneously called Bluefields. The plant is not so tall as the Bluefields, is naturally more reclining, and the fruit is somewhat different

51, 52, 53), and are known to others. The Maia Oa and Abyssinian varieties are very rare, occasionally being grown for ornamental purposes. The fruits of the abaca, and Abyssinian and Oa varieties are not edible, but are of value because of their production of abundant pollen.

INTRODUCED VARIETIES

CAVENDISH OR CHINESE

The Cavendish or Chinese banana (No. 4498)⁹ is the leading commercial variety of the Hawaiian Islands, its wonderful adaptability to local conditions making it rank supreme among the many banana varieties so far cultivated (pl. 7, A). The brief history of its origin is interesting:

The dwarf banana was found growing in southern China by early travelers to the Orient, and in 1826 was brought to Mauritius, Indian Ocean, by Charles Telfair, who seems to have been the first European to obtain plants of the species. The dwarf plants grew vigorously, fruited profusely, and seemed to be practically immune from attack by insect pests and disease, convincing the grower of the superiority of the species over all other banana species in his extensive collection. Two plants, sent to a Mr. Barclay, of Burryhill, England, in 1829, were grown in a hothouse and propagated by means of offshoots. After the death of Mr. Barclay, one of the plants was sold to the Duke of Devonshire and grown at Chatsworth in 1836 by the gardener, a Mr. Paxton. The gardener published a description of the plant in the Magazine of Botany for 1837 (11, p. 197). A. B. Lambert, a European botanist whose extensive herbarium was open to every man of science, made a study of the dwarf banana in 1836 and exhibited some of the plants at a meeting of the Linnean Society in London, together with an old Chinese drawing which he believed identified the origin of the species. Mr. Lambert gave the dwarf banana the specific name of *cavendishii*, probably in honor of Henry Cavendish (1731-1810), a noted English scientist, and relative of the Duke of Devonshire. The Chatsworth gardens were the original source of all the Cavendish bananas for commercial cultivation.

John Williams, a missionary of the South Sea Islands, who heard of the dwarf species at Chatsworth upon his return to England in 1834, carried some of the plants in 1838 to Tonga, Samoa, and the Society Islands, where they were propagated and flourished. Ten years later the species was introduced into the Friendly Islands and Fiji, where it effectively put a stop to occasional famines.

According to Hillebrand (14, p. 443), the Cavendish or Chinese banana (*Musa cavendishii*) was introduced into the Hawaiian Islands from Tahiti about the year 1855. In a very short time it superseded all other varieties on account of its superior fruiting qualities and its low form of growth, which affords it protection from high winds. Within the last hundred years the species has been introduced into Egypt, Brazil, French Guiana, Barbados, Trinidad,

⁹ Accession number under which the variety has been propagated at the station.

North Australia, and the Canary Islands, where it is being cultivated with success as a commercial banana.

Plants.—From 8 to 12 feet high; trunks, erect or slightly reclining, 4 to 8 feet long, 8 to 14 inches in diameter at base. Leaves, 8 to 10, spiral arrangement of petioles distinct, length 4 to 6 feet, short, stout petioles, green with pink or red margins; blades short and broad, glaucous, both sides joining petiole evenly (pl. 2, B).

Flowers.—Pistillate, 8 to 9 centimeters long, ovary green, angular, slightly curved; perianth, small, drab, 5-lobed, yellow, rolled, middle lobes the largest. Petal, cream colored or translucent, keeled, apicula erect, pale yellow; stamens, rudimentary; pistil, style straight, slim, stigma irregularly lobed, yellowish to drab in color.

Staminate flower 5.5 centimeters long, ovary clubbed, apple green in color; perianth, whitish, 5-lobed, yellow, middle and two outside lobes long, two secondary small. Petal 1.8 centimeters long, translucent; apicula erect, cream colored, and with point of petal on each side of base. Stamens 5, long as pistil, anthers cream colored, darkening at margins with age. Style white, slim; stigma small, irregularly lobed. The rachis often extends nearly to the ground and the dead staminate flowers and bracts are persistent.

Fruit.—From 6 to 8 inches long, 1½ to 2 inches in diameter, usually curved, angular when young, but without angles at full ripeness; base tapering to short pedicel, apex blunt, skin yellow when ripe, medium thickness; pulp, cream colored, sweet, and of pleasing flavor. The bunches vary from 50 to 125 pounds, depending upon the culture.

BLUEFIELDS OR GROS MICHEL

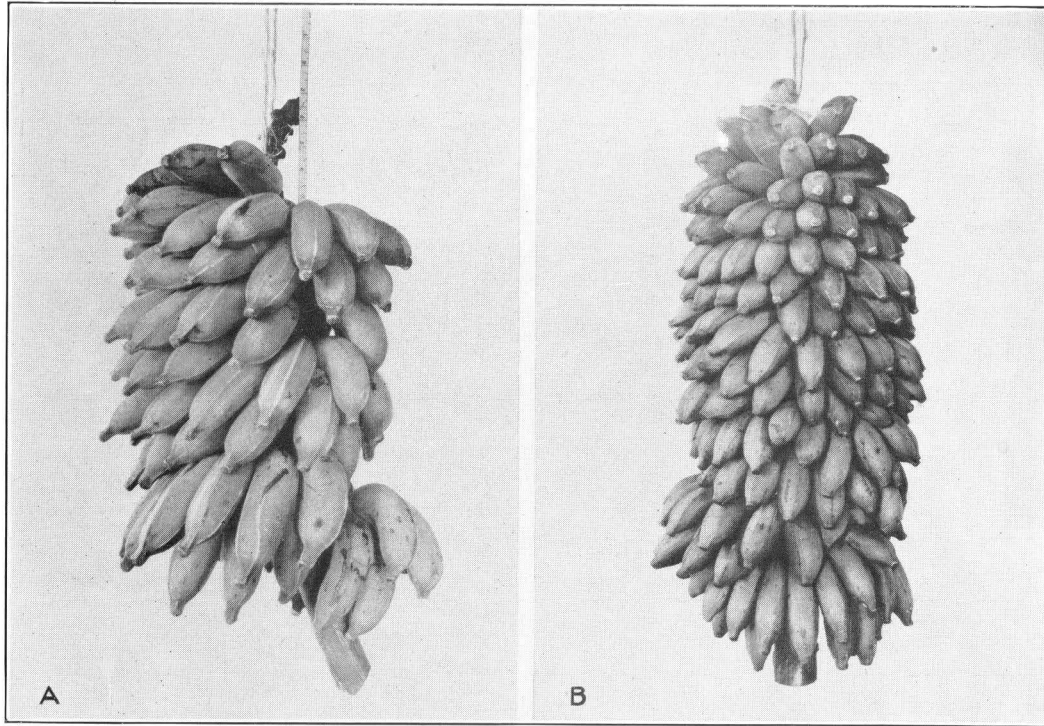
About the year 1840 an improved type of banana was observed in Martinique, West Indies, and introduced by Jean Francisco Pouyat into Jamaica, where the variety was called the "Pouyat" or the "Martinique" (10, p. 155). It was the leading banana of Jamaica for many years, and became known as the Jamaica or Gros Michel after the banana industry in Costa Rica began to develop. The variety is now well established in Fiji, New Guinea, and Queensland, where it is known as the Gros Michel. It was introduced into Hawaii early in 1903 by Philip Peck, of Hilo, and by the Territorial Board of Agriculture and Forestry near the close of the same year (13, p. 42). The following year the station introduced 130 "heads," or bases of large suckers (Acc. No. 72), from the port of Bluefields, Nicaragua. These reached Honolulu December 26, 1904, via New Orleans and San Francisco. After this introduction the banana was generally known as the Bluefields (No. 4544). Botanically, it is a variety of *Musa sapientum*.

Plants.—Tall, with upright trunks varying from 15 to 20 feet, 12 inches in diameter at the base; outer sheaths green, with blackish and reddish blotches. In some localities where there is an abundance of sunlight, the petioles and midribs of the underside of the leaves, as well as the younger growth, are washed with a cast of red. The plants sucker freely, forming large clumps. The bunches are on long, stout, well-curved stems, which hang nearly straight down. The hands of fruit are compact and stand nearly parallel with the stem. As the pistillate fruits are forming, the rachis continues to extend to considerable length, shedding its staminate flowers and developing a characteristic bend which is peculiar to few varieties (pl. 8, A).

Flowers.—Pistillate, about 14 centimeters long; ovary, large, light green; perianth, whitish, with cast of brown appearing as streaks or splotches in a few hours after exposure from under the rising bract; perianth lobes, 5, the two outer long and pointed, middle, short and wider, the two intermediate, small; all lobes tipped with yellow. Corolla consisting of a single free petal, white to iridescent, 2.8 centimeters long, broadly keeled, margin of sides turned inward, apicula turned inward and upward. Stamens, rudimentary and without anthers, pointed, shorter than perianth. Pistil, style stout,



A.—The Bluefields is one of the largest and best varieties grown in Hawaii. It does very well in regions of considerable rainfall and little wind. The picture was taken on the farm of George Moku, near Napoopoo, Hawaii
B.—A bunch of Bluefields fruit grown at the station under rather unfavorable conditions. Bluefields bunches of fruit often attain great size



A.—The Brazilian variety, grown mainly for local trade. The plants withstand considerable wind and produce in localities of little rainfall without irrigation
B.—The variety Lady Finger, imported into Hawaii from Porto Rico. The plants are excellent for dry localities, where they fruit well. A good banana, best suited for local markets

whitish, 3.6 centimeters long. Stigma, large, irregularly 3 to 6 lobed, brownish and often marked with small reddish spots.

Staminate flower, whitish, 7.5 centimeters long; ovary, club-shaped, 2 to 3 centimeters long; perianth, lightly shaded with brown, 5-lobed, the two outside long and pointed, middle, shorter and broader, and two intermediate, all tipped with yellow. Free petal, 2.5 centimeters long, translucent, several folds at base of a rather prominent apicula. Stamens, 5, longer than pistil, anthers, curved outward, brownish at margins. Pistil, style slim and white, nearly as long as stamens, stigma, small and irregularly lobed.

Fruit.—Bunches, large, ranging from 60 to 150 pounds, 7 to 10 or more hands, withstand shipping green without wrapping fairly well; individual fruit, 7 to 9 inches long, tapering pedicel, beaked apex, nearly straight, apex often slightly turned outward, 4 to 5 angled, the ridges almost disappearing at full maturity; skin, thick, bright yellow; flesh firm, core indistinct, consistency and flavor excellent (pl. 8, B).

BRAZILIAN

How the Brazilian variety (No. 4494) came to be so named is not known. Hillebrand (14, p. 433) states that the variety was introduced into Hawaii from Java about 1855, via Tahiti, Society Islands. Higgins (13, p. 45) believes the variety to be either Pisang radjah or Pisang medja, "the desert banana" of Java. It is grown on all the larger islands of the Hawaiian group and is commonly found on the local markets. The area devoted to the variety has been greatly extended on windward Oahu during the past three years (1923-1925). The Brazilian is designated by the Chinese as "Park-yuk," meaning "white flesh," and sometimes it is erroneously called the Apple banana. The variety withstands considerable wind and is often used as a windbreak for other varieties. Results of experiments show that the fruit can be satisfactorily shipped to the markets of the Pacific coast.

Plants.—Size, medium to large; trunks, 12 to 20 feet tall; color, green tinged with pink, upper parts of sheath coverings being marked with irregular patches of dark brown; petioles, 2 to 3 feet long, stout; blades, light green, 7 to 10 feet long, 22 to 27 inches broad. Young sheaths and petioles, frosted with a bloom. The rootstocks sucker freely.

Flowers.—Pistillate, 4.7 centimeters long; ovary, light green in color; perianth, whitish in color, turning drab to brownish with age; 5 lobes, 3 large and 2 secondary, small, all bright lemon yellow in color. Petal, large, broad, and translucent, apicula turned inward, stamens short, rudimentary, black pointed.

Staminate flowers, 6.5 centimeters long; ovary, cream colored, washed with red; perianth, cream colored turning drab or grayish with age; 5 lobes, 3 large and 2 secondary, small, all bright lemon yellow; petal, white, translucent bladdery, apicula, small, erect, with shorter projections on each side of base. Style, slim, white; stigma, small and oblong, irregularly lobed, extending to about the same length as perianth; stamens 5, shorter than perianth, sometimes 3 short and 2 long; anthers, very black, imperfect; some nectar in petal about base of style.

