THE MAGNESIUM STATUS OF MICHIGAN SOILS AND THE EFFECT OF SEVERAL MAGNESIUM SOURCES ON THE YIELD AND CHEMICAL COMPOSITION OF CROPS

Thesis for the Degree of Ph. D.
MICHIGAN STATE UNIVERSITY

Leslie W. Tobin

1960

This is to certify that the

thesis entitled

The Magnesium Status of Michigan Soils and the
Effect of Several Magnesium Sources on the
Yield and Chemical Composition of Crops

presented by

Leslie W. Tobin

has been accepted towards fulfillment
of the requirements for

Ph.D. **degree in** Soil Science

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Major professor

Date May 20, 1960

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By

Leslie W. Tobin

A THESIS

Submitted to the School for Advanced Graduate Studies
of Michigan State University in partial
fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Soil Science

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G 20842
5/24/62

ACKNOWLEDGMENT

The author wishes to express his sincere gratitude to Dr. R. L. Cook, Dr. Kirk Lawton, and Dr. J. F. Davis for their encouragement, guidance, and support during the time this work was conducted.

Acknowledgment is given to J. Porter, P. J. Rood, E. D. Longnecker, S. M. King, G. Wright, and C. Carter for their assistance with the field work.

The writer is grateful to K. N. Satyapal and K. Kinra for their valuable assistance with the laboratory work.

Sincere appreciation is expressed to J. Schickluna under whose supervision the soil tests were conducted.

Acknowledgment is also given to various County Extension Agents, graduate students, and other members of the Soil Science Department who may have been of assistance at one time or another during the course of this study.

To my wife, I express my gratitude for her encouragement and financial assistance.

The financial support given this project by the International Minerals and Chemical Company was greatly appreciated.

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ABSTRACT

A field study was conducted over a three year period with various crops to evaluate the effect of magnesium fertilization on crop yield and mineral composition. Fourteen different crops were grown on 37 different soil types in 41 counties of Michigan.

Treatments consisted, for the most part, of two soluble magnesium carriers applied broadcast at the rate of 100 pounds elemental magnesium per acre. Soil samples collected previously to fertilization were analyzed for exchangeable bases, and fresh plant samples, collected during the growing season and dried plant tissue collected at harvest, were analyzed for magnesium, potassium, and calcium.

In general, yields of most crops at the 125 locations were unaffected by soil treatments of magnesium from either magnesium source. In a few cases, yields were increased 10 percent or more by one of the magnesium sources, but rarely did this occur with both magnesium carriers for the same trial. Depressions in yield occurred in about as many instances as yield increases.

Soil test results showed that over one-half of the coarse textured soils sampled contained less than five percent magnesium on the exchange complex in the surface layer. In contrast, the exchange complex of about three-fourths of the fine textured soils had a magnesium saturation of 10 to 20 percent. About 15 percent of the coarse textured soils and five percent of the fine textured soils showed calcium-magnesium ratios exceeding 20:1. In spite of the fact that many of the soils were relatively low in native magnesium and contained wide calcium-magnesium ratios, crop yields were not affected.

Chemical analyses of the fresh and dry plant tissue revealed that the magnesium content of most of the crops was appreciably increased at many of the locations by applications of one or both magnesium carriers. Significant increases in magnesium composition occurred in fresh potato tissue in 1957 with magnesium sulfate applications and in dry potato tissue with both magnesium sulfate and Sul-Po-Mag in this same year. In addition, a significant increase in the uptake of magnesium was observed in dry cucumber plants by applications of both magnesium carriers in 1957. The application of 400 pounds of magnesium per acre as magnesium sulfate in 1958 to field corn and sweet corn showed a significant increase of magnesium content in both the fresh and dry tissue tests. These changes in magnesium composition failed to affect the yield.

Results show that the magnesium composition of the plant was affected, to some degree, by the amount of exchangeable magnesium in the soil. A significant correlation between soil and plant magnesium occurred in the case of dry field bean and potato plants.

No definite relationship between magnesium and potassium in the dry plant tissue was observed with the exception of potatoes. Here, a significant negative correlation of these two elements was obtained with the magnesium sulfate treatment. The potassium-magnesium ratios in the dried plant material varied from 3:1 to 11:1 for different crops.

The results of this investigation would indicate that the application of soluble magnesium on most agronomic crops grown on the fine textured soils in Michigan is not necessary at this time. Tests do show that many coarse textured soils of the state are relatively low in exchangeable magnesium, and applications of either dolomitic limestone where lime is needed, or use of fertilizer which contains magnesium could insure against possible magnesium deficiencies occurring in the future.

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I. INTRODUCTION

Magnesium, a divalent cation, is an essential element in the growth of plants. In acid soils of the humid region in the United States, magnesium ranks third in order of adsorbed cations, being exceeded only by hydrogen and calcium ions. It is found in varying proportions as the carbonate in dolomite and in primary silicate soil minerals as biotite, hornblende, augite, and olivine. Magnesium is a crystal constituent of secondary silicates including talc, serpentine, chlorite, vermiculite, illite, and montmorillonite. In addition to the above mineral sources, plants obtain their magnesium from that in exchangeable form adsorbed on the surface of clay particles and organic matter.

Although the magnesium ion usually exceeds potassium on the exchange complex of most soils in the humid region, it usually follows calcium and potassium in percent composition of the plant ash.

Magnesium is relatively more abundant in the leaves, young growing tips, and seeds than in the stems or roots. As a constituent of chlorophyll, magnesium enters into the composition of green plant tissue, and thus, differs from most other cations required for plant growth. Although the chlorophyll molecule contains 2.7 percent magnesium, this is only a small part of the total magnesium content of leaves. In addition, magnesium is found in protoplasm and in soluble form in cell sap.

It has been suggested that magnesium ions may be used over and over in growth so that the total supply needed by a plant is not great.

If the theory of cation constancy holds in plant composition, it would be expected that certain relationships would occur between magnesium, calcium, potassium, and sodium. Also, the accumulation of magnesium and phosphorus in the seed and other storage organs of the plant indicates there is a relationship between magnesium and phosphorus in reproduction and growth. These ideas will be developed further in the next phase of this paper.

Most mineral soils contain a sufficient supply of available magnesium for most of the crops commonly grown. If a soil is lacking in magnesium, certain physiological disorders in plants appear which differ between various crop species. Generally, these symptoms are characterized by an interveinal chlorosis first occurring on the older leaves. Since the early 20's when "sand drown" of tobacco was diagnosed by McMurtney (28) as a deficiency of magnesium, magnesium starvation symptoms on other crops have shown up primarily in the Atlantic and Gulf Coastal states. It is probable that these disorders occurred here first due to the lack of magnesium bearing soil minerals in the sandy textured parent materials, the mild climate and abundant rainfall resulting in considerable leaching of the element, the use of more highly refined fertilizers, and the duration and intensity of crop production.

No definite magnesium deficiencies had been reported under field conditions on mineral soils in Michigan at the time this investigation was initiated. In fact, greenhouse studies by Satyapal (35) on the surface soil of 13 representative soil types of Michigan indicated there was little possibility of magnesium deficiency occurring in crops of soybeans, millet, and wheat. However, very little information on field response of crops to supplemental magnesium had been reported. It was also known that some soils appeared to be low in exchangeable magnesium. Over a period of time, considerable interest was exhibited by representatives of the fertilizer industry, the Cooperative Extension Service, and the Agricultural Experiment Station as to whether some crops might respond to magnesium fertilization, especially those grown on the coarse textured soils.

This study initiated in 1956 and carried out over a three year period, was an attempt to determine the magnesium status of mineral soils of Michigan. A further purpose was to evaluate any yield response to various magnesium carriers, and to determine the chemical composition of the plants which might reflect both native and applied magnesium in the soil.

