HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

J. G. SMITH, SPECIAL AGENT IN CHARGE.

BULLETIN No. 2.

THE ROOT ROT OF TARO

BY

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Agriculturist, Hawaii Agricultural Experiment Station.

UNDER THE SUPERVISION OF

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

HONOLULU, HAWAII, *July 25, 1902.*

DEAR SIR: I have the honor to transmit herewith a bulletin on the root rot of Taro, prepared under my supervision by Mr. T. F. Sedgwick, agriculturist of this station. This bulletin gives the results of Mr. Sedgwick's experience and observation during his residence in Hawaii, together with an account of the experiments begun under the direction of the station to determine the cause and means for prevention of the destructive disease that threatens the extinction of the crop. Although the investigation has not been terminated, some results have been secured that appear promising for the prevention of the disease. I respectfully recommend the publication of the article as Bulletin No. 2, of the Hawaii Agricultural Experiment Station.

Very respectfully,

JARED G. SMITH,
Special Agent in charge of Hawaii Experiment Station.

DR. A. C. TRUE,
Director, Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.

A. C. TRUE,
Director.

Publication authorized.

JAMES WILSON,
Secretary of Agriculture.

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HISTORY OF TARO.

Taro, botanically known as *Colocasia antiquorum esculentum*, is a perennial plant, 1 to 2 feet high, with heart-shaped, peltate leaves and large fleshy rootstocks, from which the poi of the Hawaiians is made. In Japan, China, Porto Rico and elsewhere the tubers are cooked and used like Irish potatoes and the young tender leaves are used as a pot-herb. It is one of the principal food products, not only of the native Hawaiian, but of many of the native races of the Orient.

According to DeCandolle the taro plant is a native of India; from which country it was transported first to Ceylon, Sumatra, the Malay Archipelago and Egypt, and more recently to the Fiji Islands and New Zealand. From New Zealand it undoubtedly accompanied the present native Hawaiian race in its migration to Samoa, Tahiti, and finally to these Islands.

The plant has been in cultivation so long that there are many cultural varieties, differing from one another in size, maturity, form and habit of growth, and especially in the coloring of the flesh of the swollen root or corm, the portion of the plant which is mainly used for food, and the varieties resulting from cultivation have become so fixed, that they now have nearly the same value as separate species.

In Hawaii there are two distinct individual strains of taro, the one with red or pink flesh and the other white. Of each of these strains there are many sub-varieties or forms, each with native names. A list of such varieties is given in "Thrum's Annual for 1888," enumerating twenty-eight in all. Later lists give as high as forty-five separate forms or strains known to the Hawaiian people.

In its habit of growth and the character of the root, the Japanese taro is entirely different from the varieties cultivated under irrigation in Hawaii. The Chinese taro, or the variety commonly grown by the Chinese, is cultivated because it matures in a short season, but it appears to be more subject to rot than some others.

Taro holds about fourth place among the products of Hawaii, at least in area of land devoted to its cultivation and probably also in total value of crop. The investment in taro growing approximates from $450,000 to $500,000. It is practically all consumed in Hawaii, the export of taro flour or "Taroena," amounting to but a very small percentage of the total crop.

Taro cultivation is exceedingly profitable, and land suited to its cultivation, provided it has water rights, brings a high annual rental. The average rental per acre in the vicinity of Honolulu for

taro land ranges from $40 to $50. The average retail price of poi in Honolulu ranges from 2½ to 5 cents per pound. One acre will generally produce from twelve to fifteen tons, which sells for from $1.75 to $2.50 per hundred pounds. Land taro, or taro grown without irrigation, makes excellent poi and does not seem as readily affected with the root rot as that grown under irrigation.

The land suitable for the cultivation of the water taro, the variety which is principally grown, is a rich, deep, muck soil, bordering the streams, or occupying the lowest portions of the valleys extending back into the mountains. Land to be capable of growing taro must have an abundant supply of running water, and it needs also to be very rich. Many of the taro fields now in cultivation have been planted in taro, with hardly any rest, for one hundred years or more. The old Hawaiians understood the needs of occasional fertilizing and often allowed their patches to go without a crop for one season. They also planted certain weeds or burs in the taro patches, and spaded under the growth, thus not only giving the patch a rest, but adding a considerable amount of organic matter to the soil.