Fruit.—Bunch, small to medium size; may weigh 45 pounds or more when the variety is given good culture. The variety may invariably be identified by the basal hand of curved fruits which are twisted upward irregularly. Individual fruits at maturity are about 6 inches long; flower end terminates in a prominent beak; fruit is five-angled with angle ridges prominent. Skin, bright yellow, of medium thickness, and separates easily from the flesh. Flesh, white or light cream colored, core, indistinct. Flavor, pleasing, subacid (pl. 9, A).

RED

The Red banana (No. 4492) is not uncommon throughout the Hawaiian Islands. Higgins (13 p. 45) states that it was introduced with the Largo variety from Mexico. It was also introduced into

Hawaii by the station from the Porto Rico Experiment Station in December, 1904, under the name "Colorado." The names "Red Spanish" and "Red Cuban" are applied to the variety in other parts of the West Indies and sometimes in Hawaii. "Red" is the term generally used commercially, and is, perhaps, the most applicable. The variety is said to be of Indian origin, and is botanically known as *Musa sapientum* var. *rubra*. It is distinct in its vegetative characters, is large, and not so exacting in its requirements as are most other varieties. It is reported from tropical America as being more resistant to disease than are other commercial varieties.

GREEN RED

The Red variety frequently gives rise to bud mutation producing fruit which is more green than red in color until maturity when the green portion turns yellow, hence the name "Green Red." In variation, the Green Red variety is different from the Colorado Blanco variety. Trunks and fruit stems are striped in some instances and are green on one side and red on the other in others, and many of the bananas are green on one side and red on the other. Such bananas from tropical America are said to be sold under different trade names.

Plants.—Large and strong, 24 to 28 feet tall; trunks, 14 to 18 inches in basal diameter; sheaths, petioles, and midribs of leaves, red; leaf blades, 12 to 14 feet long, 24 inches wide, tapering toward apex, dark green.

Flowers.—Staminate flower, 7.8 centimeters long, whitish with wash of red over upper part of ovary and lower part of perianth; lobes, red with yellow edges and tip; petal, large, creamy white, several folds at the top, apicula prominent, curved; stamens, longer than perianth, anthers, white turning brown; stigma, brownish, flattened, 5-lobed.

Fruit.—Bunches, medium, weighing 30 to 50 pounds, 4 to 7 hands; individual fruits, 5 to 7 inches long, 2 to 2½ inches in diameter, stout, curved then nearly straight, angles disappearing at full ripeness; base tapering abruptly to short pedicel; apex filled; color, dark purplish red, changing to yellow and red when ripe; skin, thick; pulp, cream colored, firm, core, distinct; flavor good.

HAMAKUA

Plants of the Hamakua variety (No. 4810) were received by the station in 1922 from the Island of Hawaii, and set in the trial grounds (pl. 7, B). The plants have grown and fruited and studies have been made of their varietal characters for comparison with specimens of the variety growing elsewhere in the Territory. The Hamakua is known to some growers as Bluefields, but this is undoubtedly a mistake. The varietal characters of the Hamakua variety correspond very accurately with those of the Congo, a commercial banana of the West Indies, which was introduced into Hawaii by the station in 1904 and later disappeared without record. It is believed that a number of propagating heads of the Congo were introduced into the island of Hawaii and in time became known as Hamakua bananas.

Plants.—From 10 to 14 feet tall, reclining; trunks, green, marked with reddish cast and darker patches on the upper portions of the outer sheaths; blackish patches on the basal portion of the petioles. Leaves green, glaucous on both surfaces; petioles, greenish with narrow red margins extending as brownish lines along edges of blade. Blades vary from 5 to 7 feet long, greatest

width 22 to 26 inches. Under certain conditions the fruiting stem of the variety breaks within the stalk before the fruit matures.

Flowers.—Staminate flower, whitish or cream colored, 5 to 6 centimeters long; ovary, rudimentary, greenish; perianth, whitish, shading with age; lobes, yellow; petal, translucent, apicula, short and erect or turned inwardly, stamens, 5, whitish, considerably longer than perianth; anthers, curved outward, margins become brownish with age; pistil shorter than stamens, slim, small, brownish stigma.

Fruit.—Mature bunches vary from 50 to 70 pounds in Hawaii. Because of the arrangement and curvature of the bananas on the stem, the bunch has the appearance of the Chinese variety. As the bunch hangs from the plant, the extending rachis has a distinct bend between the bunch and the terminal bud, which often causes the variety to be mistaken for the Bluefields. Individual fruits vary from 6 to 8 inches in length, and curved, with the apex well filled, 4 or 5 angled, the angle ridges disappearing when the banana fully matures. The skin is of medium thickness, yellow in color; pulp, yellow, firm, sweet and of good flavor, comparing favorably with the fruit of the Chinese and Bluefields varieties.

LADY FINGER

The Lady Finger variety (No. 4493) was introduced into Hawaii by the station from the Porto Rico Experiment Station in 1904 under the name of "Datyl" (No. 48). It is now grown at the Tantalus substation (No. 2958), where it withstood a prolonged drought in 1923-24 much better than any other variety under trial, producing large bunches of fruit. There were probably other introductions of the variety into the Hawaiian Islands. Evidently there are several strains of the Lady Finger since descriptions from different countries vary considerably. The Lady Finger is well known in most parts of tropical America, where it is grown in some places for export trade. It is a poor shipper, however. Fawcett states that in Guiana where the Panama disease caused losses ranging from 25 to 75 per cent of the Jamaica (Bluefields) variety, the Lady Finger variety was not attacked. The variety is known in tropical America under such names as Datyl, Fig, Date, Dedo de Dama, and Guineo Blanco. Botanically, it is classified as *Musa sapientum*.

Plants.—The plant at maturity is about 25 feet tall; trunk, rather slim, erect; root system, heavy, enabling the plant to withstand considerably strong winds; outer trunk sheaths, dark with reddish brown streaks and patches; foliage, very dark green; leaf petioles, greenish with edges tinged light yellow; blade, about 7 feet long, 14 inches in greatest width, dark green above, dull green below; fruiting stem, stout, dark, gracefully curved; bunch, slender and very compact, considerably long.

Flowers.—Staminate flower, about 6 centimeters long, whitish with pinkish cast on part of ovary, shade of rose on perianth, which terminates in five lobes tipped with bright orange; petal, whitish, translucent; apicula, small with a slight projection of petal margin on each side and a fold at base; stamens with long, curving anthers extending about even with perianth lobes; pistil, style slim, stigma lobed, yellow, extending beyond stamens.

Fruit.—Bunches weigh 40 to 65 pounds; 10 to 14 hands, 15 to 20 bananas to hand; individual fruit 4 to 5 inches long; pedicel, three-fourths inch, angling, more blunt at apex; skin, thin, light yellow; flesh, whitish, firm, sweet and agreeable (pl. 9, B).

BORABORA

The Borabora or Fei banana (No. 4757) is believed to have been introduced into Hawaii early in the nineteenth century (14, p. 424) from the Society Islands where it is commonly known to the Tahitians as "Fei," and possibly by some as "Borabora," the name of an island of the Society group where the variety may have

originated. "Borobora" is said to have been translated into the Hawaiian language as "polapola," and this in turn corrupted in English into "bolabola," by which term it is sometimes improperly called.

The Borabora banana, botanically known as *Musa fehi*, is reported as growing in the forests of a number of islands of the tropical Pacific. It makes its best growth without cultivation in the higher valleys where there is an abundance of rain, but will grow under desirable conditions at the lower elevations. Fine specimens are not uncommon in Hilo and other similar localities (pl 10, A).

The variety often produces seeds at higher elevations, just as a number of other varieties of the species do at elevations of about 3,000 feet in the Society Islands. A striking peculiarity of the variety is its very large scape or stem, which stands erect, holding the bunch of fruit upright instead of hanging over as in most varieties. On account of its beautiful form and shiny green leaves, the plant is of value as an ornamental.

Plants.—Clumps, very large; suckers freely; growth, vigorous, upright, often reaching 36 feet tall; trunks 15 to 20 feet long; base, black, upper portions, green; leaves 10 to 15 feet long; petioles, short and stout; blades often 20 to 30 inches wide, shiny green above and lighter green below. The juice of the trunk and petioles is violet colored and darkens upon exposure.

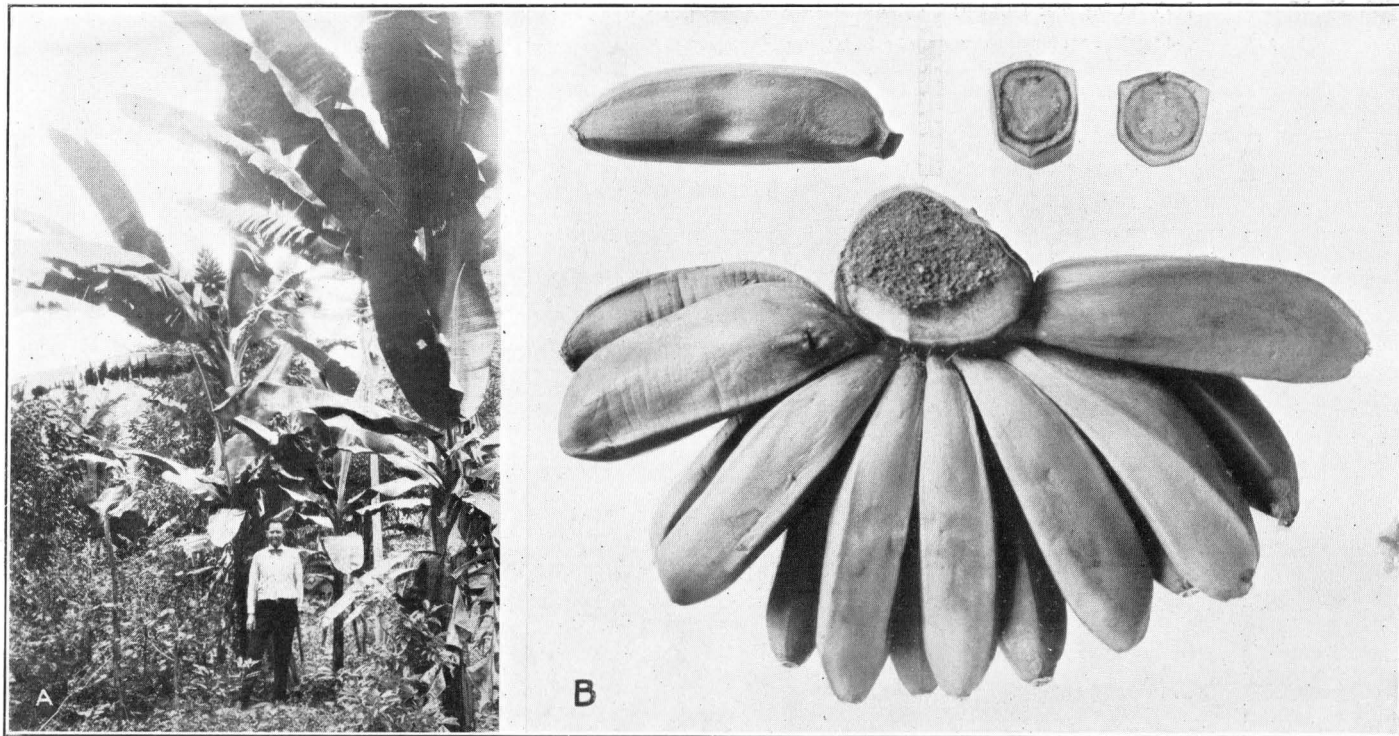
Flowers.—Arranged in compact panicles, standing erect on stout scape. Pistillate flowers with long style and uncommon, divided stigma. Nectar secretion about base of style. Ovary, dark green, 4-angled, hard, 3-celled, conspicuous core; calyx, 5.5 centimeters long, cream in color shading to pink, tipped with four light colored points, the outer two being largest; corolla consisting of one free petal, rigid, translucent or creamy white, 3.3 centimeters long, terminating in broad but sharp apicula; stamens, 5 or 6, about 5 centimeters long, with drab anthers; bracts long, narrow, tending to be persistent to near maturity of fruit.

Staminate flowers, 7.5 centimeters long; ovary, 1.5 centimeters long, apple green in color; calyx, split on one side as in species of sapientum, cream colored at base, changing to pink along dorsal part toward the four whitish tips; petal same as in pistillate flower; stamens, 5 or 6, each 5 centimeters long, white, terminating in drab anthers possessing abundance of white pollen; pistil, slim, long as stamens, cream colored; stigma, small; bracts, long, narrow, deciduous, and apple green in color.

