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THE PINEAPPLE IN HAWAII.

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INTRODUCTION.

Pineapple growing is a new industry in Hawaii. It is only a few years ago that its foundations were laid, and less than a decade since any rapid development began. As is often the case with new enterprises, it was the subject of scorn and ridicule, and land which now smiles with its golden harvest of fruit was said to be useless for any purpose except the grazing of a few cattle. The industry is now well established, and although there are many unsolved problems connected with the growing and marketing of the crop, the experimental stage is well past and the attention of homesteaders and capitalists is being attracted to this new field. With the recent opening of Government lands in various parts of the pineapple belt for homesteading, has come a demand for information relative to methods of growing pineapples in Hawaii. This station has published several bulletins dealing with special phases of the subject, such

as the management of pineapple soils,[1] the manganese problem,[2] the pineapple scale,[3] and the marketing of the fresh fruit on the mainland,[4] but no publication covering the field in general has been issued. This paper is presented as an attempt to bring together in a simple way the results of experience on the more important aspects of pineapple cultivation in Hawaii, but while general in its scope it makes no attempt at an exhaustive treatment.

SOILS.

The pineapple is not exacting as to soils. Flourishing plantations may be found in Florida on the lightest of sandy soils, while in Hawaii broad fields may be found upon very heavy soils subtended by a still heavier stratum. Good drainage is an absolute necessity. In the pineapple belt of these islands, on the areas which have up to the present time been occupied by pineapples, there are three general types of soils, including the red soils, the chocolate brown or shotty soils and the black soils. Opinions are divided as to the relative merits of the red and chocolate types. The black soils, which are perhaps the most attractive in appearance of any soils in the islands, have been found to be the least desirable for pineapple cultivation, because of the very high content of manganese, which acts as a poison to the plants. Soils containing more than 1 per cent of manganese are regarded as unfit for pineapple culture at present. This subject of manganiferous soils and the whole subject of pineapple soils in Hawaii has been discussed in Press Bulletins Nos. 23 and 29 and Bulletin No. 26 of this Station, and those who wish to look into the subject more in detail are referred to these publications, which may be had on application to the station.

LOCATION OF PLANTATION.

Pineapples are found prospering in Hawaii from sea level to elevations of about 1,200 feet or more. The usual pineapple belt lies just above the cane area, but on lands not sufficiently watered for cane the pineapples extend to the lower levels. The

1 Press Bulletin No. 29.
2 Press Bulletin No. 23; Bulletin No. 26.
3 Press Bulletin No. 10.
4 Bulletin No. 14 and Press Bulletins Nos. 21 and 22.

moisture requirements of the pineapple are supplied by a rainfall of about 50 inches per year, if this is reasonably distributed throughout the twelve months, but a very large precipitation does not appear to be injurious to the plants provided the drainage is perfect. In the district of Hilo, on the Island of Hawaii, pineapples prosper where the rainfall sometimes exceeds 12 feet per year. Standing water will not be endured, and flooding for even a short time is likely to ruin the crop. For these reasons land having a reasonable slope is generally preferred to that which lies nearly level. The facilities for transportation must of course be carefully considered in locating the plantation. A large crop can not be economically transported any great distance without a railroad outlet to some port where ocean steamers call.

PROPAGATION.

Except for the purpose of breeding new varieties, the pineapple is always propagated by parts analogous to cuttings. Of these there are four different kinds, arising from different parts of the plant. They are known as suckers, crowns, slips and stumps.

Suckers. Suckers are young shoots arising from buds in the axils of the leaves (figs. 1 and 4). They produce fruit more quickly than any other kind of plant and are very extensively used. Their fruiting, however, is not quite so uniform in time as the fruiting of plants grown from crowns. These suckers are taken from the plant shortly after the fruit has been gathered. After this time they mature rapidly, but must not be allowed to remain too long upon the plants, because they will become too far advanced and the processes which are to form the flower bud will already have been set up and will result in the bearing of a premature fruit which is likely to be worthless. Just the proper stage of maturity for removing suckers from the mother plant is difficult to describe and must be learned by experience and observation. The leaves lose their fresh green color, which is characteristic of the immature suckers, and become slightly redened and also spread out a little. If taken at the right degree of maturity these suckers may produce pineapples in from 15 to 18 months. This is a shorter period than is required for crowns at any season.

Crowns. The crown is the tuft of leaves at the top of the

Fig. 1. Plant of the "Queensland" variety from which one side has been partly cut away, showing two suckers arising from the axils of the leaves on the stem of the plant, also two slips attached to the stem of the fruit. One slip has been removed and lies at the base of the plant.

fruit (fig. 1). If the fruits are sold as fresh fruit the crowns must remain on them and so can not be used for planting. If the fruit is canned the crowns become available as a future plant. Fields planted with crowns do not mature their fruits so rapidly as suckers. It requires nearly two years to get fruit

Fig. 2. An uprooted plant, showing four ratoon suckers. One of these has been quite deep in the soil, while two have started just beneath the surface and the fourth or central sucker is a little higher. In front of the latter may be seen the shrivelled leaves and old stem from which the first fruit was cut.

from such plants. The fruits, however, will come on more uniformly, nearly all of the field fruiting at nearly the same time, while the fruits from suckers may come on partly as a summer crop and partly in winter.

Slips. The small shoots attached to the sides of the stem of the pineapple fruit are called slips (figs. 1 and 4) . These are regarded as good plants, maturing probably a little more slowly than

a sucker crop. They are allowed to remain on the mother plant rather longer than suckers after the fruit is gathered, since they do not grow to large size while the fruit is still drawing its sustenance from the plant.

Stumps. The stump is the base of the old plant, a part of which is in the ground and a part above ground. These are now used less than formerly, when suckers were more difficult to secure than at present. On good pineapple land their chief use is in making a nursery from which to draw a supply of new plants which will be taken up and set in other fields. Part of the shoots which they send up may be allowed to remain to form

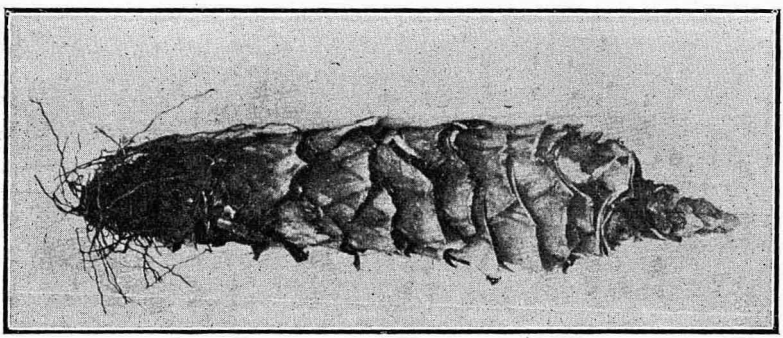

Fig. 3. A stump pruned and ready for planting.

fruit. In soils which contain rather excessive amounts of manganese, stumps are probably the best plants to use. The young plants, feeding upon the stored up food material in the stump, do not appear to suffer so much from manganese poisoning as do plants which must depend upon their own root system for sustenance from the beginning. The number of plants which may be secured from a stump depends upon whether it is young and upon the treatment which it receives. If allowed to get old and dry, few buds will start. If planted while still young and vigorous and if well supplied with moisture, as many as ten or eleven plants per stump have been found. In ordinary practice not more than three or four should be expected. These stumps are planted in a continuous line in a furrow and covered with about three inches of soil. (figs. 2 and 3).