The available irrigated taro land is about all occupied. The opening up of new areas for its cultivation would be dependent, either upon the discovery of sources of additional water supply, or upon more careful use of the water now available.

Although taro has been the staple food of the Hawaiians, it is probable that the demands for it and its products will decrease rather than increase as time goes by. Taro and its products while relished by many of the older white settlers of these Islands does not meet with the same favor among the newer population, so the probabilities are that the time will come within the next one or two generations when a large share of the taro lands now in cultivation will be planted to other crops.

USUAL METHOD OF CULTURE.

Taro is cultivated in patches of varying size. Each patch is surrounded by a dyke containing openings admitting water and allowing its exit. These patches are usually extremely irregular and depend on the contour of the land both as to size and shape. A valley containing one or two square miles will have, perhaps, two or three hundred taro patches or fields, and hardly two of these will be exactly alike in size or shape.

Before planting the taro the water is allowed to drain off the fields; the ground is then dug up, or plowed with a rice plow, and is fertilized with the leaves, stems and trimmings of the previous crop. In this way the taro rot is perhaps often transferred to new fields, through the use of the trimmings of diseased plants as fer-

tilizer. Occasionally stable manure is used, or rarely, a complete fertilizer. These are thoroughly mixed with the soil.

Taro is propagated by means of the crown of the plant with its accompanying leaf stalks. At the time the crop is harvested, the upper portion of the root is cut off with a knife, then the leaves themselves are cut off leaving about six inches of leaf stalk on the crown of the root. These tops, called "hules,"[1] are either planted in a circle around a little mound of dirt, or in rows across the field. They are usually placed about one foot apart. As soon as the patch is planted water is again turned on, but only enough is used to keep the hules moist until the roots start. The patch is not flooded.

In about a month after the hule has been planted the roots start, and the crown throws out new leaves. The period of maturity varies according to the variety, ranging from twelve to fourteen months or more, from the time the hule is set in the ground.

Cultivation consists in keeping the patch clear of weeds and the soil between the roots is sometimes stirred with pick or shovel, care being taken not to loosen the roots.

The fleshy root or corm[2] does not commence to form until about eight to ten months after the hule is planted. Until this time the corm is tapering, like a small carrot; but as soon as the crop commences to mature, that is between the eighth and twelfth months, the corm rapidly swells and becomes oval or rounded.

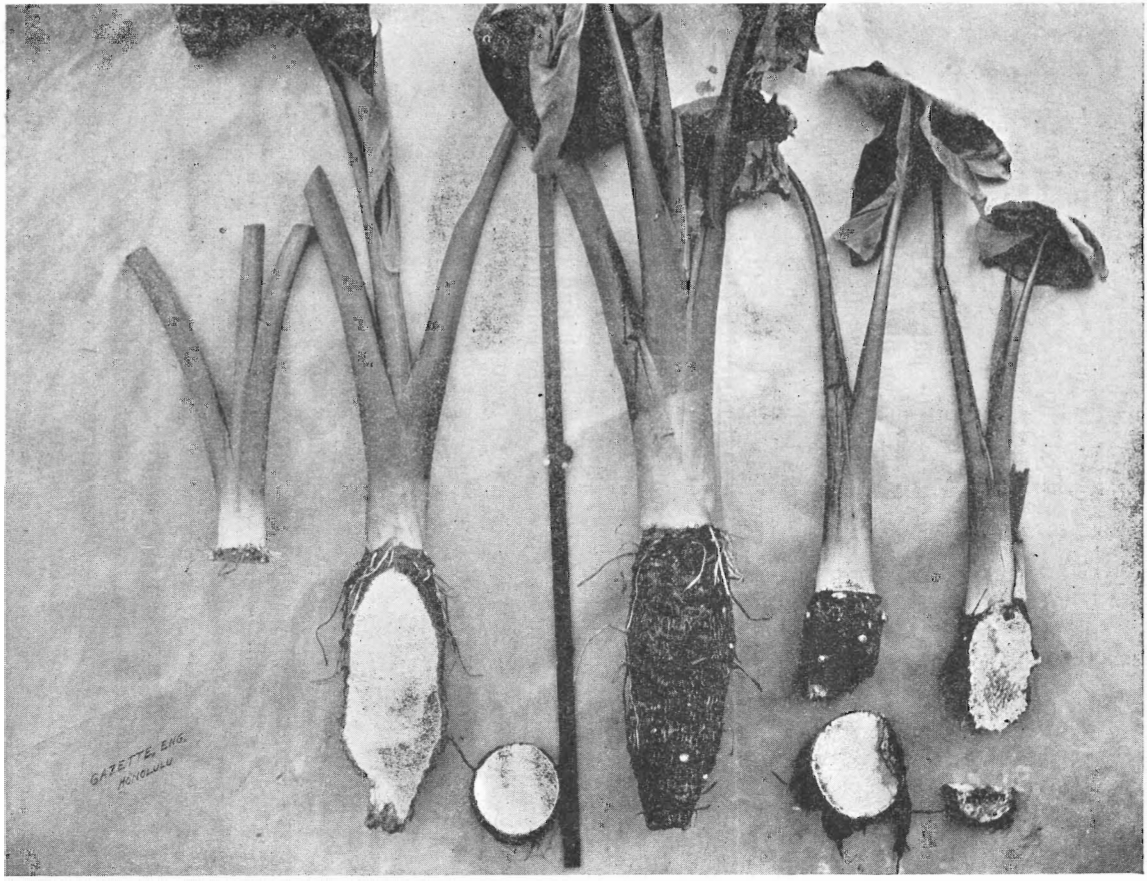
It is customary to keep a constant stream of water passing over the patch, or where there is a shortage of water to change it at frequent intervals.