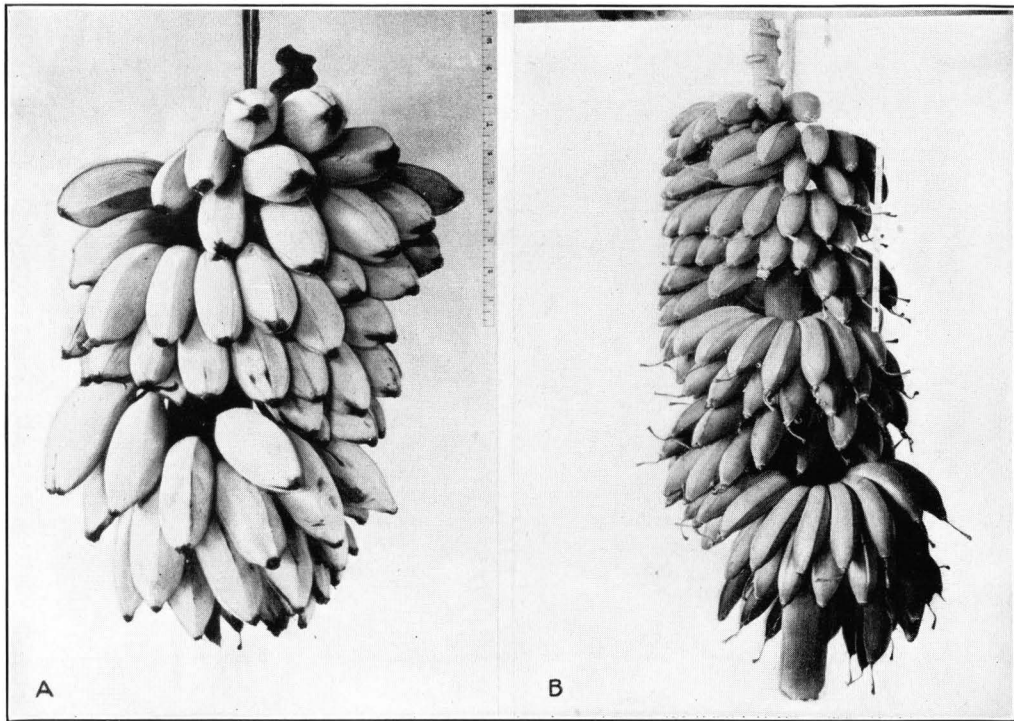
Fruit.—The bunch sometimes weighs 50 pounds, and remains erect to full maturity; number of hands, few, usually about six; individual fruits stand obliquely, are straight and angular, sessile, and pointed at apex; skin, thick, orange to copper colored; pulp, greenish sulphur-yellow, very firm, seedless when grown at lower elevations, but with distinct core; rachis extends only little beyond the pistillate flowers, the bud is small, oblong, tapering to a sharp point (with pistil dried remaining persistent, covered with greenish bracts striped longitudinally with lighter green). Bud and extended rachis fall away before maturity of fruit, giving space to the most terminal fruits. The fruit is of good flavor when cooked (pl. 10, B).

ICE CREAM

The station obtained its first plant of the Ice Cream banana (No. 4489) on January 28, 1908, from a local grower who was unable to give its origin. A study of the variety from other countries indicates that it is the Cenizo of Central America and the West Indies where it is classified by some authorities as an apple plantain. In the Philippines the variety is described as a true banana of the variety Krie (C. A. No. 5396) (15, p. 61). Its source and by whom it was introduced into Hawaii have not been determined by the writer.



A.—The borabora (*Musa fehi*) banana growing in the private garden of T. A. Dranga, Hilo, Hawaii, November, 1924. Note the stout trunk and the erect bunch of fruit
B.—Hand of Borabora. Each fruit is attached on a very short pedicel to a very large rachis containing a beautiful purplish sap



A.—Ice Cream banana. The plant is large; the fruit is of good size and frosty, light yellow in color; and the pulp is light and suggestive of its name
B.—The Apple variety is considerably grown for local markets. The characteristic of the ripe fruit retaining the dead pistils is peculiar to only few varieties

Plants.—Clumps, large, with many smooth, stout, light green, somewhat leaning trunks, 10 to 15 feet high; leaves 8 to 12 feet long; petioles, 2 to 3 feet long, cylindrical; margins with very fine brown lines which extend into blade margins; blade, broad, with rounded ends, base somewhat cordate, shiny green above, lighter green below, midrib with cast of pink.

Flowers.—Pistillate flower, 8.5 centimeters long; ovary, 6 centimeters long, club shaped, curved, sharply 5-angled, extended on a stout pedicel 3 centimeters long; perianth, 3.7 centimeters long, outside rose red with lighter margins and 3 lobes of same color, inner surface deep red. Free petal, 2.5 centimeters long, light at base, shaded to rose pink, sides depressed, dished and with delicate apicula. Stamens, 5, rudimentary; no anthers; style, stout, pinkish, stigma globular, brownish with lobes indistinct.

Staminate flower, 5.5 centimeters long; ovary, 1.7 centimeters, pinkish at base, lighter at extreme; perianth, 3.8 centimeters long, deep rose color, redder inside, 3 to 5 lobes; corolla, 1 to 3 petals, light at base, rose pink, dished with side depression forming keel; broad apicula with yellow margins; stamens, yellowish, 3.7 centimeters long, and with narrow, brownish curved anthers. Pistil, rudimentary, as long or longer than stamens. The heart is short and thick; bracts, purplish with heavy glaucous, deep red inside, rolling before shedding. The rachis extends to several feet in length.

Fruits.—From 5 to 7 inches long, $1\frac{3}{4}$ to $2\frac{1}{2}$ inches in diameter, 4 or 5 angled, stout, straight, with sides slightly inflated, apex tapering with calyx and style deciduous. Skin, coarse and with bluish tinge when young, and very glaucous, often having a silvery white color; pale yellow when ripe. Flesh, white, taste sweetish, core distinct, seedless except in rare cases; 7 to 9 hands to the bunch; weight of bunch 40 to 60 pounds. The fruit may be eaten raw, but is also used as a cooking banana (pl. 11, A).

ESLESNO

Among the bananas introduced into Hawaii by the station from Porto Rico in 1904 was an unlabeled variety which has since been identified by J. Caban, of Honolulu, formerly of the West Indies, as the "Eslesno" (No. 4495). The variety was probably named after a territory of some Spanish possession, and is more commonly known in Hawaii as the "Porto Rican." It is regarded as excellent when eaten raw, and on account of its small bunches is probably suited for local-market culture only.

Plants.—Trunk, 10 to 12 feet tall, rather small, somewhat leaning when in fruit; trunk sheaths, reddish green with more or less dark-brown patches; foliage, usually of 7 or 8 leaves, 8 to 10 feet long, 16 to 18 inches wide at full maturity; petiole, almost cylindrical, with red margins extending into reddish-brown leaf margins; blade, rich, dull green above, lighter green below; clumps sucker freely; sword suckers expand broad leaves after reaching 3 feet tall; leaf margins on peepers and sword suckers rather red; other young growth glaucous.

Flowers.—Pistillate flower, 12 centimeters long; ovary, 7.5 centimeters long, 3-angled, occasionally 4; style and stigma, 3.8 centimeters long, stigma 6-lobed; perianth, 3.5 centimeters, somewhat shorter than style, whitish in color, ridged longitudinally and lightly washed with red, margins light and 5 terminal lobes tipped with orange; two outside and middle lobes about 7 millimeters long, two intermediate narrow and shorter; inner surface of perianth beautifully streaked with dark red.

Ovary of neutral flower, 3.7 centimeters long; other floral parts rather rudimentary.

Staminate flower, 7.5 centimeters long; ovary, 2.5 centimeters long; perianth, about 5 centimeters, light, shaded with red; 5 lobes, orange tipped; corolla, consisting of one free petal, translucent or whitish, dished; no apicula; stamens, 5.5 centimeters; anther, curved, dark brown; pistil, 5 centimeters, white, tinged with pink and cream or yellow stigma; rachis extending, dropping staminate flowers and bracts from long pointed terminal buds; bracts roll before dropping, dark purple color grayed with glaucous; inner surface, rich dark red, roughened with numerous transverse indentations.

Fruit.—Bunches small, weighing 25 to 35 pounds, 5 to 7 hands with 10 to 12 fruits to hand; individual fruits, sessile, or with very short pedicel, about 5 inches long, $1\frac{1}{2}$ inches in diameter, cylindrical, with angles almost disappearing with full maturity, plump and with a prominent beak at apex; all floral parts usually shed as fruit develops; skin, rich, bright yellow, medium thickness, peels easily; pulp, light yellow, firm; indistinct core; flavor, subacid and very pleasing.

APPLE

The Apple banana (No. 4505) was introduced into Hawaii about 1868 from China (13, p. 45), where it is known as "Go-Sai-heong," meaning "the fragrance that goes over the mountain." It was also introduced in 1904 from Porto Rico by the station under the Spanish name "Manzano." The fruits of both have been identified by West Indians in Hawaii as belonging to the same variety. Plants and fruit vary greatly in size, owing, apparently, to cultural conditions. The variety when properly grown and handled produces excellent fruit.

Plants.—Clumps, large, suckering freely; trunks, reclining, 10 to 12 feet tall, basal diameter often 12 to 14 inches, green with parts of old sheaths grayish, sometimes with brownish patches on sheaths near base of petioles; leaves, 8 to 12 feet long, 16 to 18 inches wide; petioles, cylindrical, margins with purplish tinge extending to edges of blade, one side of which is attached several inches lower than the other on the petiole; blade, green above, lighter green below, glaucous.

Flowers.—Pistillate flower, ovary 9 centimeters long, 3 or 4 angled, light green, often with slight cast of brown toward apex; calyx, grayish, with two heavy brown longitudinal ridges, end terminating in 5 lobes, brownish with white margins, the middle and two outer large, two secondary small and narrow. The two outer lobes each possess a threadlike lash, 5 millimeters long; corolla, one pink, iridescent petal, somewhat ridged and more or less collapsed, 3-dimpled below prominent apicula; stamens, 5, rudimentary, drab, without anthers; style, stout, stigma, large, 6 lobes.

Staminate flower, 8 centimeters long, curved; ovary, clubbed, white to greenish cast. Calyx, 5.5 centimeters long, ridged, drab to brown, pink inside, 5-lobed with whitish margins; stamens, 5, clubbed, drab, rudimentary, anthers curved and brown; pistil, slim, longer than stamens, drab to lighter.

Fruit.—Bunches weigh 25 to 45 pounds, depending upon method of culture used; hands, 6 to 12, with 16 to 18 fruits to hand; average banana, 4 to 6 inches long, greater diameter, $1\frac{3}{4}$ inches; tapering toward both ends, 3 to 4 angled, slightly curved. Mature fruit usually retains style and stigma dried. Angle ridges disappear on full ripening. Color, rich, clear yellow. Flesh, cream colored, firm, rather dry; core, indistinct, flavor good, subacid, astringent if eaten before fully ripened. Fruit has a distinct applelike odor (pl. 11, B).

CHAMALUCO

The Chamaluco (No. 4490) was introduced into Hawaii from the Porto Rico Experiment Station on February 5, 1904, under accession No. 16. The name "Chamaluco" is of West Indian origin. The variety was reported to be resistant to disease and to produce fruit of poor quality, facts which have been borne out during its 21 years in Hawaii.

Plants.—Clumps, very large, 13 trunks, 10 sword suckers, 9 peepers, and 3 bunches in development at 4 years. Mature trunks, 10 to 14 feet tall, leaning outward from clump, basal diameter 7 to 12 inches; bright apple green in color, with patches of grayish brown on extremities of outer sheaths; young stalks, petioles, and under surface of leaves, glaucous. Foliage, rich, shiny, medium to dark green; petioles, stout, rolled, forming hollow cylinder $2\frac{1}{2}$ feet long; blade, 5 feet long by 14 to 22 inches wide, margins with fine brownish lines extending into petiole edges.

Flowers.—Pistillate flower, 7.5 to 10 centimeters long; ovary, 4 to 5 angled, rich dark red; perianth, pink outside, red inside; surface lined with longitudinal ridges, terminating in 5 bright yellow lobes, 2 outside long and narrow, middle, short and broad, 2 intermediate, very small; petal, bladderly, firm, margins and yellowish apicula turned inward. Usually, only three stamens, rudimentary; style, stout, stigma, globular and cream to brown in color.