Preparation of the Plants. Suckers, crowns and slips are pre-

pared for planting by removing a few of the leaves at the base and cutting off the end. Figure 4 shows a sucker, a crown and a slip prepared for planting. Some experience is necessary to determine how many leaves should be removed. If too many are taken off the tissue exposed is very tender and is liable to decay. Suckers sometimes require trimming on the top also, or rather the trimming of the side leaves. If left too large they are liable to be blown out of the ground by the wind. Crowns

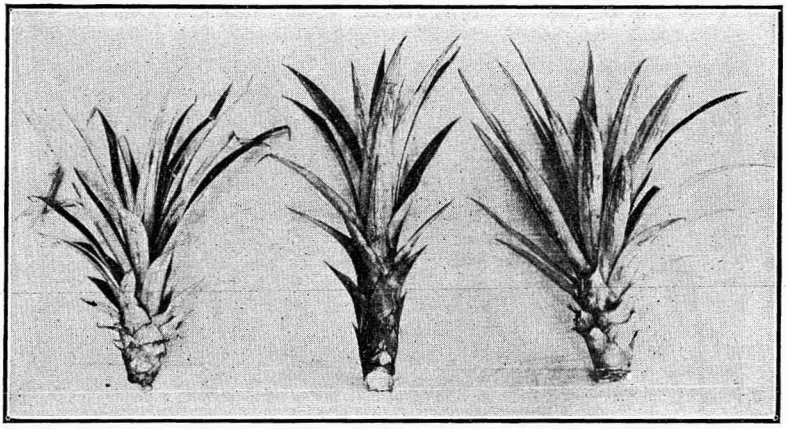

Fig. 4. A sucker (in centre) and two slips. The slip on the right has been cut, stripped and pruned in the usual manner for planting.

are commonly so much spread out that cutting back some of the side leaves, as shown in the illustration, may be necessary in order to get them sufficiently into the soil. All plants so prepared are generally allowed to lie in the sun for a few days until their cut surfaces are dried. They are thus less subject to decay. The removing of a sucker from the mother plant requires some experience. They hold on rather tenaciously, and an inexperienced hand may break them in getting them off. The leaf just subtending the sucker is usually cut off, and then it is not difficult to press down upon the sucker and break it off, after it has been moved about a little in several directions.

Selection of Plants. Of course only healthy plants should be selected as a source of supply for new plantings. To what degree certain peculiarities of form in the pineapple are inherited is not known. For example, quite a number of fruits may be

found in most fields producing multiple crowns. These crowns may be only two or three in number, or may spread over the whole of the fruit, making a large, deformed, fan-shaped top to the fruit, greatly increasing the amount of core, and in extreme cases rendering the fruit useless for marketing. Whether these plants tend to transmit such peculiar characteristics to their offspring is not known, although good results have sometimes been reported from the use of such stock. The same question arises in regard to plants which produce fruit of any particular shape. Fruits are found quite cylindrial in shape and almost as large three-quarters of an inch below the crown as at the base, while others are tapering in form. The former is very much to be desired, because it is more economical for canning purposes. Fruit tapering to a point may be much larger than is necessary to form a standard sized slice from the base of the fruit, but several slices at the top may be too small. Some experiments are now in progress to determine whether this characteristic is inherited or not. If they are proved to be transmissible, it will be possible to select plants from those of desirable form.

PREPARATION OF THE SOIL.

Most land on which pineapples are planted in these islands is either virgin or has been in pineapples previously. There are few instances where pineapples are planted on soil which has been occupied by other crops, except where some quick crop, such as watermelon, has been used as a means of preparing the soil for pineapples. Either virgin soil or that which has been in pineapples will require very thorough preparation. In the case of virgin soil it is customary to plow about 4 or 5 inches deep with an ordinary moldboard plow. This is followed by harrowing about once per month for a period of 5 or 6 months. Either spike tooth or disc implements are used. The soil is then plowed as deeply as possible, and with disc plows running at right angles to the furrows of the first plowing if possible. It is necessary to thus prepare land deeply in order to make a deep reservoir for the conservation of moisture, and also to make it possible for the water to get away from the soil which is to be occupied by the pineapple roots. Steam plowing has been practiced to a limited extent, but is not generally used. It is quite

possible that where steam plows are readily available and the subsoil tenacious, it would pay to use this means of breaking the soil deeply. This second deep plowing is followed immediately by harrowing with disc implements until the soil is in thoroughly good tilth. It thus requires about six months to properly prepare the soil.

Soils that have been in pineapples for four or five years usually require quite as much, or even more, preparation than the virgin soils, because of the hardened condition which the subsoil has acquired during the years of constant surface tillage. Not a little difficulty was experienced in the early years of pineapple growing in these islands by making the second planting upon soil insufficiently prepared, and this led to the belief by some that the pineapple was exhausting upon the soil and that probably not more than one planting could be made. Experience has taught that this idea is not well founded, and it has been well known for many years that the pineapple plant is not extremely taxing on the soil. Thorough preparation and spring planting appear to solve the difficulty. Just what methods are best to use in breaking up the subsoil, and thus giving an opportunity for the aeration of the soil and the percolation of water, is not yet a settled question. Experiments, under the personal supervision of the Director of this Station, are now in progress to determine the effect and economy of the use of a special brand of giant powder. In these experiments a drill was driven into the ground, making a hole about three feet deep. Into this one stick of the powder was placed and the soil thoroughly tamped over it. Such holes were made about 8 feet apart throughout the field and the charges set off in succession. The explosion jars the lower strata of soil, but does not disturb the surface to any great extent. The cost is about $20 per acre. What the results will be, measured by the success of the future crop, it is too early to state, but the indications are good from the condition of the soil after blasting.

If the soil is virgin it has been found a very good practice to get a short crop from it during the 5 or 6 months of preparation. Watermelons have been successfully used by some planters and with good profit. The success of this crop depends upon being within reasonable reach of a good market and upon the ability to control the melon fly. This fly is usually not a very

serious menace to the first crop planted upon virgin soil at some distance from other plantings of vegetables which are subject to the attack of the fly. It is quite probable that some cover crop will be necessary between the first and second or later plantings. Cover crops have been used to a limited extent for this purpose. They serve to penetrate to the lower depths of the soil, and when plowed under add much humus, and, if legumes, they also increase the nitrogen supply. The crops which are recommended for further trial are the pigeon pea, jack bean, cow pea, soy bean, lablab bean, and the like.

PLANTING.

Distance and Arrangement. There are many plans for the arrangement of the plants in the field. A type of one of the most common methods is illustrated in figure 5, a. This consists in placing all the rows equally distant apart, in this case about 48 inches. The plants in a row are placed 20 inches apart. The number of plants on an acre set in this manner and allowing for driveways is between 5,000 and 6,000. A second plan is illustrated at b in figure 5. Under this arrangement the rows are at equal distance. They are about 36 inches apart and the plants in the row about 15 inches apart. Under this system, allowing for crossroads, approximately 10,000 plants are placed upon an acre. This method is somewhat extensively used in certain parts of the islands with great success, but in much of the pineapple area it is claimed to be impractical. The advantages claimed for the system where it can be practiced are obviously that about twice as many plants are placed upon an acre, meaning a much larger yield, and further that the fruits approach more nearly to the desired size for canning purposes on the "plant crop," as the first crop after planting is called. With very wide planting a considerable proportion of the first crop runs to so large a size that there is loss in sizing down to the dimensions of the can. This is not wasted, now that so many secondary products are being put out, such as crushed, grated and shredded fruit and pineapple juice, yet the highest priced article is the large size slice. Those who advocate this system of planting also defend it with the claim that the plants soon cover and shade the greater part of the ground, thus eliminating much hand hoeing. The third plan illustrated (fig. 5, C.)

