THE USE OF OLIVINE FOR THE CORRECTION
OF MAGNESIUM DEFICIENCY
IN SUGARCANE

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF THE
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OF THE REQUIREMENTS FOR THE DEGREE OF
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<td>22</td>
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ABSTRACT

THE USE OF OLIVINE FOR THE CORRECTION
OF MAGNESIUM DEFICIENCY
IN SUGARCANE

Olivine basalt has been frequently used in several countries as a source of magnesium for several crops. It contains considerable quantities of silicon and iron, as well as magnesium. Olivine is considered by some authors as being easy to weather.

As olivine is an abundant material in the Hawaiian Islands, a field experiment was planted on the Island of Kauai on a Kapaa Silty Clay Soil, an Aluminous Ferruginous Latosol, in order to test its value as a cheap source of magnesium for sugarcane. Kekaha Dune Sand, a beach sand which contains fairly large amounts of olivine, was used to test that possibility.

The experimental treatments were (a) no magnesium applied, (b) 500 pounds per acre of magnesium as olivine, (c) 2,500 pounds per acre of magnesium as olivine, and (d) 500 pounds per acre of magnesium as Epsom salt. Other essential elements—N, P, K, Ca, S, B, Mo, and Zn—were supplied in quantities thought to be adequate for sugarcane. The experiment was harvested at 23 months of age, and the pertinent samples were taken to determine the weight and quality of the cane. Soil and plant samples were taken at the middle and end of the crop cycle in order to find out the effects of the treatments on the soil and on the cane plant.

The results of the harvest of the experiment showed no statistically significant response of sugarcane to the application of magnesium when applied either as olivine or as Epsom salt.
The levels of magnesium both in soil and in plant were found to be adequate. In plants, the magnesium levels showed a steady increase with age of crop.

The cation exchange capacity and the pH of the soil were not affected by the treatments.

The very low levels of extractable Si in soils and plants suggested the possibility of a silicon deficiency in the soil.

In general, the status of the other nutrients in soils and plants was found to be adequate for normal growth of sugar cane.
INTRODUCTION

Olivine basalt is a common parent rock of Hawaiian soils. It contains about 47% MgO, 40% SiO₂, and 9% FeO (Sherman and Uehara, 1956), and is one of the silicate minerals most susceptible to weathering (Jackson et al. 1948, and Jackson and Sherman, 1953). Sherman and Uehara (1956) found that when olivines weather they release magnesium in fairly large quantities. They also found that during the weathering of olivine as the bases are released by slow leaching under restricted drainage, a montmorillonite clay develops. That clay has high cation exchange capacity and exchangeable magnesium. Under similar climatic conditions where drainage is good, a kaolin clay develops.

On the Island of Kauai, on a beach at Kekaha, a deposit of mixed olivine and coral sand occurs. It was thought that this material could be useful as a source of magnesium for sugarcane fertilization. The project of which this thesis is a part was designed to test that possibility.

Olivine sometimes has been used as a fertilizer source of magnesium in other places of the world. Longstaff and Graham (1951), using soybean seedlings in cultures of sand and colloidal clay, found that the magnesium supplied by a ground olivine material increased growth by 57 to 130 percent. Semb and Qien (1960), growing oats in water culture, found that the availability of magnesium from olivine was influenced by the fineness of the olivine material and by the degree of acidity in the buffer solution. They concluded that very finely ground olivine can supply all the magnesium requirements of the plant. Nemec (1947) working on unproductive forest soils obtained an increase in the rate of growth
of forest trees of 17.5 inches per year through the use of crushed olivine basalt and diabase, where the previous growth had been 0.64 inches per year.

Magnesium is a very important constituent of plants. It is an essential constituent of the nucleus of the chlorophyll molecule. It is known to be a constituent of important enzyme systems, related to the carbohydrate metabolism, such as pyruvate carboxylase and pyruvic oxidase, enolase, and peptidase, and to be a constituent of chloroplastic proteins (Jewitt, 1963, and Evans, 1959).

The visual symptoms of magnesium deficiency in sugarcane were first described by Martin (1934). He reports that in sugarcane in nutrient solution without magnesium the young leaves are light green while the older ones are yellowish green in color. As the deficiency increases, small chlorotic spots appear which in the older leaves will become necrotic. These necrotic spots might increase in quantity and give the older leaves a rusty appearance. Humbert and Martin (1955), and Humbert (1963) indicate that the spotting is more pronounced in older than in younger leaves, and that the stalks may manifest internal browning. Evans (1959) adds that the magnesium deficient canes have shorter and thinner internodes.