Staminate flower, 7.5 centimeters long; ovary, red; perianth, pink outside, red within, extreme portion much reflexed, lobes yellow and varying in size and shape as in the pistillate flower. Petal bladderly, long, firm, deep rose pink, margins above flaring outward, one or two folds at top; apicula, light or yellowish, curved outward; stamens, 5, as long as apicula; anthers, brownish and narrower than filaments; style of pistil, long, slim, white; stigma; small, yellowish or brownish; some nectar about base of style.

Fruit.—Weighs 25 to 60 pounds a bunch, depending largely upon the kind of culture given; 10 to 14 fruits to hand, 5 to 7 hands to bunch; individual fruits 5 to 7 inches long, $1\frac{1}{4}$ to $1\frac{3}{4}$ inches thick, 4 or 5 angled, tip somewhat beaked; skin, thick, reddish turning green before maturing, checked with small corklike patches, dull yellow when ripe; flesh, whitish, seedless; core, inconspicuous; flavor, decidedly applelike when fruit is cooked.

FATHER LEONORE

The original of the Father Leonore (No. 4501) variety is unknown. The station obtained propagating material of the variety from the Moanalua Gardens near Honolulu in 1920; and the superintendent stated that the late S. M. Damon, owner of the gardens, received the first plant about 1890 from a Father Leonore, whose duties took him to all parts of the islands. The variety has been known as the Father Leonore for many years, and has done well up to 1,000 feet elevation, producing bunches of fruit weighing 60 pounds. In character, the fruit is more like the Brazilian and Lady Finger varieties than the Hawaiian bananas, hence it must have been introduced from some other part of the world.

Plants.—About 25 feet high at maturity of fruit; trunk of medium size, erect, well anchored against strong winds; trunk sheaths, streaked with abundance of dark brown, causing the plant to resemble the Lady Finger trunks; foliage and leaf petioles, dark green, margins tinged with light yellow; blades about 6 feet long, 15 inches wide, dark green above, dull green below.

Flowers.—Staminate flower, pale yellow; perianth becomes slightly gray with age as does the perianth of the Brazilian and Bluefields varieties; perianth lobes, light yellow; petal, smooth, creamy white; apicula, small, turned inwardly; stamens, 5, whitish; anthers, narrowing, much curved, and darkened at margins; pistils longer than stamens; style, slim, and stigma, small.

Fruit.—Bunch weighs 50 to 60 pounds, long, appearing somewhat like that of Lady Finger variety, but more irregular and not so compact, 8 to 10 hands, 18 to 25 fruits to hand; individual fruits, weigh 5 to 8 ounces, 6 to 7 inches long, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches in diameter, usually 5-angled, beaked apex; skin, clear yellow, medium thickness; like the Apple banana, the fruit contains considerable spongy fiber on inner surface of peel; pulp, pale yellow, melting, moist; core, indistinct; flavor, subacid, good quality; a good commercial banana for local consumption.

LARGO

The Largo (No. 4497) is native of tropical America, where it is considered by some as a plantain on account of the characters of the fruit. The variety was introduced into Hawaii from Mexico (13, p. 45), and first recorded at the station in 1908 under accession No.

1167. It is rather resistant to adverse conditions, and responds with large fruit to good culture.

Plants.—Clumps, large; suckers, numerous; trunks, 8 to 10 feet tall, large at base, tapering, reclining, apple green to lighter in color; outer sheath extremities marked with patches of brown; leaves, 10 to 12 to the crown, 8 feet long; blade, 20 inches wide, dark green above, light green below, slightly glaucous, margins marked with brownish lines; inflorescence shoots with unusually long, graceful curve of scape bearing beautiful clusters of pink flowers exposed from beneath rich bright red bracts.

Flowers.—Pistillate flower, large; ovary, long, pediceled, very angular; perianth, large, longitudinally ridged, washed with pink; petal, large, bladdery, rose colored; apicula, turned inward; stamens, 5, rudimentary; style, stout; stigma, large, globular.

Staminate flowers continue to appear from a long, somewhat spindle-shaped heart, one cluster at a time showing from under a bright red bract, curling well back and often remaining so until the flowers fall from beneath it. Individual flower, about 7 centimeters long, rudimentary; ovary, 2.3 centimeters, pinkish wash over light cream color; perianth, pink with light margins, two light, longitudinal stripes, inner surface red, terminal 5-lobed, reflexed, all tipped with bright yellow, 3 large, 2 intermediate, small and angular; petal, 3 centimeters long, bladdery, usually slightly dimpled below apicula, rose pink to purple; apicula, whitish and with one or two folds; stamens, 5, long as perianth; anthers, curving outward, some pale yellow pollen present; pistil, slim, widening into small 5-lobed flesh colored stigma.

Fruit.—Bunches, large, 5 to 9 hands, 9 to 14 large, angular fruit on each; average banana, 7 to 9 inches long, $1\frac{3}{4}$ to $2\frac{1}{2}$ inches in diameter, conspicuously 3 to 5 angled, apex, prominently beaked and often retaining the dried style of the flower, basal portion frequently extending into stout pedicel often 2 inches long. Color, light yellow at full maturity; skin, thick; flesh, pinkish, buttery, mild flavor; core, conspicuous; seedless. May be eaten raw, but is more commonly used as a cooking banana.

COLORADO BLANCO

The Colorado Blanco (No. 4496) was introduced into Hawaii from the Porto Rico Experiment Station on February 5, 1904, and given accession No. 20. Some of the plants have been distributed among growers, but the variety has not as yet become widely known in the Territory.

Plants.—From 20 to 25 feet tall; trunks, 10 to 15 feet long, slightly reclining, 16 inches in diameter at the base, tapering upward, greenish with streaks of red and brown and patches of darker brown; leaves, about 10 feet long; petioles, about 2 feet, stout, greenish, and like the midrib of the underside of the leaf, covered with a wash of pale red; blade, 8 feet long, greatest width 2 feet, base cordate with sides attached almost evenly to the petiole. The plant is much like that of the Red variety in nature of growth and character and quality of fruit.

Flowers.—Staminate flower, 7 to 8.5 centimeters long, light color, greenish cast on ovary; perianth, cream-white to drab with age, long, straight; apex lobes tipped with yellow, petal, 3.3 centimeters long, translucent, usually several depressions; apicula, erect and with several folds at base; stamens, 5, whitish; anthers extending slightly beyond the lobes of the perianth; upper part of style and stigma, pale yellow.

Fruit.—Bunches vary from 45 to 60 pounds in weight, depending upon the culture given, rachis extending to considerable length; individual fruits, 5 to 7 inches long, plump with short pedicel and angular apex, curved, then nearly straight, yellow, and angles disappearing at maturity; flesh, cream colored, firm, and of a distinct flavor; core, rather conspicuous. A good eating and shipping variety.

ABYSSINIAN

The Abyssinian variety (*Musa ensata*) was introduced into Hawaii through semitropical fruit plant and seed companies of California and Florida, where the plant is grown as an ornamental. It attains

a height of 25 to 30 feet, has a huge trunk, large leaves, and a very attractive flower cluster. The species is valued for its yield of good fiber in Abyssinia, its native land, and the flower shoot is removed from the trunk before emerging and cooked for food. The fruit pulp is filled with seeds and is not edible.

ABACA

Abaca (*Musa textilis*) is said to have been brought to Hawaii from Manila, P. I., in 1866, but the species seems to have been well distributed over the Hawaiian group before 1888 (14, p. 434). Although the plant is valued for its yield of fiber (Manila hemp), it has never been grown to any extent for that purpose in Hawaii. Recently some fiber of excellent quality was prepared from abaca grown in Kona, Hawaii, and occasionally plants of the species are found in various parts of the islands. The abaca is closely related to the banana and is of value as a source of fertile pollen suitable for use in crossbreeding. There are supposed to be a number of varieties of the species, but their botanical characters are not as yet well defined. There are at least two kinds in Hawaii indicating varietal differences. The first plants, grown at the station soon after its establishment, were listed as accession No. 76 on December 21, 1903, under the name of abaca or Manila hemp. The propagating material was obtained from a local grower and was undoubtedly stock from the early introductions. In 1912 propagating material of "Maguindanao," Manila hemp (*Musa textilis*), the same as the abaca, was received at the station from the United States Department of Agriculture under accession No. 30683 (No. 2993). Specimens growing at the station (1925) and described herewith are supposedly from stock of the earlier introductions.

Plants.—Clumps, large; with 12 or more trunks, cylindrical and of a beautiful light green color, reaching 25 feet high; leaves narrow, oblong, dark green above, bluish green below; petioles and midribs glaucous. Young growth develops as splendid sword suckers often having a tinge of purple.

Flowers.—Inflorescence a drooping compact panicle consisting of 6 to 12 clusters; the bracts covering the perfect or pistillate flowers are long, narrow, and persistent, those protecting the sterile or staminate flowers are short, red, with glaucous outside, and deciduous, dropping with the flower; the rachis is large and extends to considerable length; the terminal bud is large and plump.

Pistillate flower, perfect, consisting of short, thick, spindle-shaped ovary, long style, and pollen-bearing stamens; perianth, 5 to 6 centimeters long, shaded on dorsal portion with pink, split to the base on one side, terminating in 5 lobes, yellow at tips, the two outer sharp, middle blunt, and two intermediate small and sharp; corolla consisting of one free petal, translucent and bladderly.

Staminate flower, most parts similar to those of pistillate flower, except pistil which is small and imperfect; 5.5 centimeters long; ovary 1.5 centimeters long, stamens, 4 to 4.5 centimeters long, white; anthers, 2.4 centimeters long, pink to brownish. Abundance of pollen which is white in both types of flowers. Some nectar around base of style.

Fruit.—Bunches compact, 8 to 12 hands, and about 14 fruits to hand; individual fruits somewhat spindle-shaped, 4 to 5 angled, 2 to 3 inches long, greater diameter $1\frac{1}{4}$ to $1\frac{1}{8}$ inches; pedicel, short; style, persistent; fruits diverge from each other and stand more or less at right angles to the rachis, usually filled with seeds; fruit inedible (Pl. 12, A).

COMMON PLANTAIN

The common plantain (No. 5118), sometimes known as "Green Stem," "Monkey Plantain," and "Horse Plantain," was introduced

into Hawaii from tropical America. Plants received from the Porto Rico Experiment Station in October, 1904, were listed under accession No. 24. The variety is sometimes erroneously called the "Porto Rican banana." Botanically, it is a true plantain (*Musa paradisiaca*). It grows well in loose rocky soil where there is abundant rainfall (pl. 12, B) and is given culture very similar to that given the Maoli banana. In some localities the common plantain is highly prized as a food when cooked.

Plants.—Erect, 12 to 18 feet tall; trunk, stout, green with light brown patches, sometimes pinkish about base; leaves, about 8 feet long; petioles, nearly 2 feet, stout, margins curved nearly together and slightly reddish; blade, oblong oval somewhat tapering toward apex; greatest width about 24 inches, midrib often washed with pink; underground stem suckers freely with good culture.

Flowers.—7 to 10 centimeters long; ovary, broad and flat, whitish; perianth, light with streaks of red, usually divided forming one free sepal; lobes, prominent, orange colored; corolla portion often consisting of 2 or 3 translucent petals, somewhat flattened; stamens, 6, with whitish anthers, often deformed; pistil, broad at base of style, grooved down ventral side; stigma, whitish; lobe flattened.

Fruit.—Bunches 26 to 38 pounds, consisting of 5 to 7 hands, with 2 to several fingers, divergent, each 10 to 14 inches long, 1½ to 2 inches in diameter, angular, curved, base stalked; apex, long and pointed; skin, rather tough, smooth and yellow; pulp, pale salmon; core, inconspicuous.

DWARF PLANTAIN

The dwarf plantain (No. 4491) was introduced into Hawaii from the Porto Rico Experiment Station on October 31, 1904, under accession No. 44. In parts of tropical America it is known as "Macho Enano," and "Plantano Enano." Botanically, it is classified as *Musa paradisiaca*. The dwarf plantain does not seem to be well adapted to Hawaiian conditions. It requires a large amount of moisture, humidity, and good drainage and protection from wind. It resembles the common plantain, but is much smaller.

Plants.—Dwarf among plantains, 6 to 8 feet tall; trunk, slim, olive green, with brownish patches at base of petioles; clumps, small; leaves, dark green; petioles, short, with reddish lines along margins and at base; blade, broad and cordate.