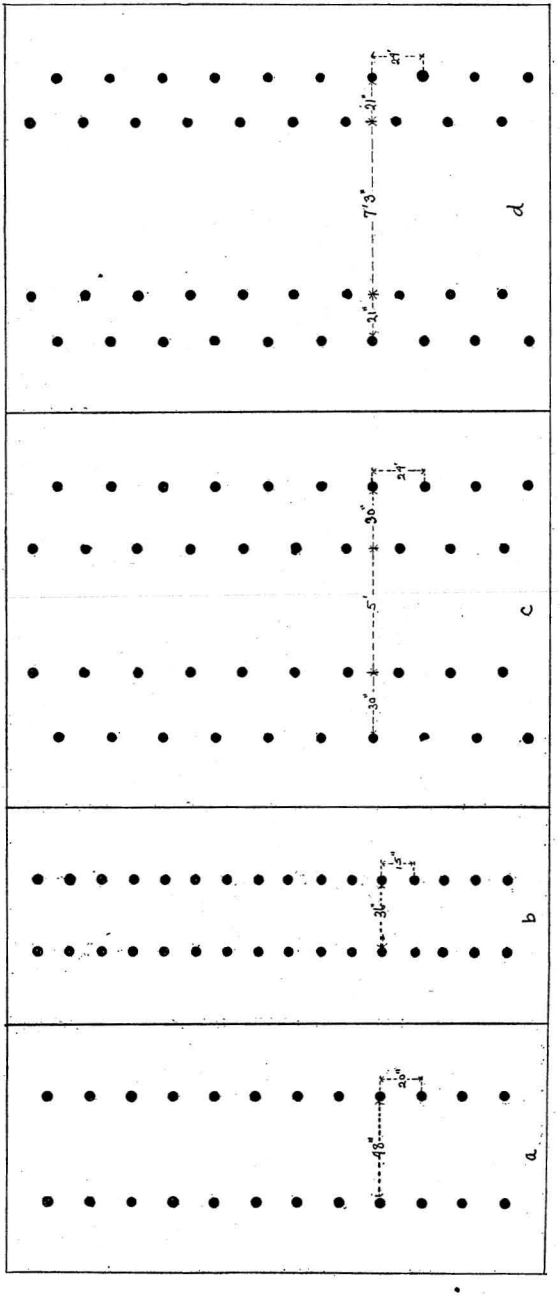

Fig. 5. Planting Plans Common in Hawaii.

provides for the setting of double rows. The plants in the row stand 24 inches apart and two rows are 30 inches apart. Then comes a space of 5 feet, followed by another double row. This plan gives about 5,000 plants per acre after allowing for land used in crossroads. This has proved one of the most popular methods of planting. It permits of the use of cultivators throughout the entire time that the plants are standing upon the soil. The plants being rather close together, support each other more or less, as they do in close planting. A fourth plan (fig. 5, d) places the plants about the same distance in the row, but makes the two parts of the double row stand closer together and leaves a wider space for the tillage by horse-drawn implements between the double rows. The plants stand about 24 inches apart in the row and the next adjoining row is 21 inches distant, the plants in the latter being placed opposite the space in the first row, or on what is called the quincunx plan. Then follows a space of seven feet three inches before the next double row, and so on throughout the field. This system has not been widely used. The claim made for it is that it permits of the use of disc implements drawn by two mules throughout the entire time that the plants are occupying the soil, and by thus ridging the soil about the plants two or even three ratoons may be taken. This system also accommodates about 5,000 plants per acre. Occasionally the plants are set in beds of three rows, quite close together, with a space wide enough for a cultivator between the beds.

Seasons for Planting. The limits of the season for planting may be said to be from April 1st to November 1st, and preferably in most years from May 1st to October 1st. Planting suckers in the spring and early summer is likely to produce a more quickly maturing crop, usually not so good as obtained from late summer or early autumn planting.

Preparing the Rows. To prepare the rows for planting, a small plow is run twice through the same furrow, throwing the soil in opposite directions. This is usually followed by a cultivator passing through the row. If fertilizer is to be applied at planting time, it may be placed in the row before the cultivator passes through. A planting line is then run up and down the row. This line is specially prepared, according to the system of planting which is to be followed. It is usually made of ordinary

clothes-line wire in which brass rivets have been placed at the same distances at which the plants are to stand. Any unevenness in the furrow is corrected by the use of mattocks and hoes, so that the plants can be set with accuracy in a straight line. A man passes along the row, distributing the plants as he goes, and is followed by the planters.

Placing in the Soil. The plants are pushed down into the mellow soil which is slightly pressed about them, one plant being set at each rivet in the line. The depth at which they are planted depends in part upon the plant itself and in part upon seasonal and soil conditions. Crowns can not be inserted more than about one and one-half inches in the soil. Suckers can be placed deeper, and in warm weather when the soil is not too wet they are placed three or four inches in the soil. In wet weather it is not safe to plant them so deeply.

Ridge and Level Planting. The method which has just been described leaves the ground nearly level when the planting operation is over. In rather heavy soils not perfectly drained there would be an advantage in putting the plants upon a slight ridge. This has been practiced to a limited extent. The difficulty with such a plan arises when the ratoon crop is in progress. It then becomes very difficult to get the soil up about the new shoots which are bearing this second crop, and failing in this there is danger of the plants breaking off. In a thoroughly drained, porous soil, placing the plants in a depression gives an excellent opportunity to get the ratoon suckers well rooted in the soil which can easily be worked toward them.

TILLAGE.

Tillage by horse-drawn implements is practiced in all wide planting systems and for a shorter time with the close planting plans. The implements used are chiefly the ordinary one-horse cultivator, but, as indicated above, two-horse implements are also in use. One grower reports excellent results from the use of an implement which strides the rows, so that the cutting parts work up quite close to the stump of the plant under the leaves without seriously injuring them. A man with one mule and the ordinary cultivator is expected to cover from 60 to 70 acres in pineapples. Cultivation is repeated about once every three or four weeks. It

is important to consider the condition of the soil when horse tillage is to be practiced. There can be little doubt that much injury is done by the constant tramping up and down the rows when only a few inches on the surface are in suitable condition for cultivation while the whole soil below is too wet and is packed tightly by the very process which loosens the surface soil. It will be understood that this does not in any way discourage the liberal use of the cultivator or other horse-drawn implements, but merely emphasizes the need of delaying its use until the soil becomes sufficiently dry beneath. Hand hoeing is practiced in practically all methods of planting, since no attempt is made to cultivate by horse power in two directions. Under most methods of planting a good laborer should do the hand work that is necessary on about 30 acres of land.

REMOVAL OF CROWNS.