II. REVIEW OF LITERATURE

A. Characteristics of Magnesium Deficiency

Magnesium deficiency symptoms have been reported on most field and vegetable crops, on some fruit trees, and occasionally on floral plants. Generally, the older leaves become chlorotic and growth is reduced. Symptoms of magnesium deficiency on some of the common crops are as follows (2): on corn, the lower leaves become chlorotic at margins and between the veins producing a streaked effect, followed by a necrosis of the chlorotic areas; the older leaves on oats turn greenish yellow and the stems weaken with a tendency to fall over; older wheat leaves show a yellow green mottling; leaves of potatoes show central interveinal chlorosis followed by necrosis and the leaves turn brittle in the final stages; bean leaves exhibit an interveinal chlorosis; leaves of soybeans are covered with small brown spots appearing mostly on the older leaves; the older sugar beet leaves become chlorotic between the veins and droop downward; red clover presents an interveinal chlorosis and a reddish brown, marginal band on the outer edges of the leaves.

B. Areas of Magnesium Deficiency

Carolus (8) of the Virginia Truck Experiment Station was among the first in the United States to recognize and investigate the correction of magnesium deficiencies on several crops. He observed that certain truck crops such as cucumbers, tomatoes, cabbage, sweet corn, and spinach, and other crops such as potatoes and field corn were the first to show magnesium deficiency. Fertilizers containing one to two percent MgO per ton for truck crops and potatoes and a lesser amount (about 10 pounds MgO) for sweet corn and field corn were used to correct the condition. He recommended, at that time, the building up of a reserve of 500 to 750 pounds of MgO per acre with the use of dolomite, and then maintaining it by use of fertilizers containing MgO. Field evidence indicated that magnesium influenced earlier maturity, size of root and fruit, and the general quality of the marketable crop.

Deficiency symptoms have either been observed or yield responses to magnesium applications have been reported in the various states on the following crops:

1. Peach trees in North Carolina (27).
2. Most vegetable crops and on alfalfa in New Jersey (3).
3. Potatoes in Maine (9), Rhode Island (25), New York (39), and Alabama (23).
4. Potato, tobacco, and apple trees in Canada (24).
5. Blueberries in New Jersey (30) and Massachusetts (1).
6. Apple trees in New Jersey (46) and New York (6).
7. Certain varieties of celery on organic soils of Michigan (22).
8. Corn in Indiana (15).

Symptoms of magnesium deficiency in crops have also been diagnosed in Germany, Holland, Belgium, and New South Wales (44).

C. Yield and Plant Composition

For the most part, where magnesium deficiency symptoms have appeared on crops, the application of moderate amounts of soluble magnesium or dolomitic limestone has improved appearance and yield (8, 9, 15, 17, 23, 39).

Studies by Bear *et al*. (2) have shown that yield responses may occur when the magnesium saturation of the exchange complex falls below 10 percent. Graham and Powell (17) have reported similar results. A value of 10 to 15 percent has been rather widely accepted as satisfactory for normal growth of many crops.

Not all crops grown on soils apparently deficient in magnesium have responded to magnesium applications (15 and 22). Usually, however, the magnesium content of the plant has been found to increase as a result of magnesium fertilization. Tucker and Smith (43) observed no increased yield of red clover with a moderate application of magnesium, but the application increased the magnesium composition when no potassium was used.

Investigations by Seatz, Gilmore, and Sterges (38) showed no yield response of snap beans to various applications of potassium and magnesium. However, the magnesium content of bean plants did increase as the rate of magnesium fertilization increased, and the magnesium content was higher at the low rate of applied potassium.

Windham (48) observed no increased yield of several vegetable crops, except beets, from magnesium applications made to a sandy loam soil. In this study, 50 pounds of magnesium significantly increased the magnesium content of the vines of cucurbits, tomatoes, and potatoes and the entire plants of beet, spinach, lima beans, and snap beans.

Corn showing magnesium deficiency in northern Indiana did not respond to applications of 70 pounds of magnesium per acre as long as potassium levels were moderately high according to Foy and Barber (15). The magnesium applications did reduce the symptoms and significantly increased the magnesium content in the corn leaves.

Other workers have either corrected magnesium deficiency symptoms or have increased magnesium contents of crops by applications of 15 pounds or more of elemental magnesium per acre (1, 4, 30, 37, and 41). In some cases, crop yields were also improved (4).

D. Potassium-magnesium Relationships

Most recent investigations indicate that magnesium deficiency in plants develops not only at low levels of exchangeable magnesium in the soil, but also, it may be induced by a high potassium level in the soil resulting from fertilization.

This relationship was observed in 1939 by Southwick (40) in an apple orchard at the Experiment Station farms at Amherst, Massachusetts. Magnesium deficiency symptoms were noted in the fall on the foliage of heavily mulched apple trees or trees which had been moderately fertilized with potassium. He concluded that 0.25 percent magnesium in leaves was the critical level for apple trees.

Data from Boynton and Burrell (6) show that magnesium deficiency was induced in McIntosh apple trees on acid soils low in exchangeable bases as a result of three or more years of moderate potassium fertilization (two to five pounds K_2O per tree).

A survey of soil and leaf samples in apple orchards in New Jersey by Wehunt and Purvis (46) showed evidence that leaf magnesium was not significantly related to soil magnesium. They also obtained a correlation coefficient of -0.69 between leaf magnesium and available potassium in the soil, indicating that potassium in the soil has a greater effect on leaf magnesium than does soil magnesium.

Working with potatoes both in the greenhouse and field, Walsh and O'Donahoe (45) observed that the application of 500 pounds of potassium sulfate per acre resulted in magnesium deficiency.

Tucker and Smith (43) when growing red clover under greenhouse conditions, obtained a correlation of -0.68 between magnesium and potassium in plant tissue. Furthermore, their data indicated that potassium exerted control over magnesium rather than magnesium over potassium.

The magnesium content of blueberry leaves was increased by application of 60 to 150 pounds of magnesium per acre as magnesium sulfate according to Bailey and Drake (1). This amout, however, had no effect on the potassium content of the leaves.

Nutrient solution studies with tomatoes by Bear, Prince, Toth, and Purvis (3) showed that a potassium-magnesium ratio of 1:1 produced the best growth up to transplanting. From transplanting to preblossom, a 20:1 ratio was most desirable, and a 5:1 ratio was best up to and during fruiting. However, all three ratios gave good growth. As the ratio of potassium to magnesium increased in the solution, the potassium content increased and magnesium decreased in the plant tissue.

Windham (48) noted that high rates of potash fertilizer (220 pounds potassium per acre) significantly decreased magnesium concentration in muskmelons, cucumbers, tomatoes, snap beans, and cauliflower.

Field experiments conducted by Foy and Barber (15) revealed that 100 and 500 pounds of potassium per acre induced magnesium deficiency symptoms on corn. This condition was confirmed by low magnesium and high potassium contents of leaves.

E. Calcium-magnesium Ratios in the Soil and Plant

In a study of the effect of cropping on the calcium and magnesium content of soils, Moser (32), by analyzing the soil before and after cropping, observed that cropping reduced the quantity of exchangeable calcium and magnesium, but did not always result in a lower calcium-magnesium ratio. Apparently magnesium is held more tightly, and as a result, the calcium was absorbed much more rapidly than the magnesium. Hence, the calcium-magnesium ratio tends to approach unity. Moser's work showed no significant correlation between the calcium-magnesium ratio and crop yields, but rather the significant factor in determining yields in this investigation was the amount of the active calcium in the soil.

Tucker (42) has reported that varying the calcium-magnesium ratio in the soil from 50:1 to 1:5 had no influence on the yield of soybeans grown on soils with high exchange capacity, but did influence yields on soils with low exchange capacity. This probably indicates that the ratio of calcium to magnesium is not important as long as there are sufficient amounts of calcium and magnesium in the soil.

Using a soil low in magnesium, Sanik, Perkins, and Schrenk (34) were unable to detect any single or narrow range of calcium-magnesium ratio in the soil as best for the uptake of all plant nutrients studied (boron, copper, manganese, and zinc), or one that would necessarily be most desirable for optimum growth of wheat and sorghum. They concluded for the particular soil that the best calcium-magnesium ratio for the uptake of boron was 4:1, for copper and manganese, 2.6:1, and for zinc, 2:1.

