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The Management of Pineapple Soils

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INTRODUCTION.

The cultivation of pineapples in Hawaii has developed during the past fifteen years into one of the important agricultural industries of the islands. This crop for the most part has been grown on virgin soils, which produced large yields of excellent fruit, and this naturally encouraged a rapid expansion of the industry. While a small part of the land is owned by the grower, by far the greater part of the crop is grown on leased land. From the beginning the pineapple growers have been controlled largely by the idea of getting out of the land maximum crops at a minimum of cost, and with little forethought for the permanence of the industry or the maintenance of the soil. Pineapples constitute practically the only crop that is cultivated on these lands. The continuous growing of any one crop on the same soil is likely to be attended with certain difficulties and can hardly be said to belong to a system of permanent agriculture. The more especially is this true when it is applied to soils containing large percentages of finely divided ferric hydrate and small

amounts of humus; soils that under the prevailing conditions naturally require the most intelligent management. There need be little cause for surprise, therefore, that conditions have arisen which at the outset were unsuspected and which are hindrances to the continued welfare of the industry.

A large part of the pineapple crop is grown on the upland plains of Oahu, principally in the Wahiawa and adjacent districts. The discussion in the following pages has been drawn largely from observations and a study of the conditions and soils in the Wahiawa district, although the deductions apply equally well to similar soils throughout the islands.

As pointed out in previous Annual* Reports of this Station, pineapple soils have been the subject of investigation at the Experiment Station for more than two years. In 1909 a preliminary report† was issued in which it was pointed out that the pineapple soils of Oahu may be divided into two classes as regards color—viz., black and red soils. In this report some of the peculiarities of the black soils were emphasized. Since then each of these classes of soil has been under continued investigation, which has resulted in the bringing together of a large amount of scientific data. In the present bulletin it is purposed to present the more practical phase of this work in so far as it relates to the management of the red soils. What follows, therefore, has no reference to the black manganiferous soils. The failure of pineapples there is due to altogether different causes.

THE CONDITIONS IN THE FIELDS.

For some time the growers have realized that in some way not definitely understood by them, their soils after a few years of cultivation begin to show indications of exhaustion. In general the first crop and the one or more rattoons following it are

* For the chemical composition of these soils, see Hawaii Sta. An. Rept. 1909.

† Hawaii Sta. Press Bul. No. 23.

quite satisfactory, but subsequent plantings result in diminished harvests. As already pointed out, pineapples constitute practically the only crop that is cultivated on these soils. Before replanting a field it is customary to haul off and remove all of the old plants, thus taking from the land every vestige of plant residue produced thereon. From 15 to 24 months being required for the production of the first harvest, followed by one, two or three rattoon crops of one year each, makes necessary the continued cultivation of the land for three or four years. Generally the virgin soil is porous and naturally absorbs and drains away excessive rains before the water becomes stagnant in the soil, and brings about a water-logged condition. After the virgin soil has undergone the necessary preparation to insure good tilth, it is granular and porous. It has what the farmer calls a shotty texture.

After a few years cultivation, however, there is brought about a noticeable difference in the appearance of the soil. It loses its granular texture, tillage becomes more difficult and natural drainage is retarded. Following a heavy rain the soil becomes compact, and dries out into a hard mass which, unless it is cultivated before thoroughly drying out, becomes almost solid. The same condition may be brought about even during the early growth of the first crop by an overflow of the ditches during excessive rains, which frequently cause the pineapples to show a stunted growth from which they rarely recover. Usually the second planting even on soils that produced abundant harvests, results in greatly reduced yields.

LACK OF DRAINAGE.

The reduction of the pineapple-producing power of these soils has called for inquiry, both by the farmer and by the Station. Various expedients such as fertilizers, lime, manure, etc., have been tried, and often with indifferent success. Without excluding other possible factors it has been recognized for some time that the fundamental difficulty is associated with inade-

quate drainage, that under the existing conditions the water-holding power of the soil becomes greatly increased, that percolation and consequently drainage is hindered by the methods employed. In the old fields there are generally isolated plants or small areas that are more thrifty than the surrounding plants. Close examination has shown that the more thrifty plants are found on slight elevations such as a back furrow or ridge made by throwing together two furrows, etc. Upon pulling up the unthrifty plants the roots are often found to be dead, except perhaps one or two small roots near the surface. Sometimes only one root barely beneath the surface of the soil is the only living subaereal part of the plant. The underground part of such plants is frequently undergoing putrefactive decay, and even several days after rains they may be surrounded by a wet soil containing stagnant water.