A few growers remove the crowns from young, developing pineapples, believing that this causes the upper end of the fruit to "fill out" more and thus make a better fruit for the cannery. This has not become a general practice, and there is much room for doubt as to whether it really increases the weight of fruit available for slices. It gives the pineapple the appearance of being more developed at the top, but about three-fourths of an inch of the upper end is always eliminated and it has yet to be proved that the pineapple below this point is of any greater diameter because of having its crown removed. If new plants are in demand, the removal of the crown means the loss of a plant, and a pineapple without a crown cannot be used in fresh fruit shipping.

GATHERING THE CROP.

Seasons of Maturity. The pineapple appears to have a decided inclination to fruit during the summer season. Another season of lighter crop comes in the winter. The months of July and August are the most important ones for the gathering of the crop, and a large percentage of the fruits must be handled during a period of two or three weeks. There are, however, ripening pineapples here and there in the fields throughout the entire year. It has been found possible to control the seasons

of maturity to only a limited degree. For example, if suckers are planted about April 1st at Wahiawa, it is quite likely that the crop of fruit will be produced in one year from the following summer; that is to say, in sixteen or eighteen months from the time of planting. Suckers set about June 1st are very likely to flower during the autumn flowering season and mature a considerable crop during December and January, about 19 to 20 months from planting. This appears to be about the best time to plant in that locality for a winter crop. At this time, however, plants are not as easy to secure as later in the season, since both suckers and slips mature chiefly after the fruits have been removed. If the planting is delayed until the first of July, the next flowering season, which for the winter crop will be in the autumn, will not find these plants sufficiently matured to produce flowers, and as a result they will pass over to the next spring and will mature their first crop of fruit in June and July, about two years from the time of planting. The accompanying table will serve to show in a general way the probable time for the maturity of crops from plantings at different times during the planting season at Wahiawa. Of course, seasons differ and the table must be regarded only as approximating the probable outcome.

Gathering Fruit for the Cannery. The fruits required by the canneries for their best grades of canned product weigh from 3½ pounds upward. For such the highest prices are paid, and anything running under this standard must usually be sold at half price. Most canners prefer fruit running about four pounds. The fruit should be as nearly cylindrical as possible, as indicated elsewhere in this paper, in order to supply as many slices as possible from each fruit. Pines for canning are gathered when they are quite ripe, but many of the fruits are taken before they have lost all traces of green color. If, however, only a trace or two of green on one side of the upper portion of the fruit is to be found, the flavor of the fruit as a whole is about perfect.

Care should be taken in handling the fruits so that they will not become bruised on the way to the cannery. Fruits for canning may be broken from the plant and need not be cut, as is necessary for fresh fruit shipping. They are carried out to the ends of the rows and placed in piles on the driveways. Here

Approximate seasons of maturity at WAHIAWA.

Time of Planting 1912	Mar. 31, 1913	Apr. 30 "	May 31 "	June 30 "	July 31 "	Aug. 31 "	Sept. 30 "	Oct. 31 "	Nov. 30 "	Dec. 31 "	Jan. 31, 1914	Feb. 31 "	Mar. 28 "	Apr. 30 "	May 31 "	June 30 "	July 31 "	Aug. 31 "	Sept. 30 "	Oct. 31 "	Nov. 30 "	Dec. 31 "	Jan. 31, 1915	Feb. 28 "	Mar. 31 "	April 30 "	May 31 "	June 31 "	July 31 "	Aug. 31 "	Sept. 30 "
April 1	12	13	14	15	16	17	18	.....	.....	21	22	.....	.....	.....	.....	.....	28	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
					Main crop					Part crop							Ratoon													
May 1	.....	12	13	14	15	16	17	18	19	20	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	31	32	33	.....	.....	.....	.....	.....	.....	.....
						Part crop			Main crop												Ratoon									
June 1	.....	.....	12	13	14	15	16	17	18	19	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	30	31	32	.....	.....	.....	.....	.....	.....	.....
							Part crop			Main crop											Ratoon									
July 1	.....	.....	.....	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	.....	.....	.....	.....	.....	.....	.....	.....	.....	37	38	39
													Part crop			Main crop												R 1r		
Aug. 1	.....	.....	.....	.....	12	13	14	15	16	17	18	19	20	21	22	23	24	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	36	37	38
															Part crop		Main crop											Ratoon		
Sept. 1	.....	.....	.....	.....	.....	12	13	14	15	16	17	18	19	20	21	22	23	24	25	.....	.....	.....	.....	.....	.....	.....	.....	35	36	37
																	Main crop											Ratoon		
Oct. 1	.....	.....	.....	.....	.....	.....	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	.....	.....	.....	.....	34	35	36
																	Main crop					Part crop						Ratoon		

Consecutive figures indicate the number of months from planting to harvest.

they are laid into lug-boxes built expressly for this purpose. These boxes measure about 13″x16″x22″ and must be strong. They are frequently reinforced by wire bands, such as are frequently used to strengthen packing cases. These lug-boxes after being filled are placed upon the wagons and carried either to the cannery or to the railroad siding. If to the latter, they are placed upon flat cars with racks built expressly for this purpose and are taken immediately to the cannery. It is desirable to can the fruits the same day they are gathered or the day following.

RATOONING.

Reference has been made to the suckers which grow from the axils of the leaves. These may arise from below ground or higher up on the plant. (fig. 2.) Some of these are removed for new plantings, but two may be left to produce the next year's crop. This is spoken of as a "ratoon" crop, even though the sucker may arise from a point well above ground. Judgment should be used in selecting the suckers which are to be left for the next crop, leaving the lowest possible. If the soil can be kept about them, the support will be good and they will send out roots of their own, whereas a high sucker when heavily laden with fruit is liable to be broken off. Do not leave a sucker which will interfere with another on a neighboring plant. Usually two suckers are left on each plant for the ratoon crop, provided they are well placed.

Usually one plant crop and one ratoon are taken from a field, and good fields may yield a profitable second ratoon, or even a third, after which the field must be plowed up and replanted as described elsewhere.

FERTILIZERS FOR PINEAPPLES.

The Hawaiian pineapple industry being of recent development and having been carried on largely on virgin soils, very little systematic investigation of fertilizing has been pursued. The department of chemistry of this station conducted two extensive plot experiments with fertilizers. One of these was to determine whether any of the fertilizers would overcome the yellowing, stunted effects noticeable on the black soils. The report

of this work[1] is "that the application of liberal amounts of various high grade fertilizers, in conjunction with good tillage, drainage, etc., has not resulted in overcoming the yellowing of pines on this land." The other series of experiments referred to was made upon red soil, but no reports of this work have been published.

Mr. Carlton C. James[2] has published a report of extended experiments with fertilizers on pines on virgin soil at Waimea, Oahu. Mr. James concludes from the results of these experiments that nitrogen is not the dominant element in pineapple fertilizing. Nitrate of soda seemed to have injurious effects, and if nitrogen should be required in any soils it would appear better to apply it in some organic form, such as hoofmeal, or in the form of sulphate of ammonia. On this soil, however, no form of nitrogen alone gave increase in the crop sufficient to pay for the fertilizer. It must not be forgotten, however, that the results might be different where pines have been grown on the land for many years.

As sources of phosphoric acid, which appeared to be a most important factor, superphosphate, reverted phosphate and steamed bonemeal showed good results. Superphosphate in particular gave very excellent results, greatly increasing the yield and the net profit. Its beneficial effects appeared to be increased on land treated with lime. It should be remembered, however, that lime must not be added to soils that approach the limit of safety in their manganese content.