Flowers.—Pistillate flower, including ovary, 7.7 centimeters long; perianth, whitish, washed with pale red; lobes, bright yellow; petal, long, translucent with yellow apicula; sometimes two additional petals, free or partly attached to inside of perianth; ovary, 3 to 4 centimeters long; greenish, stout, and club-shaped; stamens, 6, 4 centimeters long; anthers, whitish; style of pistil, abruptly swollen at base and grooved down ventral side; stigma, rather small, 3-lobed, pale yellow. Sterile flowers are few.

Fruit.—Bunches 18 to 25 pounds; fingers, 8 to 12 inches long at maturity, 3 angled, 1¼ to 1¾ inches in diameter, light green to yellowish when ripe; flesh, salmon colored and core, noticeable; flavor, subacid; 3 to 5 hands to bunch, 3 to 5 fruits to hand. Useful as plantain flour for delicate pudding.

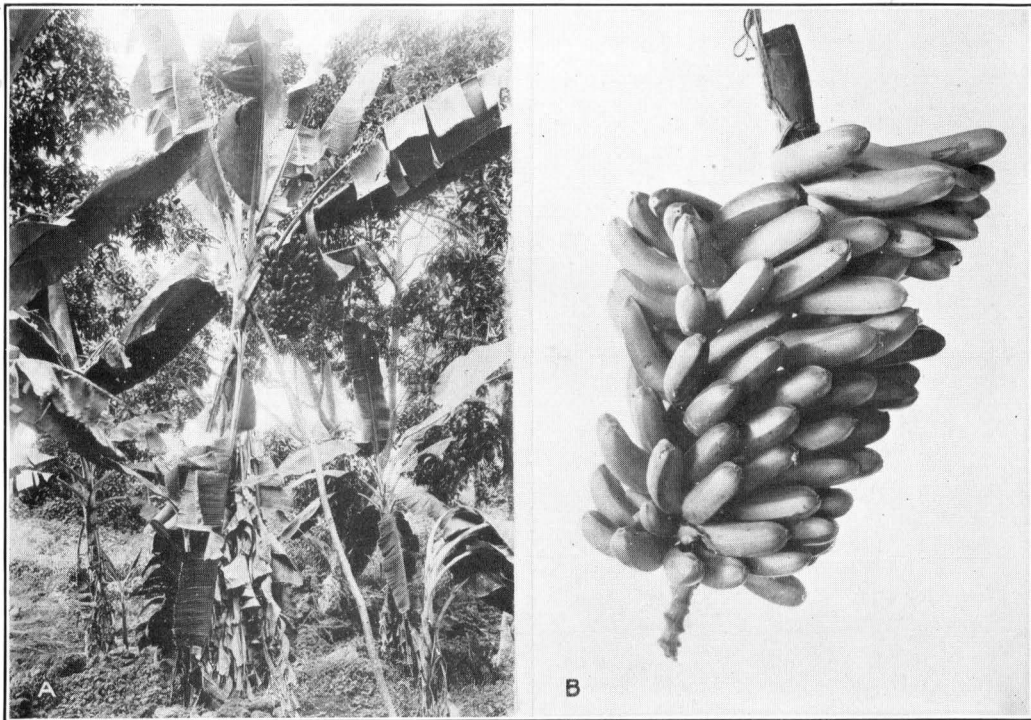
HAWAIIAN VARIETIES

MAOLI GROUP

Varieties of the Maoli group have unusually large plants requiring great quantities of moisture and considerable protection from the wind. The bunches of fruit are large and compact; individual fruits are long, well-filled to the ends, and covered with thick, heavy



A.—The Abaca is not an edible banana, but its free pollen-producing habit suggests its value in the production of new and resistant varieties of bananas
B.—Common plantain. Photographed in North Kona, Hawaii, where the cooked fruit is considered an excellent food



A.—Maia maoli, the leading variety of the Hawaiian cooking bananas. Produces very large bunches of fruit
B.—The Kaualau, one of the Maoli group of Hawaiian varieties. It is cultivated at lower elevations than are most Maoli bananas

skin, which, on ripening, turns to a rich, waxy yellow color. The pedicel is long and the flesh is yellow. The floral parts are slightly tinged with pink.

MAIAMAOLI

The fruit of the Maiamaoli variety (No. 4731) is the most common and best cooking banana found on the local market. The plants are of easier culture than most other varieties of the Maoli group, and thrive best in the porous rocky a-a¹⁰ soils where the roots become deeply anchored. In heavy soils the plants are more easily blown down. The Hawaiian name "Maiamaoli" is a combination of two words, "Maia," meaning banana, and "maole," derived from "maori," a south Pacific Polynesian word probably referring to the origin of the fruit.

Plants.—Tall and erect; trunk, 10 to 14 feet tall, diameter at base about 10 inches; green, with faint tints of pink; brownish patches on sheaths near bases of leaf stalks; leaves, about 9 feet long; blades, nearly 7 feet long, greatest width 2 feet; petiole margins curved well upward almost together, forming a deep trough, edges tinged with narrow lines of pink extending into brown marginal lines of the blade, the base of which is lobed, one side attached on petiole somewhat higher than the other (pl. 13, A).

Flowers.—Staminate flower, 6 centimeters long; ovary, light green with reddish wash; perianth, whitish with overwash of pink, fading toward the extreme end; lobes, pale yellow, the middle and two outside rather long, the two secondary slim; the free petal, whitish, iridescent, slightly dimpled in front; apicula, erect with several folds at base; stamens, 5, sometimes 6, whitish anthers with light brownish margins; pistil, style, whitish, slender; stigma, small, but rather prominently lobed; light buff in color. No pollen evident.

Fruit.—Borne on strong stems of rather short curve; bunches weigh 60 to 90 pounds, and are well packed; 7 to 9 hands, with 10 to 12 bananas to larger hands; individual fruits often weigh 10 to 14 ounces, long, round, and well-filled at both ends; pedicel, 1 to 2 inches long, the angle-ridges becoming insignificant at full maturity; skin, thick, tough, and bright, waxy yellow at full ripeness; pulp, yellow, firm; core, distinct; flavor, good. The fruit is excellent when served as a cooked vegetable, and may be eaten raw.

HAI

The Hai variety (No. 4760) forms the largest plants of any of the native bananas, and usually produces the largest bunches with very large individual fruits (pl. 6, B). It is not so hardy as are some other varieties, blows down easily, and when neglected often fails to produce vigorous suckers, resulting in the death of the clumps. The term "Hai" is said to be a contraction of "Mohai," meaning sacrifice.

HAIKEA

Belonging to the Hai variety, or closely related to it as a strain or subvariety, is the Haikea, which possesses many of the varietal characters of the latter, but is not so tall and all its parts have a whitish bloom. The flower and mature fruit have no identifying varietal characters. The suffix "kea" has reference to the whitish cast of the green parts of the plant.

Plants.—The Hai banana plant at maturity often reaches 15 to 24 feet high; diameter of base of trunk, 12 to 17 inches; trunk sheaths, green with consider-

¹⁰ Chinker form of laval flow.

able reddish cast about the base, becoming browner higher up toward base of petioles; leaves, 8 to 12 feet long, 2 feet broad; petioles, 3 feet long, green, or sometimes with reddish wash extending along midrib of underside of leaf; petiole, margins purplish, and curved upward, forming deep gutter.

Flowers.—Staminate flower, ovary short and clubbed, apple green, with reddish lower end; perianth, light, streaked with red, becoming lighter toward the 5 tips, which are long and bright yellow; petal, iridescent, margins irregular; apicula, prominent, with one or two folds at base; stamens, longer than perianth, with anthers turned outward; margin dark, where split to expose pollen-bearing surfaces; pistil, style slender, white, with small quantity of watery nectar about base; stigma, small, irregularly lobed. Rachis extending from bunch to considerable length, terminating in a rather long bud having dark wine colored bracts with bright red inner surface.

Fruit.—Bunches large, often weighing 100 pounds; 6 to 10 hands; individual fruits, 10 to 16 ounces, 3 to 5 angled, often a little curved, filled at ends, but not as blunt as Maïamaoli fruit; pedicel, 1 to 2 inches long; skin, thick, tough, bright waxy yellow at full maturity; flesh, firm, yellow; core, distinct; flavor, subacid to sweet. The fruit is used as a vegetable when cooked. The well-ripened fruit has a pleasing flavor, and may be eaten raw.

MANAIULA, MANAI ULA, OR MALAI ULA

The Manaiula (No. 4762) is an excellent Maoli banana. The word "Manai" has reference to the hard, sharp-ended fiber taken from the midrib of the leaf and used for stringing leis (wreaths); "ula," meaning "red," relates to the slim red ovaries of the pistillate flowers. This color character of the ovaries is found in several varieties from other parts of the tropical world, and is one of the main characters of the Hawaiian variety. The clumps require renewing about every third year to maintain production of large bunches.

Plants.—Eighteen to twenty feet tall; crown of foliage, large and vigorous; trunk, 10 to 15 feet long, 10 to 15 inches in diameter at base, tapering upward; color, light green to flesh color with tinges of red; leaves, 8 to 10 feet long, 20 to 26 inches at greatest width; petioles, stout, flesh-colored; margins, red, curved upward and inward forming almost a closed gutter; blade, light green above, pinkish cast below with midrib on underside of leaf washed with pink; young growth, including suckers, reddish.

Flowers.—Inflorescence, a compact, drooping panicle, bracts, reddish-brown, glaucous outside, deciduous.

Pistillate flower, 9 centimeters long; ovary, curved, dull reddish brown; perianth, short, recurved, dark red with pinkish stripes; corolla, one free petal margin incurved, dished, delicate red; stamens, rudimentary; style, 3.4 centimeters long; stigma, distinctly lobed, cream colored.

Staminate flower, 6.6 centimeters long; perianth, streaked with red; corolla, one free petal light red, bladdery; stamens, 4.6 centimeters long; anthers, prominent; style, pale reddish, undeveloped; stigma small, deciduous with bracts from short rachis; terminal bud plump.

Fruit.—Dark reddish-brown when young, changing to green during the first few weeks after the flowering period; yellow at full maturity; bunches, about 8 hands, weighing 50 to 75 pounds; individual mature fruits, 4 to 5 angled, 6 to 8 inches long, slightly curved, 2 to 2½ inches in diameter; blunt at apex; pedicel, 1 to 2 inches long, stout; skin, thick, tough, waxy yellow when ripe; pulp, coarse, firm, seedless, orange colored; core, distinct. An excellent Hawaiian cooking banana.

KAUALAU

The Kaulau variety (No. 4758) is of easy culture and excellent quality. It is most natural on the island of Hawaii, but may be found growing in many other parts of the Territory, adapting itself to lower elevations and withstanding strong winds. The term "Kaulau" means "rain on the leaf."

Plants.—Average height at maturity, about 16 feet; upright with dark green foliage. The variety is generally identified by its large bunches of smooth, plump fruit varying in size according to the culture given; trunk, 8 to 10 feet tall, somewhat tapering, green with patches of brown on outer sheaths; leaves, 8 to 10 feet long; petioles, 1½ to 2 feet stout, green, margins curved inward and slightly tinged with pink; blade, oblong, oval, with greatest width about 24 inches; surfaces, rich dark green; petioles and midribs of younger plants, usually washed with cast of pink.

Flowers.—Staminate flowers extend from rachis of bunch of fruit nearing maturity, 6 centimeters long; ovary, clubbed, light green with cast of pink in spots; perianth, light colored with streaks of pink diminishing toward the tips, two longitudinal pink stripes inside, five rather long orange tips, 3 prominent, 2 intermediate, narrow; petal, flaring upward from base, iridescent to rose-colored above, margin rolled inward; apicula, small and turned inward; stamens, considerably longer than perianth; anther margins light brown, darkening with age; pistil, slim, about as long as perianth; style white; stigma small, clubbed, yellow.

Fruit.—Bunches, large, weighing 60 to 125 pounds, flaring at base, 7 to 10 hands, 9 to 17 fingers; individual fruits, 8 to 14 ounces, 6 to 8 inches long, straight, plump, angles almost disappearing, base stalked, apex blunt, color, rich, waxy yellow; skin, medium thickness and toughness; flesh, light yellow, fine texture; core, indistinct. A cooking banana of excellent quality (pl. 13, B).