A similar set of symptoms appearing in the Hawaiian Islands has been called "freckling", and is of common occurrence in the mauka fields of the windward side of Kauai. Anonymous (1963) reported that this freckled appearance was frequently associated with soils containing rather small amounts of exchangeable magnesium. It has also been reported that the freckling symptoms disappeared and the sugar yield in-
creased when calcium silicate as TVA slag was added (Anonymous, 1962, 1963, and Clements, 1965).

Acknowledgement

The author gratefully acknowledges the assistance of the staff of the Department of Agronomy and Soil Science, University of Hawaii. He wishes to thank the Ministry of Agriculture of Venezuela for providing the financial support for this study. Also, he wishes to acknowledge the assistance of Mrs. Betty Someda for typing the manuscript.
MATERIALS AND METHODS

Kekaha Dune Sand

The Kekaha dune sand is an olivine-coral sand found on the leeward beaches of Kauai. It is supposed to have originated from cinders of volcano eruptions that fell into the sea which after a varying period of time was brought to the sea shore intermixed with coral material (Younge, 1965). In this study, a Kekaha dune sand was used as a source of olivine and magnesium.

Composition. The Kekaha dune sand utilized in the field tests on sugarcane was analyzed as follows:

- 54.3% olivine
- 30.7% magnetite
- 15.0% calcium carbonate

Since olivine contains about 27% magnesium, the total magnesium present in Kekaha dune sand is estimated to be 14.7%

Experimental Procedure

Field experiment. A field experiment was established on an Aluminous Ferruginous Latosol soil at the Kauai Branch Station, University of Hawaii, on the Island of Kauai. It was planted in November, 1962 using the cane variety H-39-7028 in a randomized complete block design comprising four treatments replicated four times. The size of each plot was 40' x 50', with eight rows of cane 5 feet apart.
Treatments

Experimental. The specific treatments under test were as follows:

<table>
<thead>
<tr>
<th>Magnesium (pounds/acre)</th>
<th>Carrier (pounds/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>500</td>
<td>3,333 as olivine</td>
</tr>
<tr>
<td>2,500</td>
<td>16,665 as olivine</td>
</tr>
<tr>
<td>500</td>
<td>5,000 as Epsom salt</td>
</tr>
</tbody>
</table>

Basic treatments. The basic treatment applied broadcast over the whole area, consisted of 600 pounds nitrogen per acre as urea (46% N), 600 pounds potassium as potassium chloride (50% K), 1000 pounds phosphorus as superphosphate (21% P), 10 pounds boron as borax (11.3% B), 2.5 pounds molybdenum as sodium molybdate (55% Mo), and 50 pounds zinc per acre as zinc sulfate (20% Zn).

Soil

Description. The Kapa'a series under study is a deep and well drained Aluminous Ferruginous Latosol developed on moderate sloping lands on the Island of Kauai. It was developed from parent material similar to the Nali and Pahi series, with which it is associated. It occurs at elevations between 200 and 1000 feet and receives a mean annual rainfall of 60 to 100 inches (Womack, 1960, and Plucknett, 1961). Its description is as follows:

0-6" Dark yellowish-brown; extremely hard, sticky and plastic clay; very fine granular structure; porous mass; many roots; few hard pebbles.

6-11" Dark yellowish-brown; firm sticky and very plastic clay with many coarse and fine yellowish-red mottles;
with mottled material moderate, subangular blocky structure; very few fine pores; many roots; few worm casts; and hard angular pebbles more numerous with depth.

**Sampling.** Three different composite samples of soil were taken for this study. They were: (a) from the topsoil of each plot, (b) from the subsoil of each treatment, and (c) from an uncultivated area adjacent to the experiment.

**Soil Analysis**

**Cation exchange capacity.** The cation exchange capacity was determined by using ammonium acetate as washing solution, followed by washings with methanol and then potassium chloride solutions to end up with an extract from which ammonia was distilled, and titrated with 1/14 M sulfuric acid, Jackson (1958). The results were expressed as milliequivalents per 100 grams.