Studies by Camp (7) on citrus trees in Florida indicated that a calcium-magnesium ratio in the soil of between 5:1 and 8:1 would be most ideal. Hunter, Toth, and Bear (21) have noted that the calcium-magnesium ratios in alfalfa plants were roughly proportional to the calcium-magnesium ratios in the soil.

An investigation by Longstaff (26) using soybeans showed that the calcium content in bean plants increased proportionally to the uptake of magnesium.

In some early work concerning the availability of phosphatic fertilizers, Gray (18) observed that magnesium sulfate increased the amount of phosphorus absorbed by sudan grass especially when calcium phosphate fertilizers of low availability or solubility were used. Hence, he postulated that the ratio of available calcium to magnesium might have something to do with phosphorus absorption.

F. Magnesium-phosphorus Relationships

The exact relationship, if there is any, between magnesium and phosphorus is either not known or if known, appears to be contradictory. It is known that seeds are relatively high in magnesium and phosphorus, but there is lack of agreement as to whether there is joint assimilation of these two elements. Cooper, Paden, and Garman (11) suggested the possibility that plants may have developed some mechanism for excluding excessive quantities of calcium from seeds and other organs of reproduction. They further stated that it is probable that magnesium phosphate may be the most stable phosphate compound that can be utilized by the energy available to most seedling plants.

In a general discussion of the effect of magnesium on plant nutrition, Zimmerman (51) has related that magnesium may be a carrier of phosphate, and is thus believed to be closely related to phospho-lipid formation and to the synthesis of nucleoproteins in plant cells.

Truog, Goates, and Gerloff (41) obtained a direct correlation of phosphorus and magnesium content in peas as a result of various magnesium and phosphorus treatments. Nutrient solution studies showed that both the phosphorus and magnesium content of peas rose appreciably and consistently with increasing concentration of magnesium and that increasing the supply of magnesium increased the phosphorus content more than did increasing the source of phosphorus.

From a survey of soil and leaf samples from apple orchards, Wehunt and Purvis (46) concluded that available soil magnesium had no effect on the phosphorus content of leaves, but that phosphorus uptake appeared to be governed by a potassium and magnesium balance. Likewise, Longstaff (26) after growing soybeans in sand cultures with varying amounts of magnesium bearing minerals found that available magnesium from mineral sources had no appreciable effect on the phosphorus and potassium contents of the plants.

Work by Hunter (20) on alfalfa revealed no close correlation between the uptake of magnesium and phosphorus. Although the percent phosphorus in this legume increased significantly as the calcium-magnesium ratio in the soil decreased from 4:1 to 1:4, the rate of increase was much less than that for the percent magnesium.

Willis, Piland, and Gay (47) obtained no significant differences between calcium and magnesium as regards their influence on the absorption of phosphate in soybeans. With an abundance of calcium a deficiency of magnesium did not limit the absorption of phosphorus.

According to studies of Tucker (42) with various exchangeable calcium-magnesium ratios in soils, when calcium exceeded magnesium, increasing the magnesium had little effect upon the concentration of phosphorus in soybean plants.

G. Hereditary Factors Affecting Magnesium Uptake

It is well accepted by most investigators that plants differ in the absorption of various nutrients. These differences in absorption are known to occur between species as well as between varieties, and between inbred lines of such crops as corn.

For example, Foy and Barber (16) worked with Ohio 40-B, an inbred line of corn, which often showed magnesium deficiency symptoms. They found that this line was not limited by its root absorbing ability since the total cation exchange capacity of its roots was similar to other lines. They believe, however, that this line is limited in its ability to move the magnesium to the leaf. This indicates that inbred lines may carry genetic factors which control the utilization of magnesium. Some lines will grow over a wide range of magnesium concentration while others apparently need a high concentration. Foy and Barber suggest that plant breeders may have to consider this idea in future work.

Observations and tests by Johnson, Davis, and Benne (22) at the Michigan Muck Experimental Farm revealed that Utah 10-B variety of celery suffered a disorder characteristic of magnesium deficiency. In spite of the fact that sufficient exchangeable magnesium appeared to be present in the soil, heavy soil applications of two to four tons of magnesium sulfate per acre or numerous spray applications were required to control the disorder. None of the magnesium applications increased yields but improved quality of the crop was noted.

It is apparent then that some magnesium disorders may be attributed to a genetic factor as well as to unbalanced soil conditions.

III. METHODS AND MATERIALS

A. Scope of Experiment

This study was carried out over a three year period from 1956 to 1959 using 14 different crops on 37 different soil types in 41 counties of Michigan. An attempt was made to select sites where the common agronomic and some horticultural crops could be grown over a wide range of soils and climatic conditions. Figures 1, 2, and 3 at the end of this section indicate the crops grown and counties where the experiments were located.

In Table 1, the number of locations for each crop by years are shown. In addition to the 18 corn experiments harvested in 1956, three additional fields were sampled for chemical analysis.

B. Fertilizer Treatments and Application Rates

Treatments and application rates of fertilizer and magnesium materials are reported in Table 2. Treatments for 1957 were identical to 1956 except that the foliar spray treatment was deleted and the number of replications was increased from two to four. A basic fertilizer treatment of 1,000 pounds of 5-20-20 was applied broadcast by hand before plowing on all plots except the check. In some cases the check treatment received no fertilizer of any kind, while the remainder of the trials received the usual amount applied by the cooperator at planting time. Soil applications of magnesium sulfate and Sul-Po-Mag were also made before plowing on annual spring planted crops. Hay and winter grain fields were topdressed with the basic fertilizer and magnesium treatments at the same time.

C. Experimental Design and Plot Sizes

A pre-randomized block with two replications was used in 1956 and with five replications in 1958. Because there was an equal number of treatments and replications in 1957, a Latin Square design was utilized. All plot sizes were 20 x 20 feet for hay and small grains and 20 x 30 feet for row crops.

D. Soil Sampling

Composite soil samples were taken from each replication at the 0 to 6 inch and 12 to 18 inch depths prior to application of fertilizer. The soil samples were air dried, screened, and stored for chemical analysis.

E. Plant Samples

Fresh plant tissue samples were collected from each location when the crops were two-thirds to three-fourths mature. Samples from two replications were usually combined except in 1956 when the two replicates were kept separate. These samples consisting of leaves and petioles were quick frozen for chemical analysis at a later date.

Each trial was closely examined for the presence of magnesium deficiency symptoms at the time of tissue sampling.

Other plant samples were also taken just prior to or at harvest-time. These samples were composed of leaves and petioles from cucumbers, melons, and cauliflower; stems and leaves from sugar beets and potatoes; leaves from corn and the entire above ground portion of the plant from small grains, hay, and beans. The samples were dried, ground, and wet ashed for chemical analysis.

F. Harvest

Each crop was harvested at the appropriate time with harvest areas varying from about 20 to 50 percent of the total plot. In addition to yield data, test weights for small grains were conducted, specific gravity was determined on potato tubers, and percent sugar and percent purity were determined on sugar beets. Neither the mature seed, fruit, root, or tuber were analyzed as it was felt that the entire vegetative portion of the crop would give a better picture of total magnesium absorption and the nutrient status of the crop than individual storage organs, seeds, or fruits.

G. Laboratory Procedures

1. Soils

All of the surface and subsoil samples from each location were analyzed for pH, available phosphorus, and potassium using the Spurway Reserve test (0.135 N HCl, soil-acid dilution 1:4). The data for individual samples are given in Tables 15a to 20a of the Appendix.

The exchangeable cations were determined by extraction with neutral ammonium acetate according to the method of Schollenberger and Simon (36); the exchangeable hydrogen was estimated using para-nitrophenol buffer solution as described by Woodruff (49); the total exchange capacity was derived by summation of the exchangeable hydrogen and bases.

An analysis of exchangeable potassium, calcium, and sodium was carried out on the leachates from the ammonium acetate extractions of the soils using the Beckman DU flame photometer. The conditions of operation of this instrument for each of the three elements is given in Table 65a of the Appendix.

