though there are not often rains heavy enough to endanger soluble fertilizers.

Kohala soils—

	Per cent.
Lime	.240
Phosphoric acid	.470
Potash	.518
Nitrogen	.415

These lands are old and poor in available elements, as the following table represents probably the average of available plant food, as found by the aspartic acid method:

Available elements in Kohala soils—

	Lbs. per acre.
Lime	200 to 300
Potash	35 to 75
Phosphoric acid	15 to 20

These figures are extremely small and show the urgent need of high grade soluble fertilizers. Strange to say, certain of the planters still apply bone meal, and low grade and comparatively insoluble fertilizers, believing that they give as good results as the high grade. Fertilizers have not been very successful in Kohala, due largely to the droughts, and we fancy also to the kinds of fertilizers used. If there is one district where science would dictate the use of a soluble fertilizer it is in Kohala, where there is not sufficient rainfall to cause the decomposition of bone meal and allied substances. Of late years potash is being used more largely, and on at least one plantation more soluble fertilizers. Irrigation plants are being installed, and no doubt with a control of the water, fertilizers will be more generally used and with profit to the plantations.

ISLAND OF OAHU.

Almost all of the plantations of this island have irrigation plants. The rainfall is small but the supply of water is controlled by pumps. On the famous Ewa plantation the ordinary agricultural analysis does not show marked quantities of phosphoric acid, lime, nitrogen and potash. Most of the soil, however, is a washed soil, finely divided and very deep. The method of fertilizing there is different from most places. Soon after the crop begins to grow it is given a top dressing of a high grade soluble fertilizer and this is followed up by one or two dressings of nitrate of soda, and another of fertilizer. A few years ago the fertilizer contained:

8 per cent available phosphoric acid.

7½ per cent potash from sulphate of potash.

6½ per cent ammonia from three sources, nitrate of soda, sulphate of ammonium and organic.

Both the potash and ammonia were afterwards increased and the phosphoric acid decreased. At the present time all of the ammonia is derived from nitrate of soda and sulphate of ammonium, and most of the phosphoric acid from water-soluble phosphates. This is that the fertilizer may be soluble in the water of irrigation. Labor on the plantations is scarce and more expensive than formerly and every labor-saving method possible must be used. The fertilizer is applied in the cane rows and followed up by irrigation water, which dissolves the fertilizer and carries it down to the roots of the cane. In this way no labor is required to cover the fertilizer, as was formerly the case. The enormous yields of Ewa are made possible by the extreme depth of the soil, and the large quantities of manues used. There is not the same danger of losing the nitrate of soda that there would be were the soil of less depth.

On other plantations of the island nitrates are used, but not to the same extent, and the high grade fertilizers contain both sulphate of ammonium and organic ammonia. The following will represent about an average formula for use on an irrigated plantation:

Fertilizers used on Oahu—

7-8 per cent phosphoric acid soluble and available.

8-10 per cent potash from sulphate of potash.

7-8 per cent ammonia, 1-3 each from nitrate of soda, sulphate of ammonium and organic.

Chemical analysis shows rather a lower content of nitrogen in the soils, and ammonium compounds give very good results.

ISLAND OF MAUI.

Most of the plantations of Maui are situated in or near a broad plain that divides the two parts of the island, and are subject to approximately the same weather conditions, though the soils differ from each other very essentially. As in other districts, no analysis can be given to represent the whole district, yet for purpose of comparison we give an average of a number of analyses:

Soils of Maui, near Wailuku—

	Per cent.
Phosphoric acid	.270
Lime	.295
Potash	.357
Nitrogen	.388

There is nothing unusual in these percentages; the nitrogen is rather low, and none of the percentages are very high. All of the plantations in or near this plain are irrigated plantations, the rainfall being very small. Most of the plantations use ammonia from the three forms, nitrate, sulphate and organic; potash from sulphate of potash, and phosphoric acid from soluble phosphates. Here again the phosphoric acid in the fertilizers has been materially reduced, and the potash and ammonia proportionately increased. At Spreckelsville the management formerly used large quantities of fish scrap and fertilizers carrying a large quantity of phosphoric acid, but since the plantation has changed ownership approximately the same methods of fertilizing have been adopted which have given such good results at other places. Most of the plantations under consideration are under one management, and the most intelligent attempt has been made to fertilize in a scientific manner that has as yet been made anywhere in this Territory. Analyses of the various fields have been made to determine the available plant food. These large fields being comparatively uniform in composition, it is possible to get samples representing a number of acres. From these analyses different fertilizers are recommended and used for the different fields.