Potash in the form of sulphate and of muriate showed good effects, but even better results followed the use of sulphate of potash magnesia.

MARKETING.

The subject of shipping and marketing Hawaiian pineapples has been discussed at length in three bulletins of this station[3] and need not be considered in detail in the present paper, since the earlier publications are available to all those who may be interested in the matter. Only a brief summary of the most important features of packing and shipping will be mentioned.

1 Hawaii Experiment Station, Press Bul. 23.
2 "The Effect of Fertilizers on the Growth of Pineapples," by Carlton C. James, Hawaii Forester and Agriculturist, Vol. VIII, No. 5.
3 Hawaii Expt. Sta. Bul. 14, and P. Buls. 21 and 22.

Care in handling is the first essential in the successful shipping of pineapples. This begins when the laborer places his hand upon the fruit to harvest it and must continue until it is delivered to the consumer. Select normal fruits from fields producing a healthy crop, free from the symptoms of manganese poisoning, manifested by reddish fruit and yellow leaves. Fruit for shipping without refrigeration must be cut quite green. In the summer time the stage of maturity generally regarded as best is indicated by the appearance of a light pea-green color about the "eyes" or segments of the fruit near its base. In the winter season they may be allowed to advance further on the plants and show a slight yellowing about the base.

The laborer cuts the stem with a knife, for it must not be broken as is done with ripe fruits for the cannery. The fruits are carried to the driveways at the ends of the rows and are there placed in lug-boxes. They may be left exposed to the sun for an hour or two and the effects will be beneficial. The spores of the Soft Rot fungus are destroyed by direct sunlight.[2] The fruits are then carried to the packing house, placed upon their crowns and allowed to cure. This consists in the elimination of excessive heat and the drying and shriveling of the stems, which takes place in about a day or more. A few stems are likely to fail to become dry, and these must not be shipped, since they are almost sure to decay.

CRATES AND PACKING.

The crates which have been used extensively in Hawaii measure 15 x 17 x 40", inside measurement, and will contain from 130 pounds to 150 pounds of pineapples. The heads and a portion through the center are made of about 7/8" material and the slats are 3/8" thick. This is rather a large package and various attempts have been made to devise a more satisfactory size. A very small crate, holding about five or six good sized fruits, has been used by one of the largest shippers for express shipments. A medium sized crate measuring 15½ x 16 x 22¼", inside measurement, appears to be one of the most suitable packages yet devised for freight shipments. It will be observed that it is of convenient size and has flattened edges. Practically no

2 Larsen, Expt. Sta., H. S. P. A., Pathological Series Bul. 10, p. 15.

packing space is thus sacrificed, but the shape prevents the crates being placed so closely in the ship or car that no air can circulate among them.

For packing material excelsior only is being used at present. Hay made from wild grasses was much used formerly, but now will not pass the California quarantine regulations. The use of a paper wrapper for each fruit has not become at all general in Hawaii, but is to be recommended. The bottom of the crate is covered with excelsior. Each pine is wrapped with a layer of this material passing about the base and is then placed in the crate. The next fruit is placed in the opposite direction, with the crown close to the first fruit. When one layer of fruit is in the crate more excelsior is worked in about the pines and on top of them. The second layer is begun by placing a pine immediately over the crown of the first one in the tier below, and so alternating until the crate is full. An essential point in packing it to get the fruits closely nested together and tightly in place, so that when the slats are nailed down there will be no shifting of position within the package.

SHIPPING.

The fruit must be placed on the ship where it will be well ventilated, dry and reasonably cool, and it must be carefully handled. Because of inadequate facilities for ventilating the 'tween decks of the steamers, most shippers prefer to have their fruit on deck and covered with a tarpaulin. This should not rest closely upon the crates, but should be raised so as to give better ventilation and avoid heating. It is also important that the crates be raised slightly from the deck and that they be so placed that the air can pass freely among them.

VARIETIES.

It is commonly stated that there is but one variety of pineapple grown commercially in Hawaii. On the contrary, there appear to be at least two distinct varieties, and possibly several strains of the commoner of these, the Smooth Cayenne. Some of these differences attracted the attention of the writer, and selections were made in the summer of 1910 and the cuttings planted for comparative study. These will be maturing fruit

during the 1912 season. A recent visit to the Island of Kauai, where the pineapple industry is of later development, revealed two varieties quite distinct in whole fields, the plants having been received from different plantations on Oahu or Hawaii. One of these is the Smooth Cayenne of the ordinary tpye, fig 6, centre of foreground. It is a stout, robust plant, quite free from disease

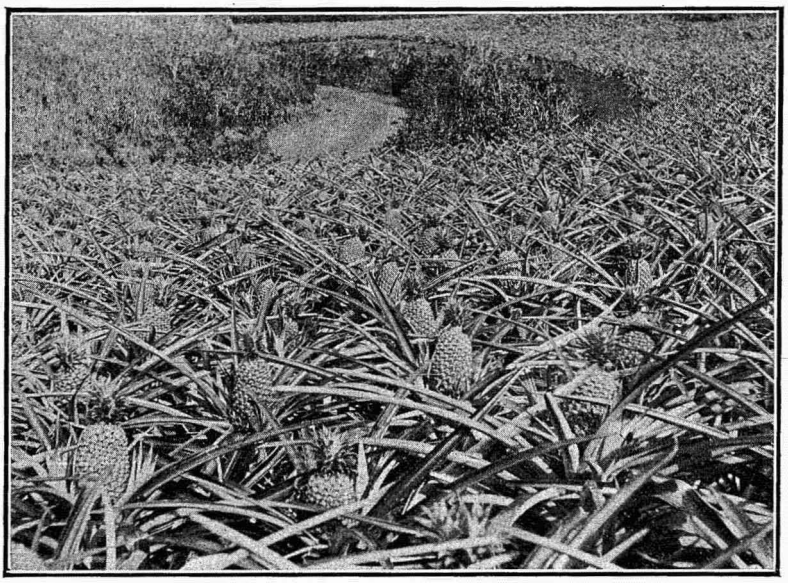

Fig. 6. A plant crop of the "Queensland" variety chiefly. Note the large cone-shaped fruits, standing high, above the leaves. A Smooth Cayenne occupies the centre of the foreground. Note how much lower it is among the leaves, the absence of slips and the barrel-shaped fruit.

as seen on the plantations of Kauai. The fruit is produced upon a very short stem, which carries few slips and usually none. The fruits incline to be barrel-shaped, with an occasional specimen tending toward a conical form. They become well ripened within and the flesh is of good color, flavor and texture before the green color has entirely disappeared from the outside. These are spoken of on Kauai as the "Hilo" pineapple, since the original stock for their plantations is said to have come from that district.

Another variety is found of taller growth, but not more vigorous, (figs. 1, 6, 7.) The fruit is larger in size than the Cayenne, with a decided tendency to the conical shape and producing many

Fig. 7. A ratoon crop of the "Queensland" variety. Observe the great height of the fruit and the other characters referred to in Fig. 6.

slips on its stem. This is probably the variety which Capt. John Kidwell, the pioneer in commercial pineapple growing in Hawai, refers to as having been introduced from Queensland many years ago.[1] It appears to have persisted in cultivation on some of the plantations, mixed with the Cayenne, and the two have passed as one variety. The cone-shaped fruit is by no means as well adapted for canning as the Cayenne, and growers should segregate the varieties in selecting plants for new fields.