**Exchangeable magnesium.** The method for the determination of magnesium in plants described by Johnson and Ulrich (1959) was adapted for magnesium determination in soil extracts. The filtrate from ammonium hydroxide washing was dried out and its organic matter removed with 1:1 hydrochloric acid, and diluted. From the dilute filtrate an aliquot was taken and treated with 2 ml triethanolamine and 5 ml ammonium hydroxide–ammonium chloride buffer solution to eliminate interference of heavy metals. Then five drops of Eriochrome Black T indicator were added, and titrated with EDTA solution as described by Johnson and Ulrich (1959). The results thus obtained represent the amount of cal-

*Equivalent to absorbed plus soluble magnesium.*
calcium plus magnesium. Magnesium was obtained by subtraction of calcium from the total calcium plus magnesium.

**Exchangeable calcium.** The method of plant calcium determination by EDTA titration described by Johnson and Ulrich (1959), and using the modified calcein indicator of Tucker (1957), was adopted to determine calcium in soil extracts. An aliquot was taken from the same extract used for magnesium determination, and treated with 2 ml of triethanolamine and 5 ml sodium hydroxide—sodium cyanide buffer solution to eliminate heavy metal interference. The Modified Calcein Indicator (about 10 milligrams) of Tucker (1957) was added and then titrated as described by Johnson and Ulrich (1959).

**Exchangeable potassium.** Potassium was determined from the soil extract by flame photometry as indicated by Jackson (1958).

**Extractable silicon.** Extractable silicon was determined through the method of Fox (1965). The soil was shaken for 4 hours with an extracting solution made of 500 ppm Ca(H₂PO₄)₂ at pH 3.5, and at a soil:extracting solution ratio of 1:10. After filtering, a 5 ml aliquot of that extract was treated with 4 ml of 10% ammonium molybdate solution, 1 ml 12 N HCl and 3 ml 10% oxalic acid, made to volume and read colorimetrically.

**Available phosphorus.** Available P was determined through the modified Troughton method using 0.02 N H₂SO₄ as extracting solution and 1:100 soil: solution ratio, and determined as the phospho-molybdate complex.

**Available sulfur.** Available S was determined through the method of Fox et al. (1964) using Ca(H₂PO₄)₂ as extracting solution, evapo-
rating and digesting the extract to destroy organic compounds and
determining it turbidimetrically as BaSO₄ precipitate.

pH. The pH determination was done by using a 1:1 ratio of soil
to water, digesting for 30 minutes with occasional stirrings, and then
measuring it with a glass electrode.

Plant

Sampling. Five stalks were taken from each plot at 10 and 22
months of age of the crop. From leaves 3, 4, 5, and 6, the sheaths
and blades were separated and processed for further analysis as indi-

The fifth matured internode was sampled as indicated by Clements
(1961) as follows: the middle portion of the recently mature fifth
internode, counting downward from the oldest living leaf, was cut off,
sliced, dried at 80° C, and ground in a Wiley Mill. The fifth and the
8-10 internode samples were taken from the same stalks as the sheaths
and blades.

The 8-10 internode material was sampled as indicated by Anonymous
(1959) as follows: the central portion of each internode corresponding
to leaves 8, 9, and 10 was cut off, chopped to thin slices and dried at
80° C, ground in a Wiley Mill and stored for further analysis.

Analysis

Magnesium. The magnesium content of the sheaths and 8-10 inter-
nodes was determined by titration with EDTA, following the procedure
given by Johnson and Ulrich (1959), and it was expressed in percent
dry weight.
**Calcium.** Calcium determination in both cane sheaths and internodes (8-10) was as follows: from the extract of the ashed material, 5 ml aliquots were taken, then 2 ml 50% triethanolamine and 3 ml of sodium hydroxide - sodium cyanide solution were added as indicated by Johnson and Ulrich (1959), after which about 10 mg of Modified Calcein Indicator were added, and titration with EDTA performed. The results are expressed as percent dry weight. The Modified Calcein Indicator is prepared with 1 part of calcein, 6 parts of thymolphthalein and 100 parts of potassium chloride (Tucker, 1957). The color change of the Modified Calcein Indicator, from green to purple, is sharper than the light-green to brown change of calcein alone.

**Potassium.** K in sheaths and 8-10 internodes was determined by flame spectrophotometry as described by Anonymous (1957a).

**Silicon.** Si content of cane sheaths and 8-10 internodes was determined gravimetrically following the method by Clements (1959). The extract from the ash of the silicon determination was used for the determination of Mg, Ca, and K in both sheaths and 8-10 internodes.

**Phosphorus.** P content of sheaths and internodes was determined colorimetrically on ash extracts and reported on a dry matter basis. 3.5 N ammonium molybdate and stannous chloride solution were used for color development (Anonymous, 1957).