The determination of magnesium was made colorimetrically from the same extracts by the method of Drossdoff and Nearpass (13). The results of these analyses may be seen in Tables 21a to 27a of the Appendix.

In 1956, the surface soil samples were composited for the analysis of exchangeable cations. However, in order to check agreement between the samples composited, the cations present in individual surface soil samples were determined for ten locations. These results appear in Table 23a of the Appendix.

For the years of 1957 and 1958, two out of four surface soil samples were composited for the exchangeable cation determinations giving two composite samples for each location. Four subsoil (12 to 18 inch level) samples were composited for these same tests.

2. Fresh Plant Tissue

The frozen samples were finely cut and 10 grams of the tissue was placed in a Waring Blendor with 200 ml of Morgan's extracting solution (acidified sodium acetate). One-half of a teaspoon of Darco carbon was added and the samples macerated for a period of two to five minutes depending upon the toughness of the individual crop.

In 1956 calcium and potassium were determined colormetrically on the extracts according to a modified procedure of Wolf and Ichisaka (50). Analysis for calcium and potassium in 1957 and 1958 was accomplished by use of the Beckman DU flame photometer. Although the high concentration of sodium in the Morgan's solution gave some interference with potassium, the values were relative and the procedure was justified in order to speed up the determinations.

Analysis for magnesium in the tissue extracts was carried out from the thiozole yellow procedure of Mikkelsen and Toth (29). The results of these analyses are found in Tables 28a to 44a of the Appendix.

3. Dry Plant Tissue

The dry plant tissue was wet ashed by a modified perchloric acid method of Piper (33). Calcium, potassium, and sodium were determined on the extracts using the Beckman DU flame photometer. Instrumental conditions used were similar to those for soil analyses which are listed in Table 65a of the Appendix.

Analysis for magnesium was completed using thiazole yellow method of Drossdoff and Nearpass (13). The samples were analyzed for phosphorus using the Molybdenum Blue colormetric method employing ammonium molybdate and the Fisk-Subbarrow reducing agent (14). A Coleman colorimeter equipped with a 650 mu filter was used to determine phosphorus concentration.

RAND McNALLY LOOSE LEAF OUTLINE MAP 18 MICHIGAN

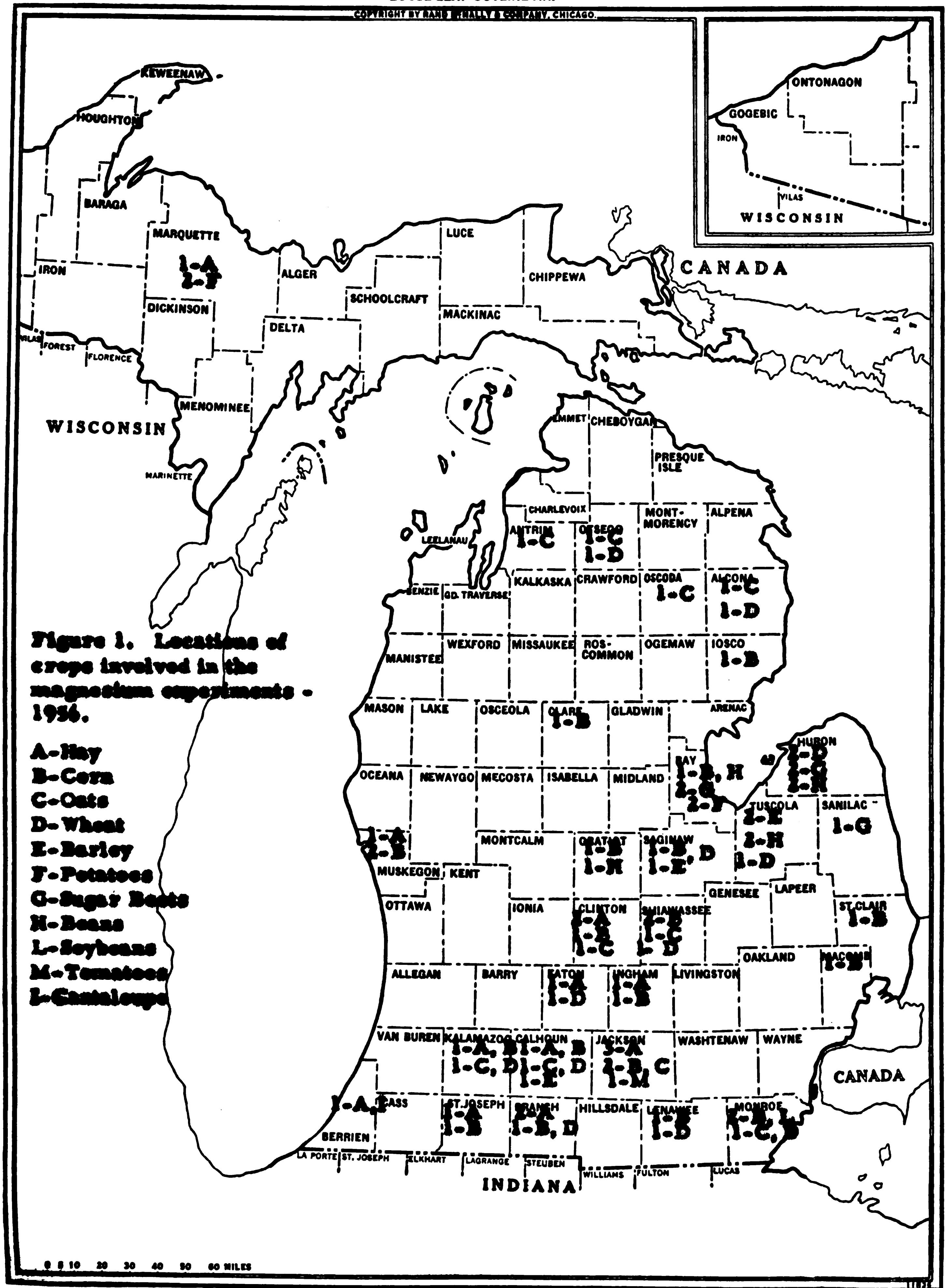


Figure 1. Locations of crops involved in the magnesium experiments - 1936.

A-Hay
B-Corn
C-Oats
D-Wheat
E-Barley
F-Potatoes
G-Sugar Beets
H-Beans
L-Soybeans
M-Tomatoes
I-Cantaloupe