The pineapple, like all cultivated plants, requires free circulating air around its roots; it demands oxygen just as animal life requires it. Probably nothing is more effective in preventing proper aeration in soils than stagnant water, or a water-logged condition in which the inter-spaces or pores of the soil are more or less completely filled with water. Air is then largely excluded, the necessary oxygen is shut out and conditions unfavorable to plant growth ensue. Under such conditions the soil bacteria can not perform the functions so necessary in the preparation of plant food, and fertilizers can not do their normal duty. Evidently the development of roots near the surface of the soil, above referred to, is an effort by the plant to secure oxygen through its absorptive organs.

The introduction of surface ditches has usually been beneficial, but rarely of itself restores the soil to its original fertility, and not even when used in conjunction with liberal quantities of high-grade commercial fertilizers. It has been suggested that under the influence of a tropical sun, continuous cultivation would bring about an oxidation of the soil organic matter. Humus, as is well known, has the property of making heavy

soils more porous and thus aiding drainage, and if the humus should become decomposed it would materially affect these lands. Experiments have shown, however, that a slow decomposition of the humus takes place, but that it goes on at such a slow rate as largely to preclude it as the principal factor. Likewise the lack of available plant food, important as it may be, is not at the bottom of the difficulty, for literally hundreds of experiments by the growers and the Station as well, where all sorts of commercial fertilizers in every kind of mixture have been applied in various quantities, have not in themselves restored the land. It is true the nitrifying power of the soil becomes greatly reduced, but the application of commercial forms of nitrogen has not proven effective.

Mechanical analyses of the virgin and cultivated soils show that the ultimate particles that constitute the soil have not been materially altered, which they could not be reasonably supposed to be. The ordinary operations of cultivation are not of such nature as to pulverize and grind to powder the coarser particles of the soil. The mechanical analysis shows, however, that when reduced to its ultimate particles these soils contain a very small percentage of grit or coarse material, and a relatively high percentage of clay and fine silt. They are what would be classified as heavy clay soils, although the so-called clay is of a different nature from true clay in a chemical sense, and while possessing some of the same properties, behaves in other senses vastly different. The word clay in this bulletin is used in a physical sense only, and has reference to the size of the soil particles.

THE CAUSE OF FAILURE.

While the percentages of clay or other constituents are not materially different in the new and old soils, the degree of granulation of the clay is greatly modified. The virgin soil when shaken with a column of water, will soon settle out, leaving practically a clear solution above it, whereas the older cultivated

soils when so treated give rise to a turbid solution which will not settle out for weeks.

In the state of nature where good tilth is attained, the particles that constitute the clay content of a soil, particles which when separated are extremely small and will remain in suspension in water almost indefinitely, are collected into aggregates or granules, which granules act as units and impart to the soil properties in every way similar to those brought about by ultimate particles of a much larger size than clay. The bringing about of such conditions in the soil is variously styled grauulation, flocculation, coagulation, etc. It is an important function of cultivation to aid nature in cementing the clay particles into granules, and is accomplished by admitting sunlight and air, and subjecting the soil to different degrees of moisture, carbonic acid, etc.

These soils are frequently cultivated and usually well prepared, but instead of an open granular structure being maintained by this operation, the soil steadily becomes more difficult to till, drainage is hindered, and deflocculation results. The soil is simply puddled. What are the causes of this phenomenon? The principal causes are cultivation, tramping over and otherwise disturbing the soil when it is wet. It is a principle known by farmers for centuries that the cultivation of clay soils when they are wet injures the land and brings about conditions which it may take years to overcome. The intelligent farmer in older agricultural regions will only as a last resort allow the cultivation of his clay soils when they are wet. In the cultivation of wet clay soils the loosely-bound granules become broken up and separated into their component particles, and when once the bonds of union are severed, it is by no means easy to reunite them. We need no better illustration of the effects of tillage on wet soils than is to be found right here among the rice-growers, who deliberately puddle the soil by working it when it is wet in order the better to prevent loss of irrigation water through seepage and drainage.

It is a common practice in the pineapple sections of the islands to cultivate when the soil is practically saturated. At certain times heavy rains thoroughly wet the land and these are often followed by strong winds and a hot sun, which brings about a rapid drying of the surface. Frequently the cultivators are sent into the fields when the surface seems dry enough to cultivate, but the soil two or three inches below the surface is wet almost to saturation. The mere trampling of the soil at such times when continued through a period of years tends to bring about deflocculation of the clay and, therefore, puddle the soil, so that effective drainage is hindered.