**Nitrogen.** The determination of nitrogen in blades and internodes was run by the Kjeldahl method (Clements, 1959), and is expressed on a dry matter basis.

**Sulfur.** S in cane sheaths was determined gravimetrically. The sample was dry-ashed with Mg(NO₃)₂, and sulfur determined on the extract by precipitation with BaCl₂ (A.O.A.C., 1960).
Samplings at Harvest

Yield of harvested cane was based on all growth taken within a 10-foot diameter circle taken from each plot of the experiment at harvest time. The fresh material was weighed to obtain tons of cane per acre, and then sub-sampled for the evaluation in the laboratory of cane quality; namely, Brix, Purity, Pol percent cane, and Pol ratio. Cane quality was evaluated through the use of Pol ratio method of cane analysis.
RESULTS AND DISCUSSION

Harvesting of the Experiment

It is revealed from the data of mean squares in Table II that there were no differences for yields of cane, or yields of sugar for treatments and replicates. The mean squares for P01 ratio and fiber percent cane, show differences which have no significance.

In every case, however, the mean square of treatments was smaller than that of the replicates. This can be interpreted to show that the natural variation in fertility of the soil had a greater influence on the yields of cane than did the treatments.

The coefficient of variance, as an estimate of the experimental error, partially evaluate the variation in fertility of the soil (Snedecor, 1956, and LeClerg et al., 1962). The coefficient of variance of yields of sugar in this experiment was over 19%, a value considered relatively high in sugarcane experimentation. This fact gives further support to the proposition about the dominance of the wide variation of fertility of this soil.

Table I shows that despite the nonsignificance of treatment in the analysis of variance, that the yields of cane and sugar for olivine treatments are higher than for the check or zero olivine application. That magnesium itself is not deficient appears to be evident from the fact that the Epsom salt with Mg at 500 pounds per acre caused a small yield loss.

The coefficient of variance for fiber percent cane is usually low because its variation is mainly accounted for by varietal differences. In this case, the 3.2% coefficient of variance is rather low in spite of the high variation in fertility of the soil.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Block</th>
<th>Tons of cane per acre</th>
<th>Tons of sugar per acre</th>
<th>Pol ratio</th>
<th>Fiber % cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>No magnesium applied</td>
<td>*</td>
<td>96.53</td>
<td>8.916</td>
<td>12.5</td>
<td>12.8</td>
</tr>
<tr>
<td>500 pounds magnesium per acre</td>
<td>*</td>
<td>101.28</td>
<td>9.631</td>
<td>12.5</td>
<td>12.9</td>
</tr>
<tr>
<td>as olivine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,500 pounds magnesium per acre</td>
<td>*</td>
<td>101.29</td>
<td>9.579</td>
<td>12.3</td>
<td>13.2</td>
</tr>
<tr>
<td>as olivine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 pounds magnesium per acre</td>
<td>*</td>
<td>95.75</td>
<td>7.992</td>
<td>12.9</td>
<td>12.8</td>
</tr>
<tr>
<td>as Epsom salt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Each figure represents an average of four plots.*
<table>
<thead>
<tr>
<th>Item</th>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons of cane per acre</td>
<td>Treatments</td>
<td>3</td>
<td>35.36</td>
</tr>
<tr>
<td></td>
<td>Replicates</td>
<td>3</td>
<td>158.81</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>9</td>
<td>225.56</td>
</tr>
<tr>
<td>Tons of sugar per acre</td>
<td>Treatments</td>
<td>3</td>
<td>2.338</td>
</tr>
<tr>
<td></td>
<td>Replicates</td>
<td>3</td>
<td>6.62</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>9</td>
<td>3.05</td>
</tr>
<tr>
<td>Pol Ratio</td>
<td>Treatments</td>
<td>3</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Replicates</td>
<td>3</td>
<td>11.55</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>9</td>
<td>3.73</td>
</tr>
<tr>
<td>Fiber percent cane</td>
<td>Treatments</td>
<td>3</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Replicates</td>
<td>3</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>9</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Soil Analysis

pH. Table III shows a slightly higher pH for both the application of magnesium as olivine and as Epsom salt at the middle of the crop cycle, as compared to the no magnesium application, but that difference had disappeared by harvest time. In an uncultivated adjacent area the pH of the soil was higher than in the site of the experiment.

Cation exchange capacity. The results shown in Table III indicate that there was little or no effect of olivine and Epsom salt on the cation exchange capacity of the soil.