TARO ROT.

The lowland taro, or that which is grown entirely under irrigation, suffers a great deal from a disease known as "taro rot."[3] This rot has assumed such proportions that many taro growers have been compelled to give up the cultivation of this crop and use their lands for rice, bananas or other crops. In the vicinity of Honolulu, it is estimated that this rot, in average years, causes a loss of half the crop. Certain districts are apparently free from the disease, but it has been reported from all of the Islands of the group.

The disease appears to be of two forms, one of which is due to soil conditions or lack of drainage. The other is of a fungus or bacterial nature and is due in part at least to the planting of diseased hules. The rot is first observed in the patches when the plants are about two months old, usually making its appearance on small or poorly nourished hules, or on those which are improperly planted. The

1. Pl. 1., fig. 1.
2. Pl. 1., figs. 2, 3, 4.
3. Pl. 1., figs. 5, 6.



1 2. 3. 4. 6. 8.

PLATE 1. HEALTHY TARO PLANTS CONTRASTED WITH THOSE SHOWING THE TARO ROT.

disease is entirely local. It may occur in one patch while another patch on the other side of the dyke may be free from it, or it may occur in the middle or one corner of a patch and not in the rest. Apparently there is some relation between the disease and the maturity of the hule. Hules cut from plants which have not matured fully are rather more likely to be diseased than those from fully ripened plants. The rot is also apparently somewhat dependent upon the state of cultivation of the soil, or its drainage. The center of a taro patch is usually the lowest and the most poorly drained, and very often the disease occurs in the center of the patch while the taro all around the margin is apparently healthy or only slightly diseased. The disease, which causes a rotting of the corm, apparently starts from the lower end and works up through the middle of the root. The root either becomes hollow at the age of four or five months, or if not infected until later, the entire lower portion of the corm becomes rotten.

Diseased plants may be readily distinguished from healthy ones by the form and general appearance of the leaves. The whole plant becomes stunted, the leaf stalks are shortened, the leaf blades become curled or crinkled, and instead of being a deep healthy green are yellowish and spotted. If such a plant is cut across with a knife the bundles or fibres in the root will be found to be blackened, and these black fibres can be sometimes traced into the base of the leaf stalks.

When the rot attacks the hule shortly after planting, it causes a rapid maturity; the corm instead of remaining conical in shape up to eight or ten months, changes to a spherical or oval shape at four or five months growth, and unless soon harvested becomes completely rotten.

It is the practice among the Chinese taro growers, and also to some extent among the native Hawaiians, to rotate the hules. The land and the crop are held to be too valuable to waste any time between the crops in allowing a rest. It has come to be the practice for a grower to take the hules from one patch and plant them on another patch, the idea being to change the seed. All of the hules are used, that is, no choice is made in the selection and if a crop is harvested before maturity from an infected field, hules undoubtedly bearing the germs of the disease are again used for seed.