A third type may be found side by side with these that have been described. It also has a smooth leaf, but narrower than either of the others. The plant is of weak growth and appears very subject to disease and insect attack. It ratoons very poorly and sometimes fails entirely in this respect. It produces some slips, but less than the Queensland variety. The fruit inclines to the barrel shape, and is reported by some canners to be a good keeper, but inclined to white color of flesh, which is undesirable. This type is quite unsatisfactory, on account of its weakness and failure to ratoon. Whether it is a separate introduction or merely degenerate stock of the Cayenne, deteriorated through unfavorable conditions, can not be stated at present, but that it has given uniformly bad results on Kauai, wherever planted, there appears to be no doubt. The difference is so

1 Hawaiian Forester and Agriculturist, Vol. I, No. 12.

marked that these plants standing beside either of the others can readily be distinguished at a long distance. The stock is to be avoided, whether honored with a name of its own or not.

The Red Spanish variety has been tried on a commercial scale in Hawaii, but has not met with favor. Its small size puts it out of the running with the Cayenne in these islands as a pine for canning. Quite a large number of varieties have been grown experimentally and some of these, as for example the Queen, are well worthy of a place in the fruit garden because of their excellent flavor and texture, but none of the varieties tested up to this time have claimed a place in the commercial plantation except the three described above. We have not, however, found the ideal pine, and other varieties should be tested and new kinds originated.

DISEASES.

Quite a number of the diseases of the pineapple have appeared in Hawaii, but fortunately only a few of these have caused much damage.[1]

SOFT ROT.

Soft rot is a name which has been applied to a disease affecting green or ripe pineapples. It has done some damage in the fields and en route to the cannery, but its greatest devastation has been wrought upon fresh fruit shipments to the mainland. The loss thus occasioned formerly often ran over 50 per cent and sometimes included the whole shipment. The disease is first observed as a soft and slightly discolored spot on the fruit, generally near the base, although it may occur at the crown or upon any part of the fruit. The tissue soon breaks down and becomes blackened. The disease is caused by the fungus *Thielaviopsis paradoxa,* which also grows upon sugar cane and exists in the soil. It probably enters the fruit most frequently through the cut stem or other exposed moist surface, but has been shown by Larsen[2] to be capable of penetrating the uninjured surface if suitable conditions are present. See fig. 8.

1 A careful study of the diseases of the pineapple in these islands has been made by Mr. L. D. Larsen, Asst. Pathologist of the Experiment Station of the Hawaiian Sugar Planters' Association, and the results have been published as Bul. No. 10 of the Pathological and Physiological Series. Readers who wish to pursue this phase of the subject in more detail are referred to that publication.

2 Hawaiian Sugar Planters' Assn. Expt. Station, Pathological Series Bul. No. 10.

Fig. 8. Sectional view of pineapple affected with Soft Rot.
(Courtesy of H. S. P. A. Experiment Station.)

REMEDIES.

No single remedial measure will suffice for the control of this disease. The first steps should be along the lines of proper sanitation. Decaying pineapples should not be allowed to remain about the fields or the packing houses. The lug-boxes in which green fruit for shipping is to be carried should be free from spores. They may be spread out where the sunlight can enter them for several hours, or fumigation with formaldehyde will

prove an effective means of destroying the spores that may be lingering in cracks and crevices.[1] The packing house must be kept clean, and if tight may be fumigated, but since most pineapple packing houses are open sheds an occasional spraying of the walls and floors with Bordeaux mixture would be easier. These suggestions are based upon recent knowledge of the fungus and have not yet come into general use.

The curing of the fruit by allowing it to remain upon its crown in the packing house has been found to be very beneficial. By this means several ends are gained. Any dampness that may be upon the fruit picked in rainy weather is eliminated, as also the excessive heat in pines gathered on bright days. The freshly cut stems should become shriveled and dried, and if any fail to do so they should not be shipped, as stated elsewhere.

A paper wrapping around each fruit, although not generally used in Hawaii, would prevent infection from spores in the ship or car, in addition to its other advantages mentioned elsewhere.

It is extremely important to provide on shipboard and elsewhere conditions that are unfavorable to the development of the disease. It is well known that dampness, high temperature and lack of ventilation are just the conditions in which the disease prospers, and these should not exist where fresh pineapples are in storage or in transit. The cutting of the subtending bracts, instead of pulling them off, and when the disease is prevalent the cutting of rather long stems on the fruit have both proved beneficial in the experiments conducted by this Station.

In early experiments formaldehyde fumigation was applied directly to the fruits in some cases and resulted in reducing the loss by decay, but it has been found in more recent experiments here that the gas in sufficient quantity to destroy all the spores[2] injures the green fruit by preventing it from acquiring its natu-

1 To fumigate with this gas it is necessary to have an airtight room. The gas is easily liberated from commercial formalin by means of permanganate of potash. The formalin should be about 40 per cent formaldehyde and it is necessary to use from 2½ to 3 pints for every 1,000 cubic feet of space to be fumigated. Permanganate of potash should be used in the proportion of 7½ ounces for every pint of formalin. It is only necessary to place the permanganate of potash in the bottom of a large container, pour the formalin over it and leave the room. A violent reaction takes place and if the container is not large some of the fluid will be lost. The gas is not dangerous to work with, as is hydrocyanic gas, but the operator must be prepared to get out promptly.

2 U. S. Dept. of Agr., Bur. of Plant Industry, Bul. No. 171, by Flora W. Patterson, Vera K. Charles and Frank J. Veihmeyer.

ral color in ripening. With the other precautions mentioned, however, there is not much difficulty in keeping the loss at a minimum on properly selected fruit from healthy plants.

Fig. 9. Typical Base Rot of pineapple cuttings.
(Courtesy of H. S. P. A. Experiment Station.)

BASE ROT OF CUTTINGS.

The same fungus which causes the Soft Rot of the fruit has been shown to be the cause of the rotting at the base of suckers, slips or crowns[1] shortly after they have been planted or while they are in transit on shipboard or train. The rotting away of plants after they have been set out is familiar to all pineapple growers in Hawaii and often results in a very large percentage of loss. Larsen's experiments have demonstrated that this form of the disease may be kept well in control by stripping off only a few leaves at the base and allowing the plants to dry for one week before setting them in the ground. See fig. 9.

LEAF SPOT.

Leaf Spot is a disease that has been observed by the growers for many years, particularly in the winter time, but since its effects become less apparent as the summer returns, it has not been seriously thought of. It is characterized by spots of varying size and usually of a white or straw yellow color appearing upon the leaves. This also has been shown by Larsen to be caused by the same fungus (*Thielaviopsis paradoxa*) which causes the Soft Rot of the fruit and the Base Rot of the cuttings, and to be associated with the work of a grasshopper in its attacks upon the leaves. The injury in the leaf caused by the grasshopper furnishes a common means of entrance for the fungus, but it also gains entrance through other injuries to the leaf, such as those made by the rubbing of one leaf against another. Whatever may be done to reduce the spread of this fungus, as indicated elsewhere, will of course lessen the Leaf Spot. If it becomes necessary to take further steps in control, some measures should be taken against the grasshopper. See fig. 10.

BROWN ROT.