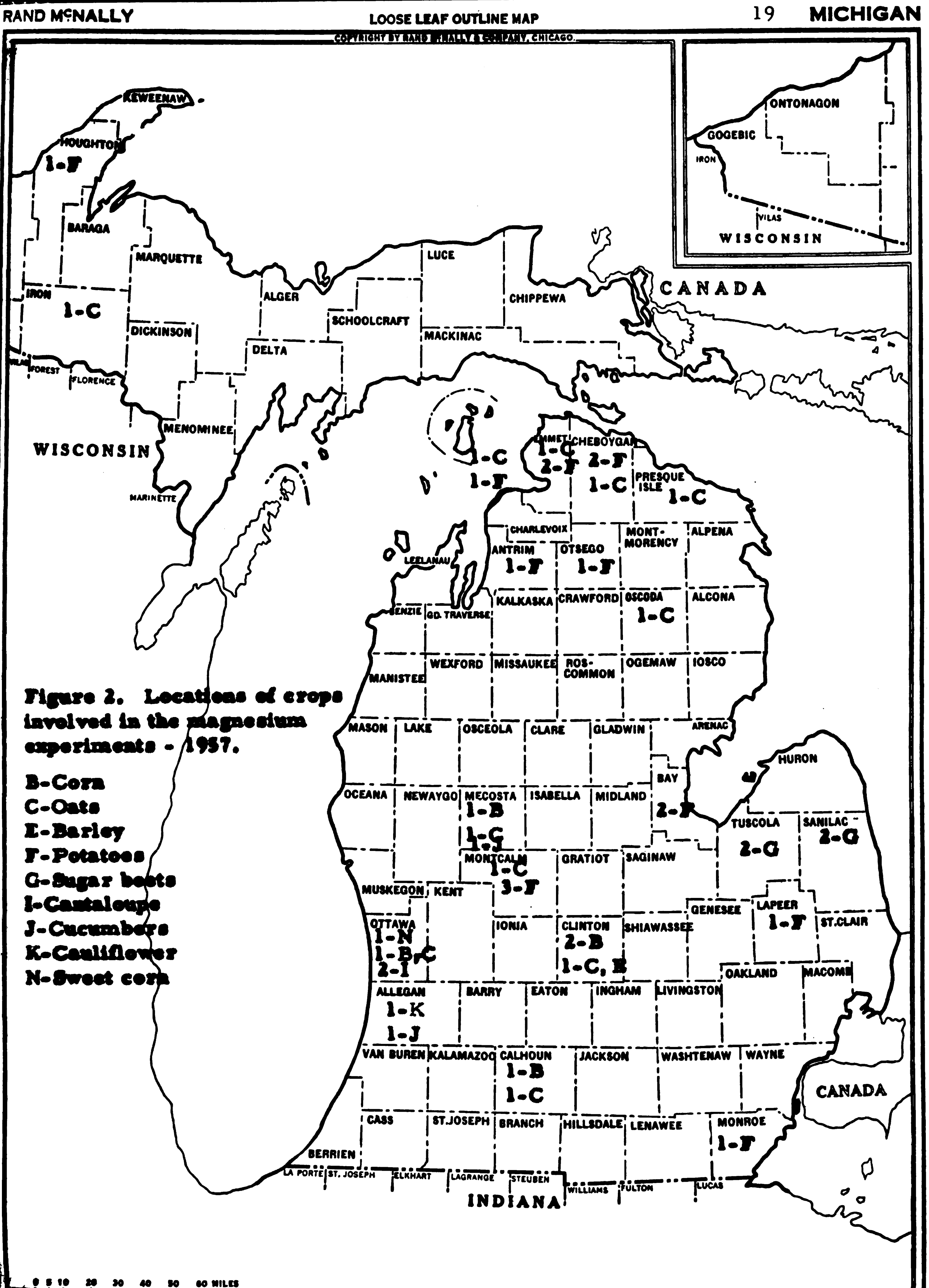
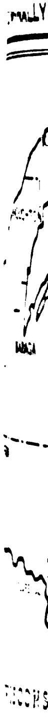


Figure 2. Locations of crops involved in the magnesium experiments - 1957.

B-Corn
C-Oats
E-Barley
F-Potatoes
G-Sugar beets
I-Cantaloupe
J-Cucumbers
K-Cauliflower
N-Sweet corn



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-Corn
-Oats
-Sweet

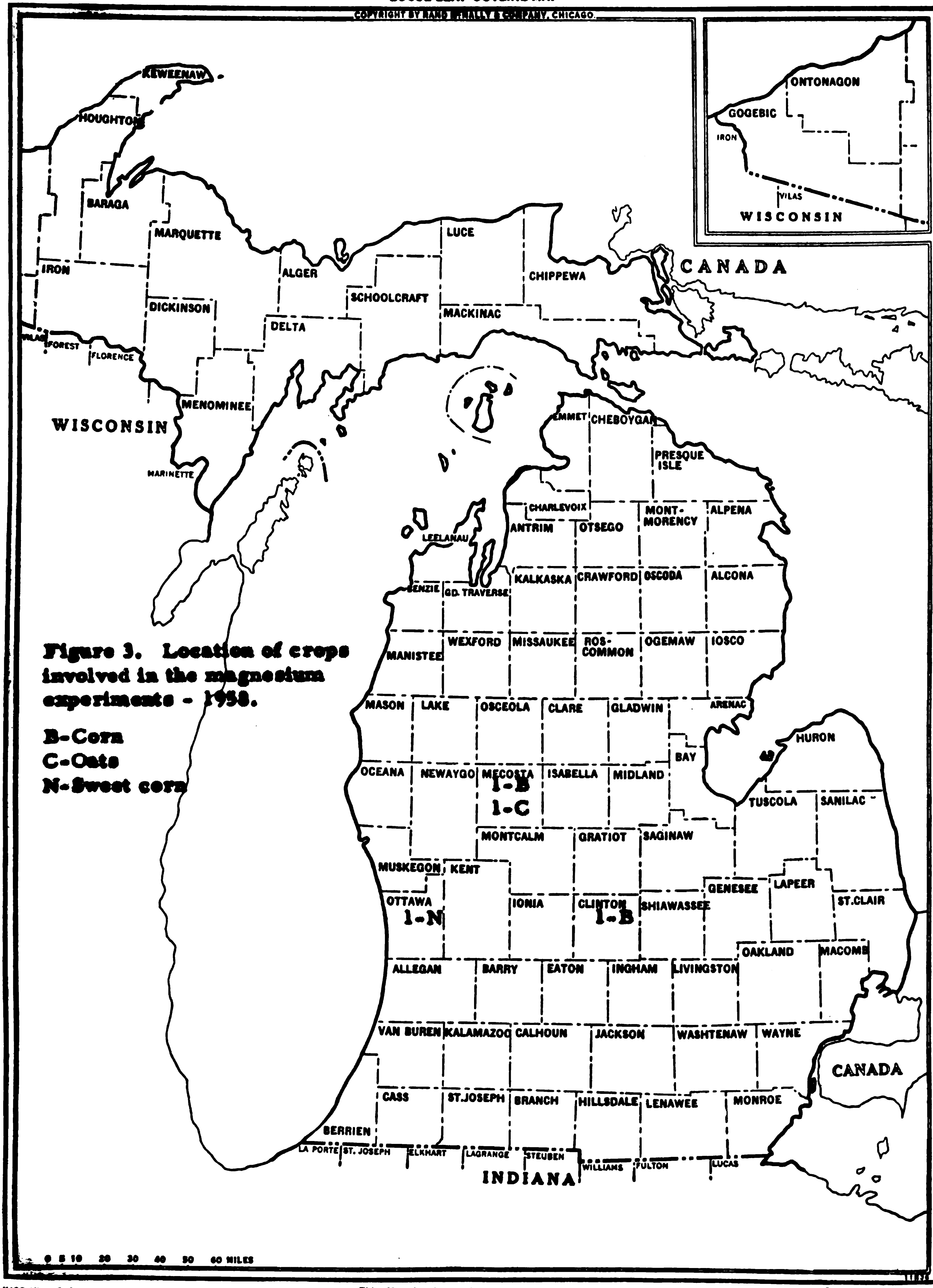

Figure 3. Location of crops involved in the magnesium experiments - 1958.

B-Corn
C-Oats
N-Sweet corn

Table 1. Number of locations by crops of magnesium experiments for each of the years indicated.

	Number of crop locations by years		
	1956	1957	1958
Hay	15		
Corn	18	5	2
Oats	11	11	1
Barley	4	1	
Wheat	13		
Potatoes	4	15	
Field beans	6		
Soybeans	2		
Sugar beets	5	4	
Cucumbers		2	
Cantaloupe	1	2	
Cauliflower		1	
Sweet corn		1	1
Tomatoes	1		
Total	80	42	4

Table 2. Treatments and application rates for magnesium field trials by years.

Treatment designation	Treatment
	1956 - 2 replications
A	Check - no fertilizer or farmer applications
B	N-P-K plus 100 lbs. Mg as $MgSO_4$[1] (1030 lbs. per acre)
C	N-P-K plus equivalent of 1 lb. $MgSO_4$ per acre per day as spray
D	N-P-K only
E	N-P plus 100 lbs. Mg as Sul-Po-Mag[2] (915 lbs. per acre)
	1957 - 4 replications - same as 1956 except C treatment deleted
	1958 - 5 replications
A	Check - N-P-K only
B	N-P-K plus 100 lbs. Mg as $MgSO_4$ (1030 lbs. $MgSO_4$ per acre)
C	N-P-K plus 200 lbs. Mg as $MgSO_4$ (2060 lbs. $MgSO_4$ per acre)
D	N-P-K plus 400 lbs. Mg as $MgSO_4$ (4120 lbs. $MgSO_4$ per acre - split application, one-half before plowing and one-half as side-dress)
E	N-P plus 100 lbs. Mg as Sul-Po-Mag (915 lbs. per acre)
F	N-P-K plus equivalent of 1 lb. $MgSO_4$ per acre per day as spray
G	N-P-K plus 200 lbs. Mg as hydrated dolomite (1000 lbs. of hydrated dolomitic limestone per acre)[3]

[1] $MgSO_4 \cdot 7H_2O$ contains approximately 10% Mg (Epsom salts).
[2] Sul-Po-Mag contains 22% K_2O and 18.5% MgO or 11% Mg.
[3] Hydrated dolomitic limestone contains 20.5% Mg.