The disease is rapidly spread by the use of these diseased hules, the passage of laborers from one patch to another, or the transfer of the dirt itself from one patch to another; and perhaps also to a limited extent in the irrigation water, as the taro patches are arranged in the terrace system, and the water which has irrigated the higher fields is used over and over again through the whole series.

The losses throughout the Hawaiian Islands due to the disease amounts to at least $70,000 per annum, and the disease seems to be on the increase.

The high rental values of the lands, and present methods of cultivation of taro work against the adoption of rational methods of combating the rot. With a crop which requires from twelve to fourteen months for its complete maturity, the cultivator feels that he must have something growing on the soil during the entire term of the lease, and a crop of taro is no more than harvested before another is planted, sometimes not more than three or four days intervening between the harvesting of the crop and the replanting of the hules.

Taro soils are generally marshy and as they are kept constantly submerged they are sour or acid. Sour soils in general are inimical to the growth of many varieties of cultivated plants, but taro, being a native of swampy regions is well adapted to cultivation on such lands. Marshy or muck soils, such as are used for this crop, are extremely rich and are capable of the continuous production of very large crops, but to do this they must be given proper treatment.

Swampy land or lands constantly flooded with water are usually deficient in potash and lime. Potash, phosphoric acid, lime and nitrogen, and a number of other elements such as iron, magnesium, sulphur, etc., are essential to plant growth. When they are present in abundance in the soil, plant growth occurs with the greatest rapidity. When one or more of these elements is lacking, growth is slow or the plant fails to develop properly, that is, it may have a one-sided growth. It may make leaves at the expense of root, or root at the expense of seed, or vice versa.

Sour soils which contain an excess of organic acids, may be corrected or sweetened in two ways. The natural way is to stir the soil and open it up so that the air and sunlight can act upon it. This process is going on in nature wherever soils are in progress of formation but like most natural processes, it is slow. The cultivator, and especially the man who has paid $50 an acre annual rental for land, cannot afford to adopt this method, and so to improve the land and render it less acid, artificial fertilizers must be used. The best of these for correcting soil acidity, or sweetening the land, is lime. There is a proverb that "Lime makes rich fathers and poor sons," that is, the liming of lands rapidly exhausts them unless the process is carried on in a rational way. The dressing of lime should not be applied oftener than once in five years. Lime not only corrects any sourness of the soil, and sour soils are very prevalent, but it improves the physical condition and makes the potash, phosphoric acid and nitrogen in them more available. Many fungus and bac-

terial diseases of plants develop at least a portion of their life in the soil and are dependent for their growth on the sourness or sweetness of the soil. Some diseased plants develop more rapidly where lime is present. Others are entirely prevented from developing by the presence of lime.

These taro soils being acid, and having been in cultivation so long as to be almost depleted of soluble plant food, the best method of combating the taro rot which suggested itself, was to sweeten the soil by the use of lime, and also to add a fertilizer. A well fed plant is like a well fed animal, more likely to escape disease. Plants having a steady supply of food from the time growth commences, often becomes resistant to disease. The taro crop is of sufficient value to warrant the use of lime and high grade fertilizers.

EXPERIMENTS ON THE CONTROL OF TARO ROT.

It having been considered desirable to inaugurate experiments for the prevention or control of the taro rot, the use of a taro patch at Kalihi was secured.[1] This taro patch contains about one-tenth of an acre. Work was begun on it in August, 1901. The previous crop had been almost an entire failure by reason of the root rot. The soil was put in proper condition, that is, it was dug up and five barrels of lime, slacked and mixed with the leaves and root cuttings from the previous taro crop, were turned under. Hules were chosen from plants which had been seriously affected with the taro rot.

At the time of planting there was a shortage of water and none was applied for one week after the hules were set. They had very little water for one month; the plants were therefore slow in starting, but when well started they grew finely and showed very little sign of rot. The leaves in this plat had a better color than those in the adjoining plats.

RECORD OF THE INVESTIGATIONS.

Notes and careful observations were taken throughout the whole experiment, beginning August 12, 1901, and closing September 15, 1902. The appearance of the rot was first recorded on December 23, four months after planting. From this date a study of the development of the disease was made. The rapidity with which it spread, and the apparent sources of contagion were noted.