Brown Rot is an appropriate name applied by Larsen to a disease of the pineapple which is rather common in Hawaii, but which has given rise to little alarm. It may affect the exterior of the fruit, appearing as a brown spot upon the surface, or perhaps more commonly it may be seen in the tissues of the fruit just beneath the surface when it is sliced at the cannery. It does

1 Larsen.

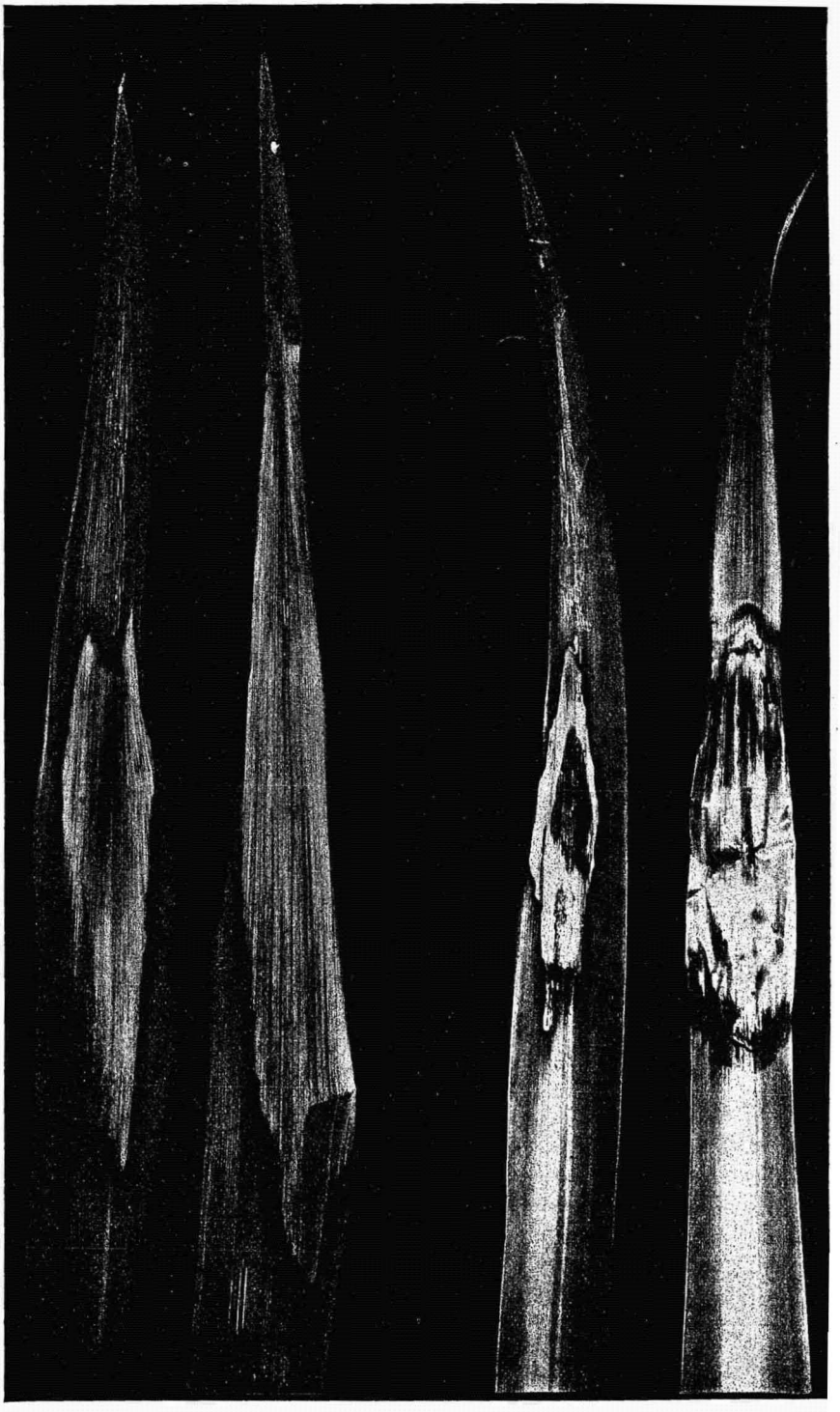

Fig. 10. Pineapple Leaf Spot. The two right hand spots were produced by artificial infection with **Thielaviopsis.** The two on the left are from natural infection, through punctures made by the spines of some neighboring leaves. (Courtesy of H. S. P. A. Experiment Station.)

not result in the breaking down of the tissues, as does the Soft Rot, but mars the appearance of the fruit externally and destroys certain slices for canning. A number of organisms appear to be capable of producing a similar appearance, but Larsen concludes that most of the injury of this nature in Hawaii is due to a fungus of the genus *Fusarium*. No remedy has been suggested for its control. See fig. 11.

Fig. 11. Cross section of pineapple, showing infection with Brown Rot. (Courtesy of H. S. P. A. Experiment Station.)

SUN SCALD.

When, through weakness of the stem or other injury, a pineapple falls over and lies in a nearly horizontal position the direct rays of the sun upon the exposed side often produce an injury which has been called Sun Scald or Sun Burn. The injury may be only slight, affecting merely the appearance of the fruit on the surface, which becomes a pale green color while the remainder of the pine is unripe and a light yellow or white when the

fruit ripens. In more severe cases, however, the whole side of the fruit is arrested in its development and the tissues within become insipid or even dry and pithy. The conditions which result in the falling of the fruit are several. A general weakness of the plants arising from improper soil conditions is a prevalent cause. Sun Scald is very common on highly manganiferous soils, where the plants show so many of the symptoms of weakness. In healthy fields plants often fall over because suckers too high up on the stem have been selected for the ratoon crop or because the soil has not been sufficiently drawn up about the plants. The weight of the fruit itself, with so great a leverage and aided by the wind, causes the branch to partly break off and fall until it rests upon the ground or upon an adjacent plant. Suckers for the ratoon crop should be selected as low down as possible, where the soil can be drawn about them.

WILT.

Wilt is one of the most wide spread of pineapple diseases and is known in nearly all countries where this fruit is grown. It exists in Hawaii, but with the exception of a few fields has not caused great damage. The disease is characterized by the wilting or loss of rigidity of some of the leaves, which fall upon the ground and become useless. As the disease extends it includes all the leaves and the plant dies. The leaves often turn reddish or yellow before they wilt. The cause of the malady has not yet been discovered and little is recommended by way of remedy except to remove diseased plants. Extra tillage about the affected plants is claimed by the growers to be beneficial. (See fig. 12.)

TANGLEROOT.

Tangleroot is a term applied to an unnatural condition in the roots of the pineapple, whereby they wind themselves about the base of the plant and fail to spread out into the soil. The condition does not usually manifest itself to any serious extent on plants that have been properly stripped at planting and which are cared for by good tillage.

Fig. 12. Plant affected with pineapple Wilt. (Early stage.)
(Courtesy of H. S. P. A. Experiment Station.)

INSECT PESTS.

D. T. FULLAWAY.

There are very few insect pests of the pineapple plant in Hawaii, and the losses thus occasioned are fortunately so small that it is ordinarily unnecessary to attempt any artificial control.

The commoner insect enemies are known respectively as the "pineapple scale" and the "pineapple mealybug." These apparently dissimilar insects both belong to the rhynchotal family Coccidae, characterized by sucking mouthparts, the absence of wings in the female, and a general sedentary habit. They are a widespread group, with which every horticulturist is familiar, and generally cause considerable damage, both in greenhouse and field.