Base saturation. The application of 2,500 pounds of magnesium as olivine and the Epsom salt increased the percent base saturation at the first sampling date, this difference was not reflected on yields.

In Table III, it is seen that the percent base saturation of the soil decreased as the crop got older.

Exchangeable calcium and potassium. The levels of exchangeable calcium in the soil at the first sampling followed the same pattern as the yields of cane and sugar, but this similarity disappeared by the end of the crop, Table IV. Calcium also shows the significant feature of high levels in this soil at the start and marked reduction at the termination of the cropping period.

The exchangeable potassium does not follow any significant pattern, but its levels appear to be above the critical level of 100 ppm K reported by Ayres and Humbert (1957) in Hawaii. At the end of the cropping period the exchangeable K has been reduced by one-half.

Exchangeable magnesium. Exchangeable magnesium did not show any significant difference for treatments in the combined analysis of variance but it showed high significance for dates of sampling.
### TABLE III. pH, CATION EXCHANGE CAPACITY, AND PERCENT BASE SATURATION IN THE TOPSOIL*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>August 1963</th>
<th></th>
<th>September 1964</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>C.E.C.**</td>
<td>Base saturation</td>
<td>pH</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----</td>
<td>----------</td>
<td>-----------------</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>m.e./100 g</td>
<td>%</td>
<td>m.e./100 g</td>
<td>%</td>
</tr>
<tr>
<td>No magnesium applied</td>
<td>5.2</td>
<td>20.5</td>
<td>33.9</td>
<td>5.2</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as olivine</td>
<td>5.3</td>
<td>20.4</td>
<td>33.7</td>
<td>5.1</td>
</tr>
<tr>
<td>2,500 pounds magnesium per acre as olivine</td>
<td>5.6</td>
<td>20.1</td>
<td>39.8</td>
<td>5.2</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as Epsom salt</td>
<td>5.3</td>
<td>21.3</td>
<td>35.7</td>
<td>5.2</td>
</tr>
</tbody>
</table>

*Each figure represents an average of four plots.

**Cation Exchange Capacity.
### TABLE IV. LEVELS OF EXCHANGEABLE BASES IN PARTS PER MILLION IN THE TOPSOIL

<table>
<thead>
<tr>
<th>Treatment</th>
<th>August 1963</th>
<th>September 1964</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca</td>
<td>Mg</td>
</tr>
<tr>
<td>No magnesium applied</td>
<td>1,108</td>
<td>112</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as olivine</td>
<td>1,105</td>
<td>108</td>
</tr>
<tr>
<td>2,500 pounds magnesium per acre as olivine</td>
<td>1,476</td>
<td>117</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as Epsom salt</td>
<td>1,272</td>
<td>102</td>
</tr>
</tbody>
</table>
In Table IV, it is clearly seen that there is a reduction in the level of magnesium from the first date of sampling to the second one, the reduction as for Ca and K being of the order of one-half the starting content. The data show that the levels of magnesium in all treatments is higher than the critical level of 50 ppm Mg reported by Anonymous (1957).

Response of sugarcane to magnesium applications has been a rare feature in the Hawaiian sugar industry (Anonymous, 1957). Evans (1959) in British Guiana reports that sugarcane response to magnesium fertilization is seen in places of very low exchangeable magnesium.

**Extractable silicon.** As shown in Table V, the variation of extractable Si among treatments at the same date of sampling is very small, but when dates of sampling are compared significance at the 5% level appears. It is also seen that the Si levels are relatively low (Fox, 1965). This, associated with the fact of the low values for the mean averages for treatments, suggests the possibility of a very small release of soluble silicon from olivine or none at all.

**Available phosphorus.** Available P as determined by the modified Truong method gave considerable differences among treatments, but those differences did not reach statistical significance. The variation among replicates was also high.

**Available sulfur.** Available S as determined by the method of Fox (1965) gave very little variation among treatment and replicates as well. Its coefficient of variance was very low.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>August 1963**</th>
<th>September 1964**</th>
</tr>
</thead>
<tbody>
<tr>
<td>No magnesium applied</td>
<td>7.26</td>
<td>4.74</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as olivine</td>
<td>7.02</td>
<td>7.73</td>
</tr>
<tr>
<td>2,500 pounds magnesium per acre as olivine</td>
<td>7.25</td>
<td>7.03</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as Epsom salt</td>
<td>7.61</td>
<td>6.62</td>
</tr>
</tbody>
</table>

*Determined by the method of Fox (1965).