IV. CROP YIELD RESULTS

Because of the differences between the treatments from year to year, it was necessary to report the yields of the various crops separately for each year as indicated in Tables 4a to 14a of the Appendix. However, the individual yield data for four treatments were combined by crop for two soil textural classes for all years in Table 3. A grouping of the soils of all locations into coarse and fine textured representatives can be seen in Tables 15a to 27a of the Appendix.

The number of locations for each crop which showed a yield response to at least one of the magnesium carriers applied to the soil is presented in Table 4, and in addition, cases where a depression in yield was found are also included. The data presented in Table 5 indicate the approximate percentage of the experiments which showed yield response to N-P-K fertilizer and those which resulted in increases or decreases in yield of 10 percent or more as a result of soil applications of either magnesium sulfate or Sul-Po-Mag. A summary of some of the data given in Table 4 is presented in Table 6.

Inasmuch as the foliar application gave such poor results in 1956, it was deleted in 1957 and is not considered in the discussion except where mentioned. Where a crop was grown for more than a year, the discussion involves the data from all experiments combined for the years the crop was grown.

A. Hay

In about one-third of the hay experiments, a positive yield response of at least 10 percent was found for applied fertilizer in either the first or second cutting. Similar increases in production due to fertilizer were obtained at two of the 15 fields for both cuttings (locations 28 and 47).

With added magnesium, there was a 10 percent or higher yield increase in either the first or second cutting at five locations. It may be noted that at locations 16 and 44 some yield response to magnesium sulfate resulted for both cuttings. However, only location 44 showed an increase in yield of hay from both magnesium sulfate and Sul-Po-Mag applications in the first cutting and at location 16 in the second cutting. Four of the five fields showing yield responses to magnesium contained coarse textured soils.

These gains were offset by as many or even more fields where decreases in yields of 10 percent or more resulted from the two magnesium treatments. The fact that such yield depressions rarely occurred in both cuttings would indicate that probably other factors may have caused the decreased growth.

B. Corn

A 10 percent or higher yield increase from fertilizer alone was obtained at about one-third of the corn locations. Only one location (number 23) showed a significant yield response at the five percent level due to magnesium (Sul-Po-Mag treatment). About one-third of the experiments showed a 10 percent or greater response to one or both magnesium treatments. Only four of the nine corn locations where yield increases were noted gave a response to both magnesium treatments (locations 51, 57, 88, and 90). On the other hand, there were two or three farms at which magnesium fertilization appeared to affect the corn yields adversely. This is difficult to explain as the percent magnesium saturation and calcium-magnesium ratio of the exchange complex of these soils were not out of line. It may be noted that the average yields varied only two to four bushels per acre between any of the treatments receiving fertilizer or magnesium plus fertilizer.

C. Oats and Barley

At one-half of the 28 locations of oats and barley, a 10 percent or greater yield response to N-P-K was found. Most of these experiments were located on sandy loam soils. At one location (68-C-26), the yield response was statistically significant. Grain yields at 10 of the trials were higher by 10 percent from either one or both magnesium applications than where no magnesium was applied. At two locations, the increases were significant; one being the spray treatment on oats at location 1 while the other involved the Sul-Po-Mag treatment on barley at location 91. In only four of the 10 fields showing some response did increased yields occur from both magnesium treatments (locations 71, 80, 13-C-7, and 59-C-22). In contrast, there was a decline in yield of 10 percent at six locations as a result of magnesium fertilization.

The average oat and barley yields for all fields were increased to some extent by fertilizer alone, especially on the coarse textured soils. The average oat yield in 1956 was increased by slightly less than 10 percent with magnesium sulfate plus N-P-K compared with fertilizer alone. Barley yields were increased on the average slightly more than 10 percent in the same year with Sul-Po-Mag. Smaller effects were obtained from fertilizer and soluble magnesium in 1957. Considering all three years, the average yield was only slightly changed by the application of magnesium to either the coarse or fine textured soils. No significant differences in test weights of grain were noted as a result of fertilizer or magnesium treatments.

D. Wheat

At only one experiment was a yield response to fertilizer recorded. A yield increase of grain of 10 percent was obtained with magnesium sulfate at two of the 13 locations but none were statistically significant (locations 2 and 20). Considering all soils, it may be noted that the average yield for wheat at all locations was rather similar for the various treatments. It may be seen from Table 3 that wheat grown on the fine textured soils responded the most to fertilizer although most of this increase occurred on only two fields. Differences in test weights of grain due to fertilizer or soluble magnesium additions were insignificant.

E. Potatoes

Apparently most of the potato fields were well supplied with available nitrogen, phosphorus, and potassium as only about one-fourth of them showed improved yields from the 1,000 pounds of 5-20-20 fertilizer applied. At only one location (number 98) was there an approximate 10 percent increase in yield of potatoes from both magnesium treatments. Even less significance may be attached to this one case, since the check plots produced the highest yield of any of the treatments.

Yields at about one-half of the experiments were depressed due to a combination of fertilizer plus magnesium applications. It is probable that a toxicity of soluble salts resulted as several growers applied over 1,000 pounds of fertilizer in addition to the basic amount applied in the experiment along with the magnesium treatments. The average yields for the two year period indicate that generally, fertilizer improved yields, but there was a tendency for both magnesium sources to depress yields, though probably not significantly so. The greatest response to fertilizer was found in experiments conducted on fine textured soils, but also on this group of soils, the largest depression in yield from magnesium treatments was recorded.

F. Field Beans

There is little indication that fertilizer or either magnesium carrier affected bean yields in 1956. There was some apparent response at one location from both magnesium treatments at location 38. However, more important is the fact that there was a depression of yields of 10 percent at one-half of the locations from the application of either magnesium material. It is interesting to note that at locations 39 and 93, the percent magnesium saturation of the exchange complex was relatively high (12.8 and 24.2 respectively). The average yields for all locations did not vary appreciably for the various treatments.

G. Soybeans

The fact that one soybean field showed some response to magnesium sulfate and the other location resulted in a yield depression makes the interpretation of the results difficult. Possibly, other factors were responsible for these differences. Application of Sul-Po-Mag had little effect on soybean yield.

H. Sugar Beets

Sugar beet yields were increased by fertilizer at all but two locations. At one trial (76-G-35) in 1957, the yield increase was significant at the five percent level. Only one field (location 40) produced a yield increase of 10 percent or higher with Sul-Po-Mag and slightly less than this with Epsom salts. At the same time, there was a sizable decline in yield of beets where either magnesium treatment was applied at location 83. The average beet yields from all locations indicated little benefit from magnesium applications.

I. Cucumber

Fertilizer generally resulted in a yield increase at the two cucumber locations. As for magnesium sulfate, it was of little benefit, but Sul-Po-Mag showed up well at location 3-J-2.

J. Cantaloupe

Inasmuch as there was almost a complete crop failure at location 70-I-30, the yield data from this trial is probably not reliable. Response to fertilizer occurred at two locations and it is likely that magnesium sulfate may have improved the yield in one field, though not significantly. A depression in yield appeared to have occurred at the other two locations. Sul-Po-Mag had little or no effect on yield of fruit at two of the three experimental locations.

K. Cauliflower

Both magnesium carriers resulted in a depressed yield of cauliflower. In fact, both magnesium treated and fertilized plots gave lower yields than the check.