To illustrate, we give a few analyses of these soils, together with the fertilizers used:

Maui soils, available elements per acre—

	A lbs.	B lbs.	C lbs.	D lbs.	E lbs.
Lime	5619	5040	5808	4344	6618
Potash	1425	1443	894	1097	1123
Phos. acid	27	20	136	30	34

Lime is ample in all the samples, phosphoric acid is low, the potash varying between quite wide limits. The nitrogen, while not given here, is tolerably constant, and the fertilizers used would be about as follows:

A and B—

8 per cent phosphoric acid, soluble and available.

8 per cent ammonia, 1-3 from nitrate, 2-3 from sulphate and organic.

8 per cent potash from sulphate of potash.

C—

7 per cent phosphoric acid soluble and available.

8 per cent ammonia as above.

10 per cent potash from sulphate.

D—

9 per cent phosphoric acid, soluble and available.

8 per cent ammonia as above.

8 per cent potash from sulphate.

E—

8 per cent phosphoric acid soluble and available.

8 per cent ammonia as above.

5 per cent potash from sulphate.

A neighboring plantation whose soil shows a lower potash than any of the above is using a fertilizer containing 11 per cent potash, while occasionally the ammonia is increased if any special circumstances warrant the same. Special dressings of nitrate of soda, and occasionally nitrate and ground coral, are applied.

ISLAND OF KAUAI.

The plantations on Kauai, with a few exceptions, do not present problems very different from those already mentioned. One plantation uses two kinds of fertilizers, one for plant cane and another rattoon; for the former a high grade soluble fertilizer, applied in liberal quantities, and for the latter a mixture of muriate of potash, nitrate of soda and ground coral. The soil is somewhat deficient in lime, hence the coral; and the manager uses the nitrate with the rattoon crop for the purpose of stimulating the growth of the cane, believing that in this way whatever fertilizer applied to the plant cane the year before is not taken up by the cane, will be used by this second crop. Theoretically, this is an economical method of fertilizing, but the writer has recommended an application of a high grade fertilizer to the rattoon crop on other plantations following this method, where the soil shows any signs of becoming depleted.

GENERAL REMARKS.

Special Cases—The seasons and existing conditions often determine the fertilizer to be applied. For instance, in one case a fertilizer was wanted in July for a cane to come off the following season. This is later than fertilizers are usually applied, but the cane needed a stimulant. Evidently whatever fertilizer was to be applied should be readily available, and the following formula was used:

12 per cent phosphoric acid, soluble and available, from double super-phosphate.

10 per cent potash from sulphate of potash.

12 per cent ammonia, 6 per cent from nitrate, 6 per cent from sulphate of ammonium.

Where the fertilizer is to be applied with the seed, a little more insoluble form can be used than when it is to be applied as a top dressing, and fertilizers applied early in the season a little more insoluble than those to be applied later, since the crop has a longer time to grow and utilize the food.

Of the forms of potash, sulphate has the decided preference among the planters. Why this is so I am unable to say, or whether the preference is founded on facts or on prejudice. There is very little difference between the price of sulphate and muriate, a slight advantage being with the muriate. My own advice has usually been for the use of sulphate. In some cases the excessive rainfall necessitates the use of sulphate, and in a few cases there is a large quantity of salt, or chloride or sodium, either in the soil or water, or in both; and in these cases it is safer to use the sulphate. Since there is very little difference in the price, it is probably a good and safe practice to use that form in which there can be the least danger.

Sandy Soils—There are many patches of so-called "sandy soil," some of them quite extensive, on the plantations and they require special treatment. The writer has had this problem presented a number of times, and it furnished the subject for a little chemical investigation, the results of which were published in the Hawaiian Planters Monthly for February, 1901. This sand is composed of fine particles of coral, in which there is incorporated more or less of soil and organic debris. It is quite porous and for that reason difficult to irrigate. The water passes through the porous coral very readily and the rows, or irrigating trenches, have to be very short. The investigation had for its object the determination of the retentive power of such soil both for water and for chemicals, soils of varying quantities of coral being used in the tests. It was proved, as was expected, that the soils containing above 80 per cent of coral sand have very feeble retentive power, both for water and for salts. Nitrate of soda, muriate of potash, and to a certain extent, sulphates of potash and ammonium, are washed out by waters of irrigation. Phosphates are readily retained owing to the lime content of the coral sand. It was recommended that phosphates, blood, sulphate of potash (and sulphate of ammonium in small quantities) be used, and this recommendation is being carried out both on the Kahuku and Kihei plantations. Both of these plantations now use two different formulas, one for the rich, red soil and the other for the sandy soil.