ELEELE

The chief distinguishing character of the Eleele variety (No. 4812) is the color of its trunk sheaths, petioles, and midribs, which are almost black, giving rise to its Hawaiian name "Eleele." The Eleele is a favorite commercial and highly prized cooking banana. The black petioles and midribs furnish material used in weaving hats and other articles. The dark portions of the plant vary in intensity of coloration somewhat, which probably accounts for its other names, such as "Poni" and "Hinupuaa," which are not truly varietal names, but synonyms of "Eleele." In the Poni the trunk is more purplish than in the Eleele and the Hinupuaa is not so dark. The clumps continue to produce large bunches for many years without transplanting.

Plants.—Usually 20 to 25 feet tall; trunks, 12 feet to arch of fruit stem, diameter of base, 8 to 10 inches, slightly tapering upward; outer leaf sheaths, somewhat blackened; leaves, 7 to 9 feet long, 2 to 2½ feet wide, oval-oblong; petiole, stout, about 2 feet long; base of blade, cordate, one side attached lower on petiole by several inches, dark green above and below.

Flowers.—Staminate flowers extend from rachis of half-developed fruit cluster; ovary, greenish, slightly washed with red near small basal end; perianth, light colored, with considerable reddish wash at margins where it overlaps the petal; 5 yellowish tips, 3 prominent, 2 secondary, slender; petal, flaring from base upward, white to iridescent toward top; margins, turned inward, small quantity of nectar within; apicula with fold at base and a deep groove below extending downward; stamens, a little longer than pistil; anther margins, drab, containing some pollen; pistil, about as long as perianth; style, white; stigma, lobed, light yellow.

Fruit.—The young fruit has the appearance of being badly smoked, and remains rather dark for several weeks following the flower, then gradually changes to dark green, and finally to clear bright yellow at full maturity. The bunches average 60 to 80 pounds in weight, 7 to 9 hands, the fingers varying from 3 to 5 angled, 7 inches long, 1½ inches in diameter, plump, and well-filled to the ends; pedicel, 1 to 1½ inches long; apex with small pit, out of which the dried remains of the style often persists; skin, thick and tough as with other Maoli bananas, clear yellow at full maturity; pulp, firm, orange colored; core, distinct, with numerous undeveloped ovaries. A good cooking banana.

KOAEE OR AEAEE

The Koae or Aeaee banana (No. 5064) is considered one of the Maoli group on account of the nature of its growth and fruit. The variety thrives best in cool, moist woodlands at elevations of 500 to 2,000 feet. Both the green foliage and fruit are beautifully striped with white, making the plant one of the most attractive of the banana varieties. The Koae was known to Hawaiians three generations ago. Doctor Hillebrand, who completed his plant investigations in Hawaii previous to 1870 and left the islands permanently the following year, describes briefly (14, p. 433) what seems to be the Koae. It is the only variegated variety growing in Hawaii and familiar to the Hawaiians. Higgins (13, p. 50) suggests that it is probably *Musa sapientum* var. *vittata*, supposed to be indigenous in St. Thomas, off the west coast of Africa. However, Fawcett's illustrations and description of *vittata* (11, pp. 214, 215) are not applicable to the characters of the Koae or Aeaee in Hawaii. Possibly the Koae is a bud mutation of some Maoli banana of the Pacific (pl. 14, A).

Plants.—Clumps usually have few large trunks 10 to 12 feet tall; outer sheaths, light green, with slight evidence of pale green, white, or pinkish longitudinal stripes; leaves, 9 to 12 feet long, 20 to 26 inches broad; petioles, green, striped longitudinally with white; margins, pink to red; blades, bright green with 20 to 40 per cent of the surface irregularly blotched with white.

Flowers.—Pistillate flower, 10.5 centimeters long; ovary, 7 centimeters long, very angular, with white longitudinal stripes; perianth, 3.5 centimeters long, creamy white with pinkish to almost chocolate colored streaks; extremity, 5-lobed with tips of lighter color; corolla, one free petal delicately tinged with pink; stamens, rudimentary; style, stout; stigma, distinctly lobed; both usually persistent to maturity of fruit.

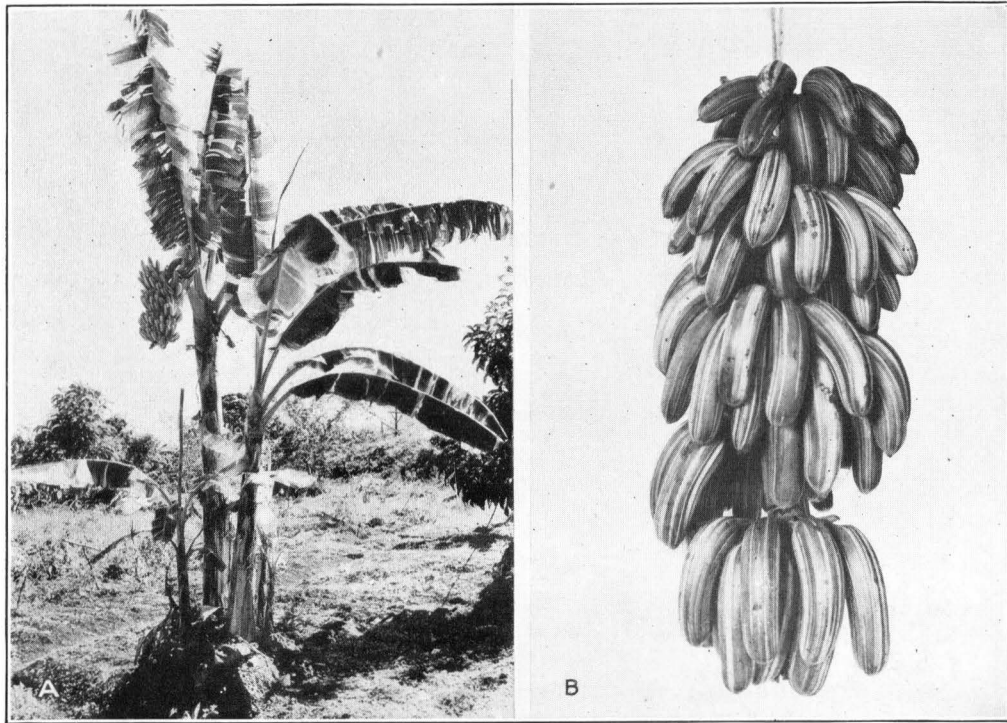
Staminate flower, 6.5 centimeters long, rudimentary ovary, 1.7 centimeters long, pinkish at base; perianth like that of pistillate flower; corolla consists of one cream-white free petal with distinct apicula; undeveloped pistil shorter than stamens, which are 4.6 centimeters long; anther, 2 centimeters. All bracts are deciduous, reddish brown in color outside with glaucous. Neutral flowers sometimes persistent; staminate flowers with bracts from rachis in regular order as the rachis lengthens. Terminal bud, small.

Fruit.—Oblong, straight or slightly curved, 6 to 7 inches long, 1½ to 1¾ inches in diameter; 3 to 4 angled, almost cylindrical at maturity, blunt, rounded apex, pedicel stout, 1½ to 1¾ inches long; style and calyx usually deciduous; skin, thick, striped longitudinally with white which almost disappears on yellowing with ripeness; pulp, coarse, firm, yellow, and lacking in flavor; core, distinct, but seedless. A fair cooking banana which is rarely eaten raw (pl. 14, B).

MAHOE OR PALUA

The Mahoe or Palua variety (No. 4763) is a favorite in some parts of Hawaii on account of the delicious flavor of its fruit. Like most of the native bananas, it grows best in moist localities, taking a beautiful upright form. Probably the most striking peculiarity of the variety is the tendency of its flowering stem to branch, which usually takes place in the cluster, giving a distinct divided bunch (pl. 2, A).

The name "Mahoe" means "twin" in Hawaiian. Sometimes the branching takes place in the stem just below the cluster, giving two distinct bunches, in which case the variety is called "Palua." The difference in the two forms, however, is not sufficiently fixed to be considered truly varietal. In the first attempt to grow the variety at the station (1923-24) the plant produced a single bunch without indication of division of stem. The double bunch is unsatisfactory



A.—The Aeae or Koa, a variegated variety. The fruit and foliage are beautifully colored. The variety is believed to have originated as a bud variation
B.—Aeae or Koa. This white-striped banana is of the Maoli group. The fruit may be eaten either cooked or raw

since it produces small fruits and does not ripen evenly. One plant of the variety, found in the Hilo district, had its fruiting stem divided in an attempt to produce six separate bunches of fruit.

Plants.—Erect, 16 to 20 feet tall; trunk, 8 to 10 feet long, basal diameter, 10 inches; color, green tinged with pink and spotted with brown; leaves, about 7 feet long, greatest width 24 inches, green above, lighter green below; petioles, stout, 2½ feet long, deeply grooved and margins reddish. The clump suckers freely and has a handsome ornamental appearance.

Flowers.—Pistillate flower, 11.5 centimeters long; ovary, sharply 3 to 5 angled, blunt at point of style attachment, pedicel at base, light apple green color; style, including stigma, 3.8 centimeters long; perianth, whitish, washed with pale red, 4 centimeters long, 5-pointed, each tipped with orange, the two extreme, 6 millimeters long, the central, broad and shorter, and the two intermediate, small and more erect; petal, iridescent, keel deeply depressed below apicula, edges rolled inward; apicula, turned inward; stamens, 5, three short and two longer, extending beyond the stigma; anthers, imperfect; style, slim, whitish; stigma, yellowish to brownish, 5-lobed.

Staminate flower, 6.7 centimeters long; ovary portion, 1.6 centimeters long; perianth, 5 centimeters long, whitish, washed with light red, apex tipped as with the pistillate form; petal, small, bladdery, iridescent, dimpled below apicula, the latter pointed, erect; stamens, 5, shorter than perianth; and pistil, long; anthers, long; pistil, slim, whitish yellowed at the flattened 6-lobed stigma.

Fruit.—Bunch of 9 or more hands, the larger 12 to 18 fruits, the smaller, 9 to 12; individual fruits, 3 to 5 angled, 4 to 5 inches long, 1 to 1½ inches in diameter, weight 3 to 5 ounces; skin, medium, bright yellow, easily removed; pulp, firm, light salmon yellow; core, indistinct; seedless; flavor, mild, subacid to sweet.

PUHI

The Puhi variety (No. 35) grows best in the moist woodlands at 2,000 to 3,000 feet elevation. The Hawaiian name "Puhi" is interpreted as meaning "eellike," the fruit presenting a rather twisted appearance during a period of early development. The variety was studied growing wild in the woods on the ranch of Albert Hu, of South Kona, Hawaii. No flowers were obtainable at the time the study was made.

Plants.—15 to 20 feet tall; some of the larger with trunks 8 to 10 feet tall; upright, green; large, upright leaves, 8 feet long; petioles, green; blades, wide at base, tapering to apex.

Fruit.—Bunches, small to medium; arched stem, long and slim. At maturity the fruits fill out and become bright yellow in color, with possibly more prominent angle ridges and pointed apex. The skin is thick; pulp, firm, yellow; core, distinct. A fair cooking banana.

EKA

The Eka variety is very similar to several other varieties of the Maoli group. Its leading character of identification is the color of its fruit, which has a reddish cast at or immediately after flowering time. The color is said to have given rise to the Hawaiian name "Eka," and is soon replaced by a rich dark green which prevails until the fruit begins to ripen. At full maturity the fruit becomes a clear, waxy yellow. The flowers are white, but are considerably washed with red, which rapidly darkens within a few hours after they are released from under the bract. The plant more closely resembles Manaiula than does any other variety of the Maoli group.

Plants.—Erect, 16 to 20 feet tall; trunks, light green with tinges of red; leaves, about 7 feet long, 24 inches greatest width; petiole and midrib on under side of leaf washed with pale red.

Flowers.—Staminate flower, 7.5 centimeters long, whitish washed with pale red; perianth, red near base; lobes, pale yellow; petal, cupped and with irregular margins, erect or curving outward; stamens, 5, longer than perianth, slightly curved; style, slim; stigma, small and whitish.

Fruit.—Bunches of medium size, weighing 40 to 50 pounds; individual fruits, curved, angular, and often retaining dead style of pistil at apex. The fruit can not be distinguished from the Manaiula variety when sold on the retail market. Skin, thick, tough; pulp, firm; core, distinct. The fruit is used mainly cooked.

IHO-U

The Iho-u is seldom found in cultivation. It grows wild in the Kona woods, and is said by Francis Gay to be commonly found in the mountain forests of Kauai, where it is generally known as a Maoli banana. The plants are slender and produce small bunches of fruit in comparison with other varieties. Hawaiians call the variety "Iho-u," meaning "snubbed nose," on account of the peculiar form of the individual fruits.