Fertilizers were applied at such times as the plants seemed to need them. The action of the fertilizer was noted after each application, and at the same time a comparison of the conditions of the plants in the experimental plat was made with those of the surrounding patches. Notes on the distinguishing characteristics of diseased plants were taken.

1. Pl. II.

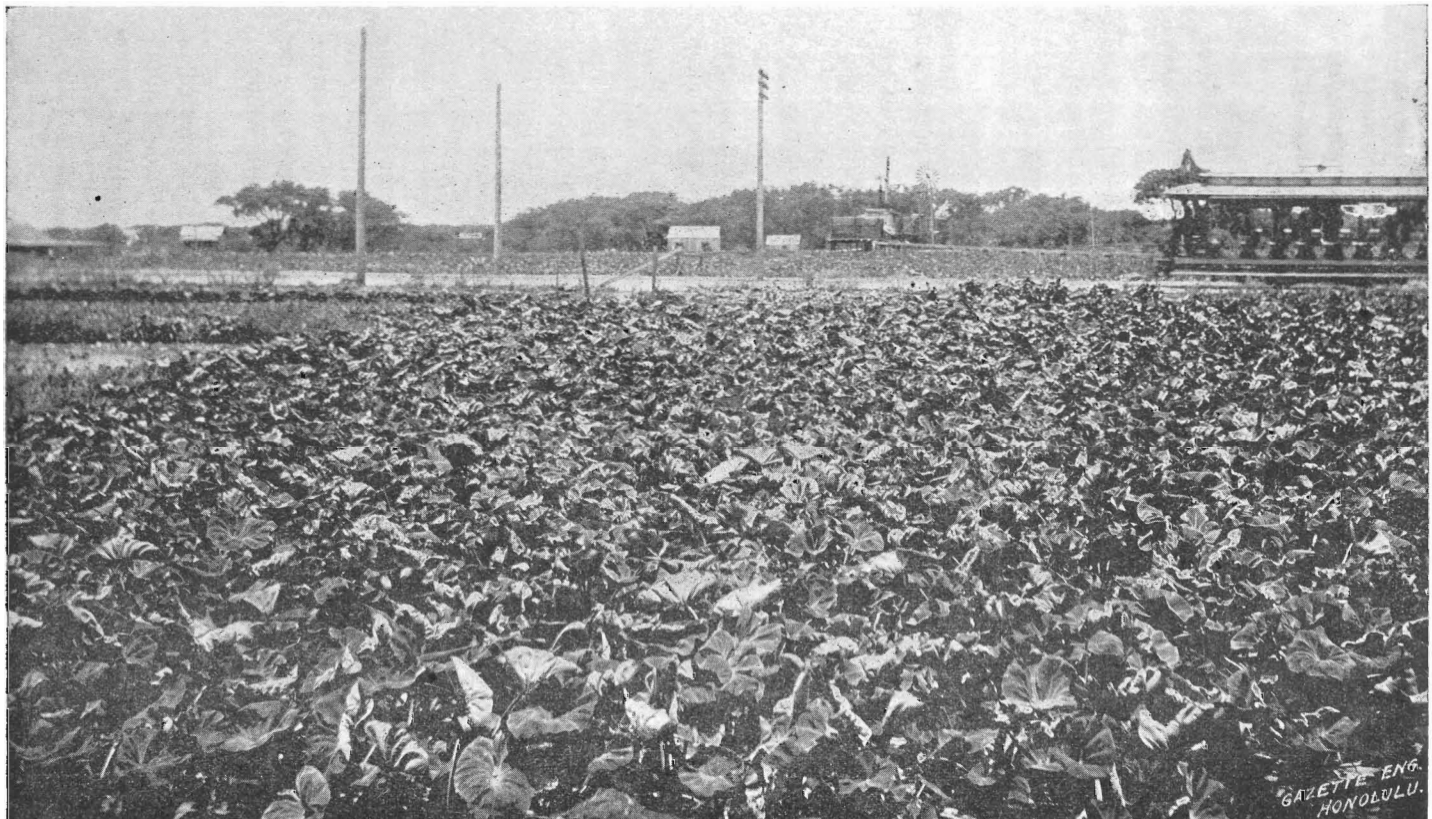


PLATE II.—EXPERIMENTAL TARO PATCH AT KALIHI, NEAR HONOLULU.