**Each figure represents an average of four plots.
Plant Analysis

Magnesium

Sheaths. The combined analysis of variance for sheath-Mg showed differences among treatments to be significant at the 5% level. It also revealed the differences for dates of sampling and for replicates to be significant at the 1% level. However, it failed to show significant correlation with sugar yields.

Clements (1959) established tentatively the critical level of magnesium in sheaths as 0.175% of the sugar-free dry weight. Anonymous (1957) and Humbert (1963) report it as being in the neighborhood of 1% dry weight. In this experiment all the treatment average values were below 0.175% dry weight and above 1% dry weight.

8-10 internodes. The combined analysis of variance of 8-10 internodes-Mg revealed no significant difference for treatments but a highly significant one for dates of sampling. 8-10 internodes-Mg did not show significant correlation with yields of sugar.

The levels of 8-10 internodes-Mg were in all cases higher than the critical level of 0.05% given by Humbert (1963).

It is interesting to note here that there was considerable increase in plant-Mg with increasing age (See Table VI).

Calcium

Sheath. The average levels of sheath-Ca were relatively high for all treatments except for the check which was at or below the critical level. Clements (1959) noted that critical level lies somewhere between 0.15% and 0.17% Ca in the dry matter.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>August 1963**</th>
<th>September 1964**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sheath</td>
<td>8-10 internodes</td>
</tr>
<tr>
<td>No magnesium applied</td>
<td>0.103</td>
<td>0.087</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as olivine</td>
<td>0.099</td>
<td>0.085</td>
</tr>
<tr>
<td>2,500 pounds magnesium per acre as olivine</td>
<td>0.115</td>
<td>0.100</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as Epsom salt</td>
<td>0.135</td>
<td>0.117</td>
</tr>
</tbody>
</table>


**Each figure represents an average of four plots.
**8-10 internodes.** The values for Ca in the 8-10 internodes are very high compared to the critical value of 0.06% as given by Humbert (1963).

**Potassium**

The results from the analyses of sheath and 8-10 internodes K showed that potassium was within the normal range for good growth.

**Silicon**

Sheath- and 8-10 internode-Si values are low, and do not follow any significant pattern, but they do suggest a high amount of variability among plots of the same treatment. The values of Si in sheaths and 8-10 internodes are shown in Table VII.

**Other Elements**

The levels of P in cane sheath, 5th and 8-10 internodes were at levels reported to be adequate for normal growth.
TABLE VII. LEVELS OF SILICON IN CANE SHEATH AND 8-10 INTERNODES IN PERCENT DRY WEIGHT AT TWO DIFFERENT AGES OF THE CROP*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>August 1963**</th>
<th>September 1964**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sheath</td>
<td>8-10 internodes</td>
</tr>
<tr>
<td>No magnesium applied</td>
<td>0.343</td>
<td>0.073</td>
</tr>
<tr>
<td>500 pounds magnesium per acre as</td>
<td>0.315</td>
<td>0.056</td>
</tr>
<tr>
<td>olivine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,500 pounds magnesium per acre</td>
<td>0.339</td>
<td>0.072</td>
</tr>
<tr>
<td>as olivine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 pounds magnesium per acre as</td>
<td>0.318</td>
<td>0.072</td>
</tr>
<tr>
<td>Epsom salt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Sampling was done at 10 and 22 months of age.

** Each figure represents an average of four plots.
CONCLUSIONS

From critical analysis of the data of magnesium content in soil and in plant, and from the statistical analysis of yield of cane and sugar per acre it is concluded that there was no magnesium deficiency under the conditions of the experiment, or else, that sugarcane was unable to show it.

As Si is present in olivine in high amounts and as it was shown that increasing amounts of olivine applied did not increase the soil and plant levels of available Si, it is suggested that either Si is not released in measurable quantities, or if it is released in considerable amounts, it is not in a form useful to the plant.

Clements (1965) found that in pot experiments planted to sugarcane there was no response to magnesium silicate bearing materials (olivine and cinder) while outstanding responses were obtained with calcium silicate slag. The above-mentioned finding seems to be corroborated by the fact that olivine, a magnesium bearing material, failed to overcome the freckling problem.

The magnesium levels of the cane sheath and 8-10 internode had a considerable increase with increasing age of the crop.

In general, the nutritional status of sugarcane was good for the whole crop cycle, except for the fact that the levels of available Si in plant and soil were very low.
LITERATURE CITED


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1965. Personal communication.


__________(1965). Personal communication.