In conclusion, it might be stated that the general tendency is toward the use of more soluble fertilizers, a larger quantity of potash and ammonium compounds and less phosphoric acid, especially when in the form of bones or undissolved phosphates. The planter sees that the freight on a ton of low grade fertilizer is the same as on a ton of high grade, and being so far away from the sources of supply it is economy to use the most concentrated goods.

These changes have been followed by splendid results. It is a well-known fact that the yield of sugar per acre has enormously increased during the past few years. Six years ago the average for the islands was 6300 pounds of sugar per acre, while now it is four and a half tons per acre. Of course, a more careful cultivation and great improvements in mills have added their part in this improvement; and we must not forget that the alert, inteligent management of the plantations, which is at the very foundation of the recent enhanced values of the sugar properties, has made it possible for these increased yields. But certainly, after all is said, commercial fertilizers pay for themselves many times over.

Methods of Soil Analysis.

The ordinary agricultural analysis is still used, and, with a careful interpretation, gives indications of the needs of the soil. The aspartic acid of the Hawaiian Experiment Station is also quite often used, and seems to give good indications of the condition of availability of the potash and lime. But it is doubtful if the method is applicable to phosphoric acid. According to the method there are extremely small quantities of available phosphoric acid in any of our soils, which comports with our belief that it is locked up with the titanium and iron and aluminum; and yet the applications of phosphoric acid have not been attended by a large increase of sugar. Indeed, as has already been stated, the tendency is to decrease rather than to increase this element in commercial fertilizers.

The quantity of fertilizers applied per acre varies considerably. The average is probably 800 to 1000 pounds per acre, while in cases it varies from 500 to 1500 pounds per acre. This, it is to be remembered, is in addition to whatever nitrate is applied, which is looked upon as a stimulant.

Nothing thus far has been said concerning the elements withdrawn by the crops from the soil, and it would seem that our methods of fertilizing do not take this into account. It has long been a favorite theory with agriculturists that we should return the exact quantities of elements that are withdrawn by one crop, and chemists have been to great pains and expense to analyze all agricultural plants with a view to compounding for each crop a fertilizer that will supply this drain. Looked at casually, this seems to be a correct theory, but it does not bear close investigation. It does not take into account the fact that the elements in the soil are not available in the exact ratio of their removal by the crops, and that the rocks are being disintegrated constantly and yielding up plant food in very different ratios in different places. A consideration of the chemical composition of Hawaiian lavas from which the soils are derived will show this.

Lime in Hawaiian lavas (see Maxwell: Soils and Lavas).

Non-hygrous lavas	9.24 per cent
Hydrous lavas	8.23 per cent
Tufas	1.41 per cent

Evidently the resulting soils would differ very materially in their content of lime, and any system of supplying lime to the soil that does not take these differences into account is wrong. Likewise the potash and phosphoric acid differ very essentially in these rocks and consequently in the soils. Again, the rains percolating through the soil carry off these elements in very different proportion. Maxwell: Lavas and Soils, page 105, says: "In the passing over of lavas into soils there have been removed eight tons (89 per cent) out of every nine tons of lime; one-half ton (33 per cent) out of every one and one-half tons of potash."

The resultant condition of the soil, say, in Hilo, where the rainfall is 200 inches per year, percolating through the soil and carrying off lime and potash, would be very different from Ewa plantation, where there is very little rainfall, and where each million gallons of water with which the plantation is irrigated carries with it 400 pounds lime and eighty pounds potash and fourteen pounds phosphoric acid. In twelve different samples of soil collected by the Hawaiian Experiment Station from eleven plantations, the available lime varied from 105 to 983 pounds per acre; potash varied from thirty to 588 pounds per acre; phosphoric acid varied from ten to eighty-six pounds per acre.