L. Sweet Corn

Inasmuch as there appeared to be a considerable response with sweet corn to both magnesium carriers applied to soil in 1957, the experiment was continued on the same farm close to this same area in 1958. In the latter year, soil treatments of up to 400 pounds of elemental magnesium did not appear to affect yield. However, the foliar spray improved the yield over 20 percent but this increase was not significant where three replications were harvested.

M. Tomatoes

A 60 percent yield increase of number one and two tomatoes was noted from the use of magnesium sulfate. In contrast, Sul-Po-Mag had no effect on crop yield in the one tomato experiment conducted.

N. Summary

In general, there was a small to moderate response to NPK fertilizer in most crops at most locations especially on the coarse textured soils. Only in isolated cases did significant responses occur from either fertilizer or magnesium. The majority of apparent responses were not of a statistically significant nature. This is substantiated by the fact that only in few instances did an analysis indicate significance and also, by the fact that rarely did the apparent response occur with both magnesium carriers. Furthermore, it is difficult to understand why there should be so many cases where the magnesium treated plots actually resulted in lower yields than the fertilized plots. Generally, on an average basis, the increased yield for any one crop at any one location was offset by a depression somewhere else.

In 1957, an interveinal chlorosis of the younger and medium aged leaves of corn was noted at locations 19-B-13 and 54-B-19 in Clinton and Mecosta counties respectively. Inasmuch as this condition resembled magnesium deficiency symptoms, its progress was noted throughout the season. The effect was noticeable over the entire fields and even on the plot areas regardless of treatment. The condition persisted until harvest time.

Because of this condition, experiments were conducted again at both locations in 1958. Corn was repeated on the same field in Clinton county, but the corn field in Mecosta county was planted to oats in 1958 on which an experiment was laid out. Corn was planted across the road on this same farm in Mecosta county in 1958 on a similar soil type. The same chlorotic conditions appeared at both of the corn fields in 1958 and also at the sweet corn location in Ottawa county.

Instead of these symptoms occurring on the older leaves as is typical in magnesium deficiency, the chlorosis was first apparent on the younger leaves as they emerged from the boot, especially noticeable when the corn was about waist high. Typical symptoms may be noted in Plate 1. As the season progressed, the symptoms persisted mostly on the medium aged and younger leaves. Again, this condition occurred over the entire field and on the plot areas and did not seem to be corrected by soil applications of magnesium of up to 400 pounds of magnesium per acre or by foliar sprays.

Inasmuch as these magnesium treatments did not correct these conditions, the writer laid out an experiment along side of the magnesium plots in Mecosta county using manganese, zinc, and magnesium alone and in combination as a foliar spray. Two foliar applications were made but a drought occurring shortly after spraying resulted in an almost complete drying up of the leaves so that an interpretation of the results was difficult. The cooperator finally found it necessary to take the corn off for ensilage. The crop yields of field corn in Clinton county and of sweet corn in Ottawa county appeared to be unaffected by these chlorotic conditions. The oat field in Mecosta county gave no evidence of magnesium deficiency symptoms.

Table 3. Average crop yields of magnesium field trials by treatment for all years.[1]

Crop	Soil texture	Number of locations	Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay[2]	coarse	9	3.1	3.3	3.2	3.3
	fine	6	2.2	2.5	2.5	2.7
Corn	coarse	11	53.2	64.4	68.2	66.7
	fine	13	59.5	62.2	61.8	62.6
Oats and barley	coarse	18	43.2	50.1	52.9	49.0
	fine	10	37.2	40.4	42.0	42.7
Wheat	coarse	4	33.3	32.6	30.0	-
	fine	9	41.0	48.0	47.7	-
Potatoes	coarse	14	248.9	251.3	248.8	249.8
	fine	5	193.7	233.6	203.7	209.4
Field beans	fine	6	29.5	29.5	28.7	28.6
Soybeans	coarse	2	23.0	23.3	22.6	24.9
Sugar beets	fine	9	17.0	19.2	19.3	19.9
Cucumber	coarse	2	57.2	79.6	75.8	85.7
Cantaloupe	coarse	3	189.4	193.0	197.9	155.6
Cauliflower	coarse	1	337.7	315.0	230.1	301.1
Sweet corn	coarse	2	53.4	93.8	98.9	102.3
Tomatoes[3]	coarse	1	13.0	10.6	18.2	10.1

[1]Yields in bushels per acre for corn, oats and barley, wheat, beans, and soybeans. Yields in cwt. per acre for potatoes, cucumbers, cantaloupe, and cauliflower. Yields in tons per acre for hay, sugar beets, and tomatoes.

[2]Yields usually include two cuttings.

[3]Yields include number one and two tomatoes.

Table 4. Locations at which crop yields were affected by various magnesium treatments.[1]

Crop	Total number of locations	Number of locations showing increased yields of > 10%			Number of locations showing decreased yields of > 10%	
		B > D	E > D	Response from both treatments	B < D	E < D
Hay	15	7[2]	2	2	6	6
Corn	24	7	6	4	2	1
Oats and barley	28	8	6	4	3	3
Wheat	13	2	-	-	1	-
Potatoes	19	1	1	1	5	2
Field beans	6	1	1	1	3	2
Soybeans	2	1	-	-	1	-
Sugar beets	9	1	1	-	1	1
Cucumbers	2	-	1	-	-	-
Cantaloupe	3	1	-	-	2	1
Cauliflower	1	-	-	-	1	-
Sweet corn	2	1[3]	1	1	-	-
Tomatoes	1	1	-	-	-	-

[1]Treatments: D = N-P-K only, considered as check for this comparison; B = N-P-K plus magnesium sulfate; E = N-P plus Sul-Po-Mag.
[2]Includes two cuttings.
[3]Response to spray treatment but not to soil treatment in 1958.

Table 5. The positive or negative response in crop yield from fertilizer or magnesium treatments.[1]

Crop	Percent of locations showing response to N-P-K[2]	Percent of locations showing response from Mg with either soil application	Percent of locations showing depression from Mg with either soil application
Hay	15	15	15
Corn	30	27	12
Oats and barley	50	25	25
Wheat	15	15	0
Potatoes	25	0.5	50
Field beans	0	16	60
Soybeans	50	50	0
Sugar beets	20	12	12
Cucumbers	100	50	0
Cantaloupe	67	33	67
Cauliflower	0	0	0
Sweet corn	100	50	50
Tomatoes	0	100	0

[1]Increase or decrease in yield of 10 percent or more.
[2]Values are approximate percentages.

Table 6. Crop locations showing positive yield response from magnesium treatments.[1]

Crop	Total number of locations	Percent of locations showing: Increase in either treatment	Percent of locations showing: Increase in both treatments
Hay	15	15	0.7
Corn	24	27	16
Oats and barley	28	25	14
Wheat	13	15	0
Potatoes	19	0.5	0.5
Field beans	6	16	16
Soybeans	2	50	0
Sugar beets	9	12	0
Cucumbers	2	0	0
Cantaloupe	3	50	0
Cauliflower	1	0	0
Sweet corn	2	100	50
Tomatoes	1	100	0

[1]Increase of 10 percent or more in yield.

V. RAPID SOIL TESTS OF EXPERIMENTAL SOILS

Rapid soil tests were made on all the soil samples using the Spurway Reserve test (0. 135 N HCl, soil-water ratio 1:4 extractant). These data appear in tables 15a-20a of the Appendix. A summary of these results are contained in Table 7 which indicates the ranges of pH and the ranges and averages of phosphorus and potassium soil tests of samples collected from the experimental fields before the various plots were fertilized.

A wide range of phosphorus and potassium levels occurred at both soil depths in the soils studied. Generally the content of available phosphorus and potassium was slightly lower in the 12 to 18 inch depth than in the surface layer. The average quantity of phosphorus extracted from the fine textured soils varied from 40 percent greater in the plow layer to 80 percent greater at the lower depth than in the coarse textured soils. According to the procedure used, the average potassium content of both soil groups at the two depths was not appreciably different.