Observations were made on the methods of irrigation to determine how they could be improved upon, first, in the economy of water, second in securing uniformity in the use of water, and third to prevent stagnant water accumulating in the patches.

Cultivating and weeding were carried on in the usual way.

SUGGESTED IMPROVEMENTS IN METHODS OF CULTURE.

IRRIGATION AND PREPARATION FOR PLANTING.

Much depends upon the proper irrigation of taro. The methods commonly employed are neither economical nor judicious. It is a common practice to let the water enter at one end of the patch and drain out again through a ditch cut in the same side of the dyke but at the opposite corner. Where this system is used one side of the patch receives abundant irrigation and complete drainage, while the water stagnates on fully two-thirds of it. Since taro grows naturally along running streams, an attempt should be made to reproduce natural conditions in the taro patch. If water is let in at one corner of the field, it would be better to have the exit diagonally across from it, and it would be even better to have more than one entrance and exit through the dyke. Furthermore, the area to be irrigated should be more carefully surveyed according to the contour of the land.

The plat of ground used for the experiments here reported, as well as most of the adjoining ones, was laid out without reference to the best use of the water or to complete drainage. One corner of the experimental plat was so much lower than the outlet that it was impossible to secure a circulation of the water and the drainage of that portion of the plat. The surface of the patch was covered with knolls and hollows. To remedy this state of affairs new outlets and inlets were made in the experimental plat, and should be made in other plats which are not arranged to make the best use of the water. This change in the experimental plat was made on February 5. From that date up to the maturity of the crop it was apparent that the taro grown where the water was constantly changing was the best. That which grew in stagnant water made little progress. The deep, undrained corner of the plat became the seat of all disease, and the plants never showed as strong growth there as in the more favored portions. A field which is kept constantly covered with water cannot be properly drained, and as has been previously stated, wherever soils are undrained they become acid, giving some of the rots and other diseases a better chance for development.

The method of permitting water to circulate is more economical

than the method in common practice and were it followed at least one-fourth more land could be put under cultivation.

After the crop is ripe and has been removed from the land, the soil should be dug or plowed and left to dry out for a month. It can then be puddled and planted. The hules should not be covered with water for at least a week after planting, and should be left without water longer than that if they continue to look healthy. When lime is added to the soil, the dressing should be applied immediately after removing the crop. The soil should then be thoroughly mixed and left bare of a crop for at least a month.

FERTILIZERS.

Most of the fields now used for water-taro have been in cultivation for many years, and many of them have not received fertilization for a very long period.

The fact has been established, with other cultivated crops, that plants grown upon depleted soils are more subject to disease than those grown on new lands, or on soils which have been heavily fertilized.

The taro plant feeds heavily on phosphoric acid and potash, and removes large amounts of these elements from the soil. If the potash and phosphoric acid removed from the field are not again returned to it, the conditions for the development and spread of the taro rot are excellent.

The basis of the experiment reported in this bulletin was *to get the soil of this particular taro patch, which had been cultivated to this one crop continuously for twenty years, into normal condition.* If the fertilizer could have been applied before the crop was planted, a very much smaller amount would have been sufficient, but the Station not having complete control of the land, it was not practicable to carry out the work in the best or most economical manner. In practice it would be too expensive to use as much fertilizer as was applied in this instance. In any commercial fertilizer containing either phosphoric acid or potash, not all of these two elements are in a soluble or available condition. The experimental field having been covered with water at the time the fertilizers were applied, a considerable portion of that which was applied was probably lost in the drainage water. It was noticed that the effect of the fertilizer was apparent in two or three patches lying below the one where the experiment was in progress.

The taro plant does not absorb fertilizers from the water except through its roots, and as its roots are in the soil beneath the main body of water, even though a large amount of soluble fertilizer is added to the irrigation water, only a comparatively small portion

will be absorbed by the mud at the bottom of the patch and in turn be taken up by the roots.

The fertilizer should be applied before the crop is planted. Whenever it is considered necessary to add fertilizer during the growth of the crop, the water should be drained off, the fertilizer worked into the mud between the rows, and the land allowed to stand without water for at least twenty-four hours.