If the exact amount of lime, phosphoric acid and potash that one crop removes were sufficient for the poorest of these soils, a very much smaller quantity would suffice for the richest.

The rainfall is a very much more powerful agent in depleting the soil of its soluble ingredients in wet districts than is cropping. Nevertheless an examination of the elements removed by cropping will show that our fertilizers tend in the right direction. According to the bulletin of the Experiment Station for 1900 the Rose Bamboo cane removes each year for each ton of sugar produced

13.6 lbs. phos. acid
114.2 lbs. potash
34.8 lbs. lime
40.5 lbs. nitrogen

or for a crop of ten tons per acre

136 lbs. phos. acid
1142 lbs. potash
348 lbs. lime
405 lbs. nitrogen.

The amount of potash removed is enormous and to replace this would require more than a ton of the commercial sulphate. The nitrogen also is quite high, while there is a comparatively small quantity of phosphoric acid. This comports with the present practice of an increase of the potash and nitrogen and decrease of the phosphoric acid in commercial fertilizers.

RECENT INSTALLATION AT THE OLAA MILL ON HAWAII

The grinding machinery consists of two modern nine-roller mills, one erected by the Fulton Iron Works, of St. Louis, Mo., and one by the Honolulu Iron Works of Honolulu, while the various buildings are as follows: a clarification building, a building for vacuum pans, evaporators, crystallizers and centrifugals, a sugar-bagging building and a railroad shed.

All the buildings are constructed of steel structural material covered on sides and roof with corrugated galvanized iron. The ground floors are made of cement concrete, the bagasse floor of checked steel plates, the filter press and centrifugal floors of cement, concrete or arched corrugated iron, while the crystallizers, vacuum pan and engine-room floors are laid with T. G. wood on steel joints.

The mill is situated so that cane may be brought to the mill either by flume or by railroad, and the trains of the Hilo Railroad Company may pass through the shipping shed, allowing 140 feet of cars to be loaded at one time under roof, with bottom or floor or cars level with the sugar-room floor.

The mill is supplied with the most modern sugar-making machinery, there being installed one quadruple effect of the Lillie automatic film evaporator type of 350,000 gallons capacity in twenty-four hours, using exhaust steam only. The vacuum pans, of which there are three, are constructed exactly alike; each pan striking twenty-five tons of dry sugar three times in twenty-four hours.

There is also installed fourteen crystallizers (in two rows), each of sufficient capacity to hold one full strike of masse-cuite from any one of the vacuum pans. There are twelve 40 x 24 centrifugals, which are driven by a Rollins engine.

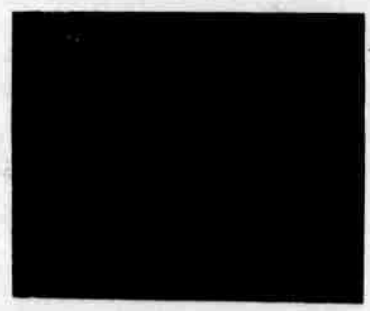
In the clarification house is all the machinery pertaining to the liming, clarification and settling of the juice. On this floor is also located ten filter presses having a total filtering surface of 5000 square feet.

The mills are driven by a Corliss engine, while the Krajewski crusher is driven by a separate Corliss engine. A 15-ton traveling crane, with two trollies, operated from the floor, travels over all the milling machinery, the whole length of the building.

In the engine room there has been installed a Westinghouse generator, driven by an Atlas automatic engine. There is installed eight arc lights and 400 016-candle-power incandescent lights, distributed all over the entire factory.

Adjoining the mill room is built a machine shop entirely of steel structural material, in which has been installed several lathes, planer, shaping machine, drill press, bolt and pipe-cutting machinery, Smithie forge, —in fact, all appliances to make any repairs of an ordinary character. This sugar mill was designed and planned by the Honolulu Iron Works Company under a contract with the Olaa Sugar Company, and it is reasonable to expect that the mill will be in operation and turning out sugar in December.

The buildings were designed in detail, manufactured and erected by Messrs. Milliken Brothers of New York, who also furnished the smokestack and the traveling crane. The Lillie quadruple effect was built by the Honolulu Iron Works.



HORNER'S IMPROVED SEGMENT CULTIVATOR (PATENTED)

HORNER'S CANE LOADER (PATENTED)