Plants.—Erect, small or of medium height; trunk tapers from base to crown, about 8 feet tall; sheaths, green, splotched with dark brown patches at the base of petioles, very much like the Brazilian variety; leaves, stand well erect, 6 to 8 feet long, of which the petiole is about 2 feet long; blade, oblong-oval, green with lighter green midrib, both sides of base attached evenly to petiole.

Flowers.—Staminate flower, 7 centimeters long, whitish with slight streaks of pink on ovary and perianth; rudimentary ovary, short, clubbed; perianth, 4.6 centimeters long, slim; apex lobes, tipped with light yellow; petal, white to iridescent, stiff, cupped without depressions on outer surface, margins turned inward; apicula, small, turned inward; stamens, longer than perianth; anthers, slim, whitish; pistil, as long as perianth; style, slender; stigma, small and irregularly lobed.

Fruit.—Stem, slender, gracefully curved; bunch, small, 5 to 7 hands, about 90 fruits to bunch; extending rachis, slim, shedding terminal bud before fruit is more than half size; individual fruits are more curved than most of the Maoli bananas, filled to both sides, 3 to 5 angled; skin, yellow, tough; pulp, yellow, firm; flavor, subacid; core, indistinct. A cooking banana of good flavor. The tips of part of the fruit often tend to retain the dead styles of the flower.

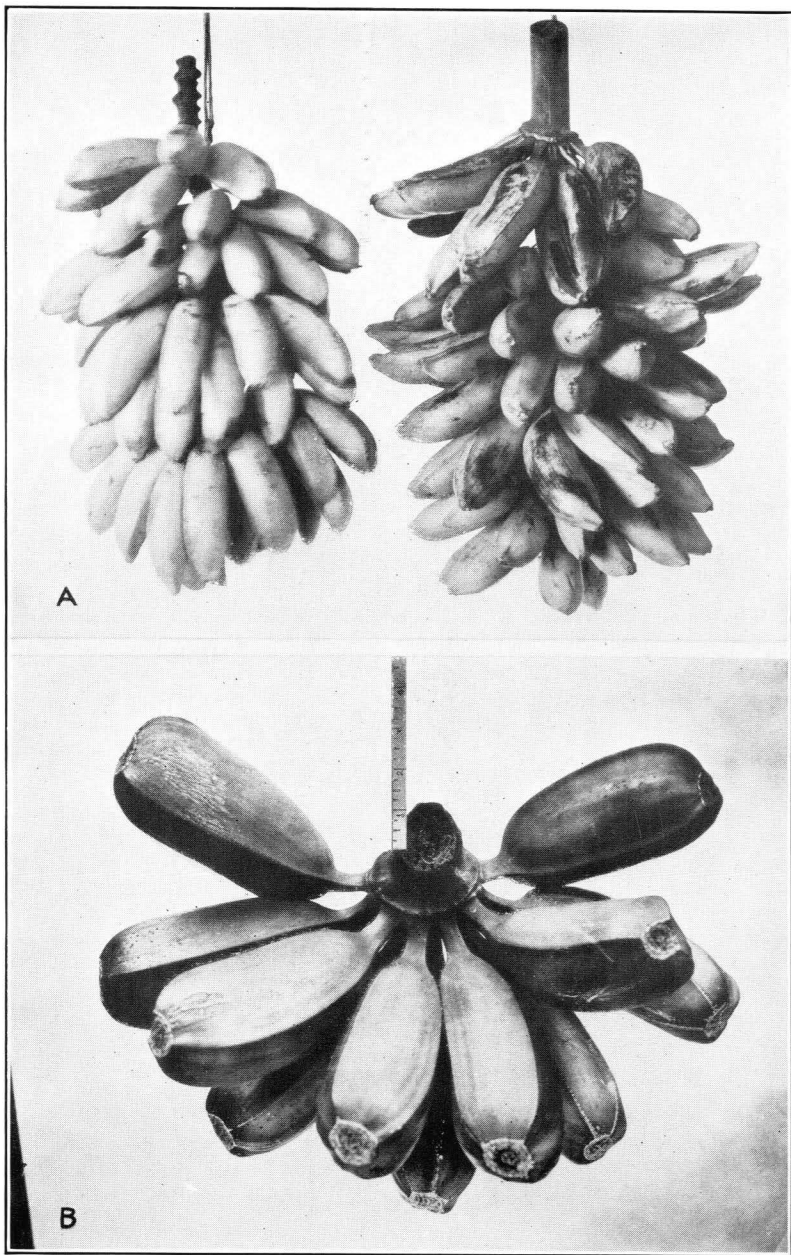
IHOLENA GROUP

Varieties of the Iholena group are identified by their erect trunks, long arched fruiting stems, and small, or medium-sized, bunches, rarely weighing over 50 pounds. Individual fruits stand out at nearly right angles to the stem, and usually are angular, tapering toward the apex; the skin is thick and yellow at maturity, the flesh is of light pinkish salmon color, and the rachis is rather long. The flowers are white or cream colored.

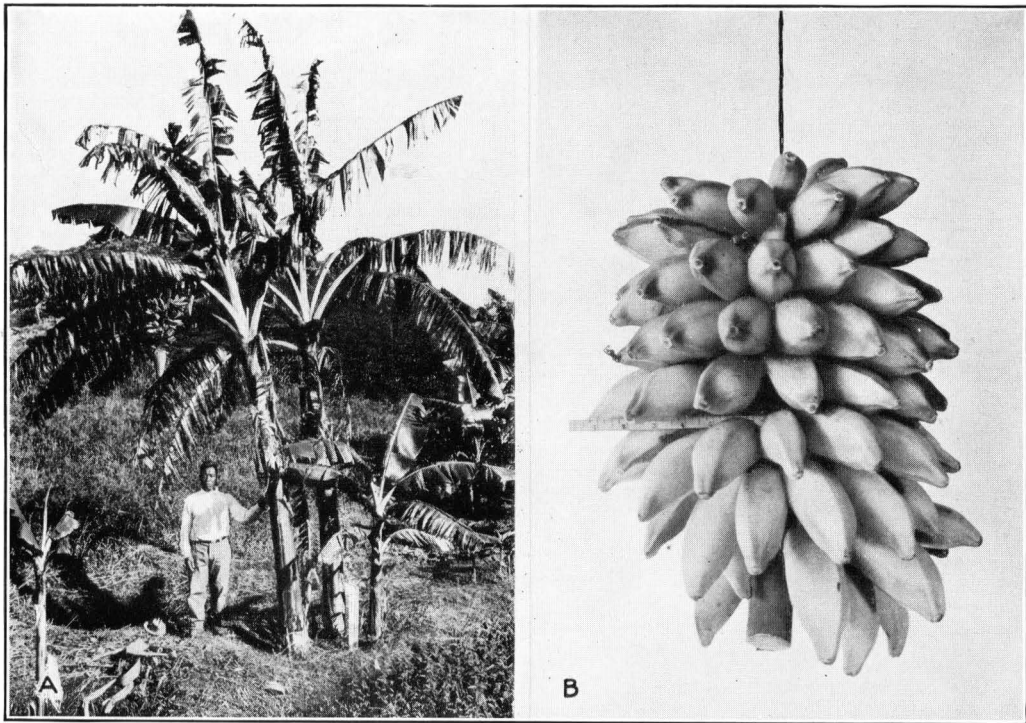
IHOLENA

The Iholena or Hilahila (No. 4499) is a favorite banana of the Hawaiians. It is well adapted to windy locations on account of its short trunk, and responds to good culture. The name "Iholena" is said to have originated from two words, "Iho," meaning "core," which is colored, and "Lena," referring to the ripe fruit.

Plants.—Comparatively low-growing, like that of the Cavendish, greatest height being 8 to 10 feet; trunks, upright or slightly reclining, of uniform diameter throughout, green with occasional streaks of purple or pink, 5½ feet tall, crowned with 10 to 12 leaves averaging 6 feet long; petiole, stout, about 18 inches long, tapering into midrib; margins, pinkish to brown line at edge,



A.—The Iholena, a favorite Hawaiian variety which turns a beautiful bright yellow several days before the pinkish or salmon colored pulp is really edible
B.—The Kaio, a variety of the Popoulu group. Occasionally found growing in the valleys of the windward slopes of the Hawaiian Islands



A.—The Kapua or Puapuanui, a Hawaiian variety in the trial grounds of the station

B.—The Lele banana, a variety belonging to the Iholena group. When thoroughly ripened the fruit can be eaten either cooked or raw. The skin is bright yellow and the flesh is light pink

curved upward, forming large gutter; blade, $4\frac{1}{2}$ feet long, 20 to 24 inches at greatest width; base, deeply cordate; apex, long, tapering, light green above, lighter green underneath; margins with narrow brown edge; under side of young foliage, slightly bronze colored; inflorescence stalk, small in diameter, but long and gracefully curved; first bracts, large, Indian red outside, lightened with streaks of yellow, glaucous, inside light red, and with numerous indentations.

Flowers.—Pistillate flower, 13 centimeters long; ovary, 9 centimeters long, prominently 3-angled, often developing into four lesser angles, color, light yellowish green; perianth, large, many ridged, two of which are prominent; light cream colored with brownish streaks, extreme end 5-pointed, all edged with bright yellow, middle tip broad, outside tips narrow and longer, intermediate tips, short; corolla of one petal, white to translucent, delicately ridged, deeply dished, much of the margin turned inward, dimpled below apicula, which is broad, prominent, and turned inward, 3 millimeters long. Abundance of jellylike nectar in petal and about base of style; stamens, 5, short, thick, with blunt black tips, some attempting to form anthers. No pollen observed. Style, short and stout, about 5.2 centimeters long; stigma, globular, light brown; lobes, indistinct.

Staminate flower, light cream colored, 5.2 centimeters long; ovary portion, 1.4 centimeters long, whitish or greenish in part; perianth, whitish, prominently 5-lobed, tips varying as in pistillate flower, but all smaller, margins yellow; single petal, white to iridescent, bladderly, depressed below broadly pointed apicula; stamens, 5, white, longer than pistil and perianth; anthers, curved and with brownish margins. No pollen grains present. Style, white, with small, rudimentary light buff stigma. Abundance of clear jellylike nectar in petal and about base of style.

Fruit.—Bunches, rather small, 6 to 9 hands, rachis extending, sheds neutral and staminate flowers and bracts, which are red, glaucous, inside bright red; terminal bud, small and tapering; fruits arranged loosely and stand out almost at right angles from the rachis; individual fruits $5\frac{1}{2}$ to $6\frac{1}{2}$ inches long, plump in middle, tapering to ends, light green turning to yellow before ripening, 3 to 4 angled, apex prominently beaked; skin, thin; pulp, firm, light salmon pink; core, distinct; flavor, subacid. A cooking banana, but eaten raw when fully mature (pl. 15, A).

KAPUA OR PUAPUANUI

The Kapua (No. 4759), like some other varieties, is known by different names in different localities, causing it to be sometimes listed as two separate varieties. Slight differences are not truly varietal, but may be attributed to local environment. The Kapua may be cultivated over a wider range of climatic and soil conditions than most of the Hawaiian varieties. Generally, the clumps consist of few trunks which are larger than those of other varieties of the Hohenla group.

Plants.—Trunks, 16 to 22 feet to arch of bunch; basal diameter, 10 to 17 inches; color, greenish with considerable pink overcast with streaks and patches of rich brown; leaves, 9 to 12 to a plant, greatest length 10 feet; blade one side of which is attached slightly lower on petiole than the other, 18 to 20 inches wide, green above, dull below; younger blades, delicate bronze color underneath; midrib, a trough above, flesh colored, below; petiole, about 2 feet long, stout; margins curved into a deep trough with varying colors from purple to pink and extending to edges of the blade as a brown line; flowering stem, reddish, long, slender, and gracefully curved (pl. 16, A).

Flowers.—Inflorescence varies from 6 to 9 clusters.

Pistillate flower, 13.8 centimeters long; ovary, 9.8 centimeters long, light yellowish-green; perianth, cream colored with slight streaks of brown developing on two dorsal ridges, terminates in 5 orange-colored tips, two outside long, middle, short and broad, two intermediate, small and narrow; petal, white, translucent, turning to cream color with age, bladderly, margins curved inward; apicula, prominent, pointed with two folds near the base; stamens, rudimentary; style, large; stigma, spherical.