The pineapple scale (*Diapsis bromeliae*) has already received attention from the station entomologist and is reported on in Press Bulletin No. 10, by D. L. Van Dine, to which the reader is referred for more detailed information. The female scale is

small, flat and circular, yellowish brown (darker outside) with a white rim, beneath which the soft-bodied, golden yellowish insect is concealed, and is usually found thickly on the leaves and sometimes on the fruit. The male scale is long and thin, entirely white, with three longitudinal ridges. (See fig. 13.)

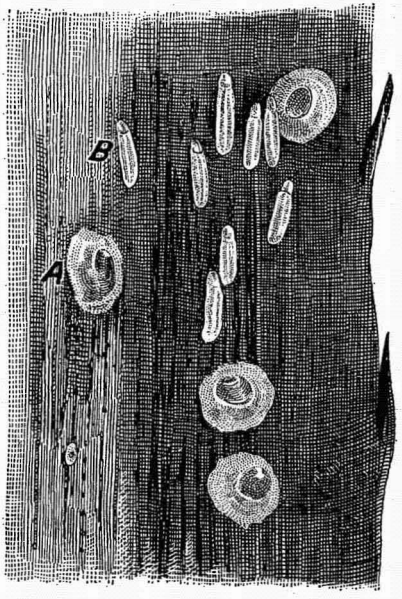

Fig. 13. Pineapple scale (Diaspis bromeliæ)
a. Female scale. b. Male scale.

The pineapple mealybug (*Pseudococcus bromeliae*) is much larger than the scale, is soft-bodied, with well developed legs, is more or less convex above and in color yellowish brown beneath the waxen coat which makes it appear entirely white. The male has not been seen. This mealybug has formerly been confused with *Pseudococcus citri,* from which it differs in the absence of a sac.. (See fig. 14.)

Both of these insects damage the plants by withdrawing the cell sap through the tubular cavity of the beak, which is thrust into the tissues. The loss of the plant juice causes withering, and the puncture gives access to the spores of parasitic fungi. Rarely, however, does either scale or mealybug become numerous enough to cause widespread injury. Presumably they are con-

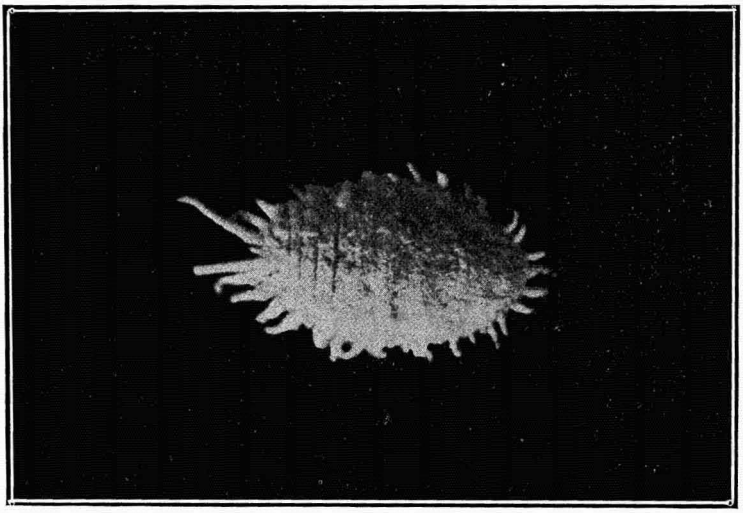

Fig. 14. Pineapple mealy-bug (Pisendocaccus bromeliæ), female.

trolled in a degree by parasites and predators Several aphelinid species have been bred from the scale, and the mealybug is destroyed by both coccinellid beetles (*Cryptolaemus montrouzieri, Rhyzobius ventralis*) and by hymenopterous parasites (*Coccophagus spp.*). Ants are very active in spreading and protecting the mealybug and are a prolific source of trouble.

When it is necessary to use insecticides to control the scale insects, kerosene emulsion and miscible oil sprays are recommended, or a small amount of tobacco dust, which is to be sprinkled over the tops. When it is practicable to fumigate with hydrocyanic gas, a cheaper and more effective treatment is possible.

Within recent years a locustid grasshopper (*Xiphidium varipenne*) has periodically attacked pineapple plants, gnawing large holes in the leaves. Fungus attack quickly follows the mechanical injury to the tissue and the leaves wither and die. The damage has not been extensive and probably never will be, as the grasshopper is controlled by an egg parasite, but the injury is usually apparent enough to attract attention and has occasionally produced alarm. (See fig. 15.)

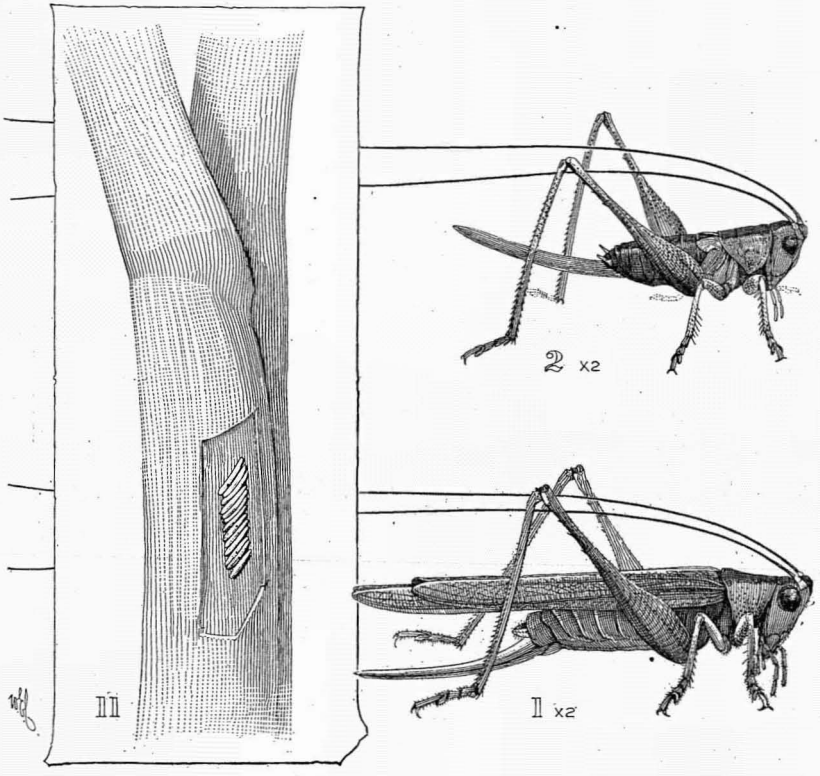

Fig. 15. Grasshopper (Xiphidium varipenne) 1 female. 2 nymph. 11 eggs. (Copied from Swezey).

Pineapple growers will be interested to know the identity of certain insects usually found around the factory dumps and refuse piles in the fields. The vinegar fly (*Drosophila ampelophila*), a nitidulid beetle (*Carpophilus humeralis*) and the ortalid fly (*Euxesta annonae*), breeding in decaying fruit and trash, are invariably found in such places and are readily recognized. Several caterpillars also, which breed in situations affording dry dead vegetable matter, along with their moths, are found around ripening and overripe fruit in the field. None of these can be classed as harmful.