Lime was applied to the experimental plat at the rate of four tons per acre. In practice one and a half to two tons would be sufficient, and this amount only once in five years. Lime not only has the property of counteracting soil acidity, but it also sets free some of the elements of the soil and in this way is an indirect fertilizer. If lime is thoroughly mixed with the soil, it would be better if the land could be allowed to remain free of vegetation for a month after the application before planting the hules. While lime makes some elements more soluble, it also makes others insoluble. This is especially true in regard to phosphoric acid.

Owing to the constantly running water in the patches, it is not wise to apply fertilizers after the plants have been set out, except during the first two or three months of their growth, which is the only period during which water can safely be drained off from the patch for a few days.

After the eighth month, the water must never be drained off the field for any reason. If it is, rot will set in at once.

The best form of nitrogen for taro is apparently ammonium sulphate, but sodium nitrate may be used. Both are very readily soluble in water and are therefore easy of application.

The following table gives the dates on which fertilizers were applied in the experiments reported above, and also the amounts used:

FERTILIZERS APPLIED TO TARO.

Date	Fertilizer Applied	Amount per Acre	Fertilizing Constituents.
Aug. 12	Lime	4 tons	
Oct. 22	Bone Meal	750 lbs.	Phos. acid 11 percent soluble. " " 11 " insoluble. Ammonia 4 "
Jan. 28	Nitrate of Soda	250 "	
Feb. 11	Complete Fertilizer	500 "	Phosphoric acid 10 percent. Ammonia 6 " Potash 8 "
Feb. 11	Nitrate of Soda	250 "	
Apr. 18	Complete Fertilizer	500 "	Phosphoric acid 8 " Ammonia 7 "
Jun 6	Nitrate of Soda	400 "	Potash 6 "

In practice once in every five years, from one and one-half to two tons of lime per acre should be applied immediately after the crop

is harvested, and at least one month before another is planted. It should be dug into the soil and thoroughly incorporated with it. Just before the hules are planted, the ground should be again dug up or plowed, and a complete fertilizer similar in composition to that used on the experimental plat on February 11, (see table, p. 17), applied; that is, a fertilizer containing large amounts of available phosphoric acid and potash, with a moderate amount of nitrogen.

Nitrogen is the most expensive plant food. It is the most readily utilized by the plant, and is also most easily lost. It would not, therefore, be advisable to add any considerable amount of nitrogen at this period before growth has commenced. Any considerable application of nitrate of soda or ammonium sulphate, would be thrown away if applied before the hules are planted.

As it appears that the field can safely be drained during the first three months of the growth of the taro, it would be well to apply some form of nitrogen, say six weeks or two months after the hules are planted, first draining the water off the field and thoroughly incorporating the fertilizer in the mud of the taro patch between the rows. From 160 to 180 lbs. nitrate of soda has been found to be the limit which can be safely applied at one time for most crops.

To recapitulate: The proper method of fertilization would be, first, lime immediately after harvesting the crop; then a complete fertilizer containing from eight to twelve percent phosphoric acid, six to eight percent potash, and three to six percent ammonia should be incorporated in the soil before the hules are planted. Then to force growth about 160 lbs. per acre of nitrate of soda should be applied from two to three months after the hules are planted, the water having first been turned off so that the nitrate can be worked into the soil and placed where it can be used by the growing plants. Nitrogen is the only fertilizer which can be added with good effect during the growth of the crop. The lime should be slacked before it is applied.

SUMMARY.

Plants affected with the rot are easily distinguished in the field, either by the stunted appearance of the plant, or by the unusual bluish green or yellowish color of the leaves. The lower portion of the corm and the fine feeding-roots which anchor the corm in the soil, are rotted away, and if an effort is made to pull up the plant it comes very readily.

The first diseased plants in the experimental plat were found four months after planting, but in some of the adjoining plats not under supervision, the rot appeared at two months. The first hules found

to be diseased were small and very badly developed, and were found to have been cut with very little of the mother taro left, or in planting they were bent or not put in deep enough, or else they were found in stagnant water. By comparing the experimental plat with the adjoining ones it could be readily seen that the fertilizer retarded maturity. That is, taro grown where no fertilizer had been applied, had a tendency not only to contract the disease, but also to mature in a very much shorter season. Some of the adjoining plats which were not fertilized, had to be harvested six months before the proper time, because of the prevalence of the rot. These facts indicate that proper fertilization at the right time, is one of the chief remedies or preventatives of taro rot.