Staminate flower, 7.9 centimeters long; ovary, 2.8 centimeters long, white with greenish cast; perianth, ridged lengthwise, cream colored, 5 terminal

lobes tipped with orange, the two outside and the middle ones long and pointed, two intermediate, slim and more pointed; nectar abundant and jelly-like; the free petal, large, white, 3.7 centimeters long, bladderly but keeled; stamens, 5, white; anthers, curved outward, brown edged, with little or no pollen; style, slim, white, changing to a yellow buff near stigma, which is small and 6 lobed.

Fruit.—Bunch, 5 to 9 hands weighing 30 to 50 pounds; about 9 to 14 fruits to hand; individual bananas weigh 6 to 8 ounces, $6\frac{3}{4}$ inches long, $1\frac{3}{4}$ inches in diameter, slightly curved, 3 to 5 angled, more cylindrical than fruit of other varieties of Iholena group, basal end pediceled, three-fourths inch long; apex, prominently beaked; skin, clear yellow, waxy, medium in thickness, very tough, not peeling well until fully ripe; pulp, firm, light salmon colored; core, indistinct; seedless; flavor, good subacid apple-like. The fruit, which is yellow for one to two weeks before fully ripening, may be eaten raw, but is most generally used as a cooking banana.

LELE

The Lele is distinguished from other varieties of the Iholena group mainly by its slender trunk, long, gracefully curved fruiting stem, and compact arrangement of fruit. It is one of the most commonly found of the wild varieties growing in the mountain gorges, but frequently responds to cultivation. The Hawaiian term "Lele" is said to mean "scaffold," where things are hung for sacrifices in a "heiau," or Hawaiian temple.

Plants.—Erect, 18 to 22 feet tall; trunk, slim, 10 to 12 inches in diameter at base, tapering upward; color, yellowish light green; leaves, about 8 feet long with greatest width of blade often 24 inches; petioles and blade surface, light green; under surface of young foliage usually of a beautiful reddish cast.

Flowers.—Staminate flower, 6 centimeters long, light cream color, with ovary of greenish cast; perianth, streaked with brownish cast, 5 lobes tipped with yellow, two outside and middle reflexed, the two intermediate, narrow and erect; corolla, sometimes consists of more than one petal, white, translucent; apicula, prominent; stamens, 5 or 6, much longer than other parts of the flower, curved outward; pistil, about as long as perianth; style, slim, and stigma, comparatively small; nectar, a clear jellylike mass around the base of style inside the bowl of the petal; the staminate flowers often have abundance of pollen.

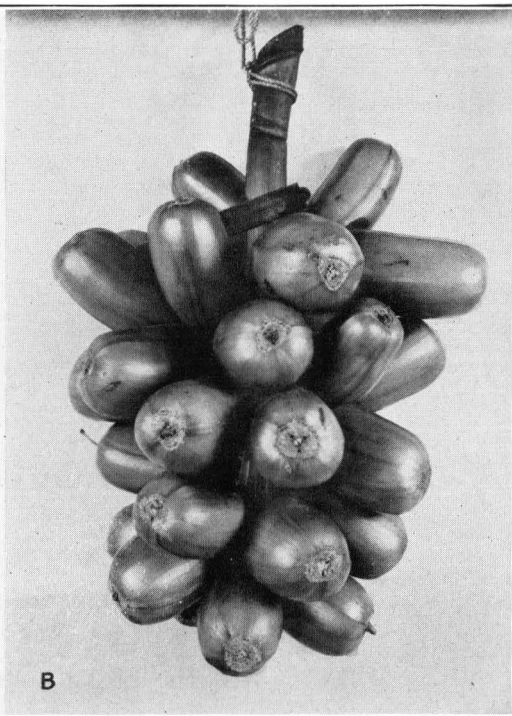
Fruit.—Bunch, compact, 5 to 8 hands; rachis, very long; bananas tapering toward both ends, 5 or 6 inches long, diameter, $1\frac{3}{4}$ to 2 inches, 3 to 5 angled; angle ridges remain prominent to full maturity of fruit; skin, thick, bright yellow; pulp, light salmon pink, firm; core, indistinct; flavor, subacid, delicious. The fruit is used either raw or cooked (pl. 16, B).

POPOULU GROUP

Varieties of the Popoulu group are characterized by their medium height and compact bunches of fruit, the fingers of which are short and thick, without angles, and set at right angles to the axis of the bunch. At full maturity, the skin is very thin and the pulp is a light salmon color.

POPOULU

The Popoulu (No. 4761) is one of the well-known native varieties, and prefers cool, moist woodland regions of the mountains, but can be easily cultivated at the lower elevations. Probably the best character of identification is the fruit, which is short, thick, and of blunt appearance. The Hawaiian name "Popoulu" means "ball-shaped like a breadfruit," and refers to the shape of the individual fruits.



A.—The Popoulu does best in the wild state, and is found growing here with other semiwild economic plants

B.—The Moa or Hua Moa, a favorite Hawaiian variety which grows both cultivated and wild in the mountain gorges. The fruit is nearly as great in diameter as in length

The Popoulu banana may be eaten raw or cooked. The maturing fruit is tender and ripens rapidly; hence, is a poor shipper for export trade.

Plants.—Medium to low growing; commonly about 14 feet tall; trunk, green, about 8 inches in diameter at base; leaves, 7 feet long, 20 inches greatest width; petioles, 18 inches long, green, midrib of younger growth often tinged with pink; usually few suckers forming small clumps (pl. 17, A).

Flowers.—Staminate flowers extend from rachis of half-grown bunch of fruit, each 5.7 centimeters long; ovary, white, with slight greenish cast; perianth, ridged longitudinally, whitish, washed with rose red at base on marginal portions; lobes, bright yellow, two outer and middle prominent, two intermediate, shorter, narrow, and more upright; petal, bladderly, but grooved longitudinally below apicula; margins curved inward with edges turned upward; apicula, prominent, with several curves and point usually erect; stamens, usually 5, white, sometimes a rudimentary sixth; anthers, considerably curved outward and with brownish margins. Pollen present. Pistil, somewhat longer than perianth; style, slim, white, stoutish at base; stigma, small, 3-lobed, and yellow or orange. Small quantity of nectar in petal at base of style.

Fruit.—Bunches of medium size, compact, weighing 30 to 60 pounds, on slender stems, 5 to 8 hands, with 8 to 10 fingers per hand; individual fruits, about 7 inches long, 1¾ inches in diameter, weighing about 5 to 8 ounces, usually 5-angled, angle-ridges almost disappearing with ripeness of fruit; basal end wide, abruptly tapering into pedicel about 1½ inches long; apex blunt and well-filled; skin, yellow, medium to thin, inner portion tending to adhere to fruit; pulp, firm, light salmon pink; flavor, pleasing, subacid, applelike; core, indistinct.

KAIO

The Kaio, or Popoulu Kaio, as it is rather generally designated, is one of the leading varieties of the group. It is not so commonly cultivated as is the Popoulu, but is much the same in plant characters and quality of fruit, being distinguished by its longer trunk of almost uniform diameter, and more compactly arranged bunches, with individual fruits set mostly at right angles to the main stem. The individual fruits are also shorter, but of greater diameter than those of the Popoulu. The Kaio and other varieties of both the Popoulu and Iholena groups are commonly found growing in many of the numerous mountain gorges on the windward sides of most of the Hawaiian Islands.

Plants.—About 18 feet tall; trunks, 8 to 10 inches in diameter, tapering very little from base to crown; outer sheaths, green with pinkish tints extending to petioles and midribs of under sides of leaves, particularly of the younger growth; leaf blades, about 8 feet long, with greatest width, 20 inches.

Flowers.—Staminate flower, creamy white; ovary, when fresh, has greenish cast; perianth, slightly tinted with pink on back, 5-lobed, 3 of medium size, 2 intermediate, very small, all tipped with yellow; petal, white to translucent, full, even margin; apicula, small and curved outward; stamens, 5, white; anthers, brownish, curved outward and usually displaying some pollen; pistil, about as long as stamens, slim; stigma, small and yellowish.

Fruit.—Stem, slender, gracefully arched; bunches, compact; at lower elevations, average about 30 pounds in weight; at higher elevations, about 50 to 60 pounds; 6 to 9 hands, 9 to 11 fruits to hand; individual fruits arranged at nearly right angles to main axis, 5 inches long, 2 to 2½ inches in diameter, 3 to 5 angled, plump, basal end tapering into short, stout, angular pedicel; apex, very blunt and marked with prominent scar where floral parts were formerly attached; skin, medium to thin and with angle ridges nearly disappearing at full maturity; pulp, firm, light salmon pink; core, distinct; flavor, subacid, applelike. May be eaten raw or cooked. The fully ripe fruit is delicious (pl. 15, B).

MOA OR HUAMO A

This variety of the Popoulu group has very distinct varietal characters, particularly those of the fruit. It is also distinguished from other Popoulu varieties by its tall tapering trunk and bunches of fruit consisting of only a few large bananas. In the mountain gorges, where the variety grows wild, the bunches often consist of three to six fruits only. When given good cultivation, the plants often produce larger bunches. The fruit is difficult to mature because irregularities of soil moisture cause the skin to split.

Plants.—Height, 16 to 18 feet; trunk distinctly tapers from base to crown; outer sheaths, green, with pinkish tints, which are also evident on the younger growth; leaves, about 6 to 8 feet long, the petiole portions being unusually long; the crown usually contains more leaves than do other varieties; fruiting stem, very slender.

Flowers.—Staminate flower, 4.6 centimeters long, creamy white, occasionally streaked with pink on exterior of perianth; lobes, tipped with yellow; petal, whitish, surface often depressed; apicula, long, with several folds; stamens, 5; anthers, rather dark at maturity; pistil, about as long as perianth; style, slim; stigma, small and dark.

Fruit.—Oblong, nearly as great in diameter as in length, about $3\frac{1}{2}$ by 5 inches, very plump at both base and apex; skin, golden yellow, very thin; pulp, firm, pinkish yellow; seedless; core, distinct; flavor, sweet and delicious. It may be eaten raw or cooked (pl. 17, B).

UNCLASSIFIED

MAIA-OA

The Maia-*oa* (No. 5091) is an ornamental variety which was probably introduced in seed form by the ancient Hawaiians for some medicinal purpose. The fruit is very small and unsuited for use as a food. The variety is of value to the banana breeder, because a portion of its flowers are perfect and through self-pollination produce seeds becoming viable in the mature fruit. The staminate flowers produce an abundance of pollen, which also may be used in crossbreeding banana varieties. The Maia-*oa* is probably a distinct species.

Plants.—In good culture the plant may reach 18 feet high; trunk, erect, slender, varying from 8 to 12 feet long and tapering upward; outer sheath coverings, dull green, considerably washed and spotted with purplish to dark-brown colors; patches of dark brown usually at base of petioles; leaves, 5 to 10 feet long, greatest width, 10 to 14 inches; petioles, washed with reddish brown, shallow groove above; prominent margins, turned outward, reflexed, and terminate unevenly in the margins of blades; blade, oblong to lanceolate, under side beautifully colored with bronze and purplish red, changeable with the leaf movement in the breeze, dull green above, with irregular blotches of reddish brown; apex of young leaf, while still rolled, terminates in long, twisted lash falling away as blade expands.

Flowers.—Ovary of pistillate flower, about 5 centimeters long, 4 to 5 angled, tapering at both ends; the cluster usually consists of 7 hands, with 13 or 14 flowers each; bracts, small, pale red, or brownish outside, gray, with slight tinges of red inside; perianth, 3 to 3.5 centimeters long, delicately ridged lengthwise, whitish to rich cream color, 5 tips small, reflexed, bright yellow, 2 outward, slim, middle, broad, 2 intermediate much smaller; style and stigma, about as long as perianth, cream colored; stigma, oblong and shading to dark yellow; petal, 1.8 centimeters long, full, smooth, iridescent; slight dimple below angular

apicula; usually abundance of jellylike nectar; stamens, 5, with cream-colored filaments, clubbed; anthers, broad, rather lavender colored when new; pollen, white, abundant, and massed; staminate flowers, very similar to pistillate, except for their smaller, rudimentary ovary.

Fruit.—Bunch, small, open, 7 hands of about 13 fruits each; unedible. The first two or three hands have fertile seeds, the remainder are undeveloped. Seeded fruits, $2\frac{1}{2}$ to 3 inches long; diameter five-eighths inch, curved, 4 or 5 angled, becoming distinct with maturity; color, green; skin, hard; pulp or flesh, a tough placenta which is filled with hard, flattened seeds that germinate in about 4 weeks.

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