Puddled soils hold water tenaciously and under such conditions denitrification instead of nitrification may take place; effective aeration is made impossible and a condition unfavorable for pineapple growth follows. The application of fertilizers to such soils is almost sure to result in disappointment, because the fundamental difficulty is not a lack of plant food. Good tilth, a good mechanical condition in the soil, is just as important as available plant food, and in its absence fertilizers can not perform their normal function and bring about the desired results. In some instances under such conditions fertilizers may even prove injurious. Nitrates in water-logged soils may be reduced to nitrites. Such changes actually take place in some Hawaiian soils, and nitrites are active plant poisons.

Furthermore, soils that contain such large quantities of finely-divided ferric hydrates under the influence of putrefactive decay may be reduced to ferrous carbonate and sulphate, either of which are poisonous to many plants.

It has been shown in other countries and here that the continued use of nitrate of soda on clay soils* also tends to bring about a deflocculation of the soil, and where it has been so used the land remains wet longer after rains. The same condition may arise from the continued use of certain other fertilizers. In

* At the Rothamsted Expt. Sta., where nitrate of soda has been in continued use for 60 years, a deflocculation of the soil has resulted. See Jour. Royal Agr. Soc., Vol. 70, 1909, pp. 12-35.

the pineapple sections, however, such fertilizers have not come into general use. In fact, no fertilizer has been used in many instances where the soil has assumed a bad condition. It has been found, however, that on some of these soils the application of nitrate of soda tends to aggravate the already existing troubles and, therefore, injures rather than benefits the growth of pineapples.

REMEDIES.

The bringing back of these soils into a condition favorable for pineapple growth can not be accomplished in a day and is far easier to prevent than to overcome once it is brought about. With the virgin soils the farmer should by all means strive to prevent such conditions. No heavy clay soils should ever be cultivated when they are wet. If the fields demand attention through the rapid growth of weeds, during rainy seasons, it will be far better to pull out the weeds by hand or cut them off near the surface with hand hoes. The results of cultivating wet clay soils aside from that of checking and destroying grass and weeds, are positively injurious and in fact really hinders one of the very objects of tillage, that is aeration.

Air and sunshine in time will bring about granulation of the soil and by thoroughly stirring it at intervals when fairly dry, nature may be aided in restoring tilth. This should always be accompanied by the best possible drainage that can be provided. When this has been done fertilizers will no doubt prove effective and can be used profitably. Barnyard manure will also aid nature in restoring these soils, by making them more porous and allowing a freer circulation of air, but should be applied some months before the land is to be planted. Lime is also generally recommended for heavy clay soils as a means of making them more friable and improving their tilth, but the application of lime to the pineapple soils of Wahiawa has at least failed to show any advantage to be derived from it. Some of the growers maintain that lime makes the cultivation of the soil more diffi-

cult, causes it to remain wet longer after rains and brings about poorer drainage. This subject is now under investigation but it is too soon to draw conclusions. It should be borne in mind, however, that while these are called heavy clay soils, the clay in them is of an altogether different nature from the clay in most countries, and it is not inconceivable that lime will react in a manner likewise different. If lime is to be added as a means of correcting acidity or for other reasons, beach sand is recommended.

It will be far easier to maintain "condition" in these soils under a system of rotation of crops. In fact, some of the Wahiawa soils are almost sure to get into a bad mechanical condition if continuously cultivated in the same crop. It is doubtful whether any crop can be most successfully grown without rotation on soils similar to these. With the vast majority of cultivated crops, it is far better and more permanent to grow them in a system of rotation. Whatever rotation is employed it should include some leguminous crop which is plowed under. This will tend to improve the tilth of the soil and at the same time add nitrogen, an important and deficient element in these soils.

SUMMARY AND CONCLUSIONS.

The continued cultivation of pineapples on the same land has already brought about conditions unfavorable to the growth of the crop. The use of fertilizers, lime and manure have not restored this soil to its original productivity. The mechanical condition of the soil becomes greatly affected and poor drainage results.

While only a slight change has taken place in the humus, the clay has become deflocculated, thus reducing the size of the pores in the soil and effectually hindering drainage. This condition in these soils is brought about and really caused by cultivating the soil when it is wet. In some instances, however, it has been caused by beating rains, accompanied by overflows. In

such puddled soils proper aeration is impossible and bad physical, biological and chemical conditions prevail.

The best remedy is that of prevention; these soils should not be cultivated when wet, for damage is sure to result. Sunshine and air aided by thorough tillage when the soil is in proper moisture conditions will assist nature in restoring tilth. The best possible drainage should be provided by introducing ditches at short distances apart. Manure, especially if accompanied with ample aeration, will tend to make the soil more porous and, therefore, aid drainage. And finally, the continued cultivation of the land in pineapples should give way to an intelligent system of rotation.