Practical experiments have shown that taro grows best if the hules are planted on virgin soil. In most patches, the taro grown on the margin of the field is the best, especially that which is next to the dyke, the soil of which the dyke is formed probably containing more plant food than the mud at the bottom of the patch. There is also usually better drainage immediately adjacent to the dyke than in the center of the field.

It has been observed that where taro is planted on virgin soil, or on land which has either been allowed to rest for three or four months, or has been planted in rice or some other crop, the plants will remain healthy for several seasons. The growing of rice on taro land is an effective remedy for taro rot, giving comparative immunity for two or three years, but the liming of the soil will be found to be more practicable.

Observations made during the past season indicate that the disease is carried only to a limited extent by the irrigation water. The experimental plat was comparatively free from disease this year, although during the previous season it had been seriously infected. The next plat below was this year badly attacked by the rot, but the second plat into which the water drained was comparatively free from it. This local infection demonstrates, that although the soil may be thoroughly impregnated with the disease, yet the plants, if they are primarily healthy, will resist rot to a greater degree than if primarily weak.

The hules used in the experimental plat were chosen from plants badly infected with the rot, and the fact that a number of plants with rotten roots were found within the first six months, would indicate how the disease is spread.

The conditions in the experimental plat previous to the beginning of the experiment were the worst that could possibly be obtained in that locality. The crop harvested in 1901 was very badly diseased, and the hules from this crop were used in the experiment, but with

all these adverse conditions, the yield from the experimental plat has been greater than in any similar area in the Kalihi District, being at the rate of 16 tons to the acre. This is much above the average.

In the experimental plat the disease appeared first on the hules which were small and weakly, many of which had been planted. A diseased plant matures sooner than a healthy one, and may have healthy looking leaves, but they are mostly dwarfed and more or less distorted. The root will develop and take on the form of an apparently matured root six months before it should do so. The taro root rot is apparently a local disease. A single diseased plant may be found among many healthy ones, or there may be a limited area in which every plant is infected.

The disease attacks the plant in two ways, and seems to present two stages of development. In one case the taro root rots from the tip. The decay gradually extends upward until the whole corm becomes a soft decayed mass. A root infected with this soft rot has a peculiar characteristic fetid odor, something like decayed fish. The other form of the disease apparently has its source in the center of the corm, or near the lower end, and the effect is to produce a hard, brown core.[1] This may be an entirely distinct disease from that commonly known as root rot.

A diseased slip will grow better on virgin soil, or soil which has been planted to other crops, than on old taro soil. Harvesting taro before its maturity has a tendency to induce disease. The planting of one variety year after year on the same patch, tends to a deterioration of the crop. The development of the rot seems favored by allowing the water to become stagnant, the taro growing best in running water. In irrigating the taro patches the water should be made to circulate over the entire plat. The usual method is to admit the water at one corner of the patch, and to have the outlet on the same side at the other corner. As a result the water stagnates over two-thirds of the field.

Hules which have no eye are often planted. These are slow to start and are more liable to become diseased. Plants growing on soil which has not been sufficiently dug up and cultivated, produce poor taro.

In applying fertilizer to a taro soil, it should be done before the taro is planted, and thoroughly mixed with the soil. The field should then remain unplanted for as long a period as possible and be again cultivated before the hules are planted.

Fertilizers promote the growth both of diseased and healthy

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1 Pl I., figs. 7, 8.

plants. Where there was an excess of lime in certain spots, a few plants were corroded by it, but there was no disease.

Nitrogen, in the form of ammonium sulphate or of sodium nitrate is the only fertilizer which can be profitably applied to taro while it is growing.

CONCLUSIONS.

The conditions necessary to secure a good crop of taro, are:

(1) A supply of good hules, free from disease.

(2) A patch so laid out as to secure the most economical use of the irrigation water.

(3) The application of proper fertilizers, at the right time.

(4) A constantly running stream of water circulating over the fields, or when this is not possible, a frequent change of water.

(5) An occasional change in the variety of the taro planted.

(6) An entire change of hules from one patch to another, or a rotation of crops, using taro land for rice or bananas, at least two years in every five.

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