The data in the Appendix also reveal that about 41 percent of the 65 soil samples of coarse texture contained 50 pounds or more of phosphorus per acre in the surface layer. About 50 percent of the fine textured soils sampled at this same depth contained amounts of available phosphorus in this same range. Likewise, about 36 percent of coarse textured soils gave tests of 150 pounds or more of available potassium per acre in the surface area, whereas only about 16 percent of the fine textured soils contained this amount of potassium per acre in the plow layer.

Although a few of the soils were extremely low in either phosphorus or potassium, the basic application of 86 pounds of phosphorus and

166 pounds of potassium contained in the 1,000 pounds per acre of 5-20-20 should have been sufficient to insure proper amounts of plant food for all the crops. Hence, none of the major nutrient elements should have been limiting.

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Table 7. The pH and the ranges and averages for available phosphorus and potassium extracted from experimental soils for two broad soil textural groups at two sampling depths.

Range	Depth Inches	pH	Pounds per acre P	Pounds per acre K
		65 coarse textured soils		
low	0 - 6	5.2	11	36
low	12 - 18	5.2	6	9
high	0 - 6	7.6	156	240
high	12 - 18	7.8	123	144
average	0 - 6	-	47	111
average	12 - 18	-	31	64
		55 fine textured soils		
low	0 - 6	5.5	10	48
low	12 - 18	5.6	3	16
high	0 - 6	7.6	249	332
high	12 - 18	7.2	162	192
average	0 - 6	-	65	108
average	12 - 18	-	55	61

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VI. CATION EXCHANGE CAPACITY AND EXCHANGEABLE BASES

A. Cation Exchange Capacity

The ranges and averages of exchange capacity for the respective soil textural groups at two soil depths were computed and appear in Table 8. Data pertaining to exchange capacity, cation saturation, and calcium-magnesium ratios of individual soils are given in Tables 21a to 27a of the Appendix.

Some of the coarse textured soils were four to five times higher and some of the fine textured soils were three to four times higher in exchange capacity at both soil depths than others of approximate similar texture. The fact that the average exchange capacity was almost identical for both depths in both textural groups indicates that organic matter may have been the most important factor contributing to the exchange capacity in the surface layer. However, the clay in the B horizon was probably more responsible for the exchange capacity at the lower depth.

B. Magnesium Saturation

Many investigators have considered the degree of saturation of the soil exchange complex as a better criterion of the magnesium needs of soils than the actual content of exchangeable magnesium. Data of magnesium saturation for the range of soils studied as well as associated information from which these values were calculated are given in Table 9.

It may be observed that magnesium saturation varied from about 0.50 percent for a few soils to over 30 percent for others. The average

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percent magnesium content was about 60 percent greater in the surface layers of the fine textured soils than in the coarse textured soils. This difference doubled at the 12 to 18 inch depth.

Information presented in Table 10 concerning the percent magnesium saturation of the experimental soils reveals that of 64 coarse textured soils, about 61 percent at the 0 to 6 inch depth and about 51 percent at the lower depth had magnesium saturation values of five percent or less. In fact, over 80 percent of all the coarse textured soils sampled at both depths had magnesium saturation of less than 10 percent.

A much higher proportion of fine textured soils fell into the 10 to 20 percent magnesium saturation class than did the coarse textured soils. If one considers five to six percent magnesium saturation in the soil as being a minimum value for normal growth as suggested by some workers, then it might be expected that about two-thirds of the coarse textured soils and about one-fifth of the fine textured soils would respond to added magnesium. As will be discussed in a later section, this was not the case.

In terms of pounds of magnesium, the variation ranged from 16 pounds in a coarse textured soil to 1100 pounds in the plow layer of a fine textured soil. The average magnesium content of fine textured soils varied from two to two and one-half times greater than in coarse textured soils for both soil depths.

C. Calcium-magnesium Ratios

A frequency distribution of the ratios of exchangeable calcium to magnesium of the soils studied is shown in Table 11. Over one-half of the coarse textured soils and about three-fourths of the fine textured soils had calcium-magnesium ratios of 10:1 or less in the surface layers. This would indicate that although the magnesium saturation

was low in many soils, the balance between the two elements was not undesirable. Although many agronomists believe that a calcium-magnesium ratio varying from 5:1 to 10:1 to be most ideal, much experimental work indicates that as long as the exchange capacity is reasonably high and sufficient amounts of calcium and magnesium are present in the soil, the ratio between the two elements is not of real importance. Up to 15 percent of the coarse textured soils, but only five percent of the fine textured soils contained calcium-magnesium ratios exceeding 20:1.

D. Potassium-magnesium Ratios

It has been reported frequently that the relationship between exchangeable potassium and magnesium in soils and plants may be more important than calcium-magnesium ratios. An analysis of soils from these trials as reported in Table 12 disclosed that the potassium-magnesium ratios varied from 1:5 to 1:6.3 in coarse textured soils to 1:7.5 to 1:16 in fine textured soils in the plow layers and 12 to 18 inch depths respectively.

To the author's knowledge, no ideal potassium-magnesium ratios have been established for soils. Bear, Prince, Toth, and Purvis (3) have reported good growth of tomatoes in nutrient solutions with potassium-magnesium ratios varying from 1:1 to 20:1. A number of instances have been reported of magnesium deficiency induced in plants as a result of high potassium levels in the soil. Just what ratio of potassium to magnesium is best for most crop plants is not really known. It has been assumed that an ideal soil would contain about two to four percent exchangeable potassium. This would be comparable to potassium-magnesium ratios of about 1:2.5 to 1:5. In the experimental soils saturation of the exchange complex with potassium was in the range of one percent. It should be remembered, however, that the samples were taken before any potash was applied.

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Table 8. Ranges and averages of exchange capacity of experimental soils for two broad soil textural groups at two sampling depths.

Range	Location number	Soil type	Depth Inches	Cation exchange capacity M.e./ 100 gms. soil
		Coarse textured soils		
low	69	Wauseon sandy loam	0-6	4.28
low	67	Wauseon sandy loam	12-18	3.86
high	9-F-4	Brevort loamy sand	0-6	15.62
high	10	Brevort loamy sand	12-18	18.32
average of 64 surface soils			0-6	9.8
average of 57 subsoils			12-18	9.8
		Fine textured soils		
low	38	Sims clay loam	0-6	6.11
low	73	Nester loam	12-18	4.91
high	34	Conover loam	0-6	19.54
high	34	Conover loam	12-18	20.14
average of 53 surface soils			0-6	12.1
average of 41 subsoils			12-18	11.9

Table 9. Ranges and averages of the content of exchangeable magnesium and degree of magnesium saturation in experimental soils for two broad soil textural groups at two sampling depths.[1]

Range	Location number	Soil type	Depth Inches	Exchange capacity M.e./100 gms. soil	Exchangeable magnesium in soil: M.e./100 gms. soil	Exchangeable magnesium in soil: Pounds per acre	Magnesium saturation Percent
			Coarse textured soils				
Low	48	Hillsdale sandy loam	0-6	11.5	0.07	16	0.6
Low	70-I-30	Newton sand	12-18	6.5	0.03	8	0.5
High	67	Wauseon sandy loam	0-6	6.7	1.13	271	16.8
High	23	Hillsdale sandy loam	12-18	10.8	1.80	431	16.6
Average of 64 surface soils			0-6	9.8	0.58	139	6.3
Average of 57 subsoils			12-18	9.8	0.56	134	5.4
			Fine textured soils				
Low	64	Blount silt loam	0-6	11.7	0.07	16	0.6
Low	37	Sims loam	12-18	7.6	0.13	32	1.7
High	96	Selkirk loam	0-6	13.4	4.70	1128	35.1
High	8	Kawkawlin loam	12-18	7.7	2.25	540	29.3
Average of 53 surface soils			0-6	12.1	1.14	273	9.9
Average of 41 subsoils			12-18	11.9	1.46	350	12.3

[1]Individual tests are composites of four soil samples for each location at the given depth; average tests are composites of four samples for the respective number of locations at each depth.

Table 10. Distribution of experimental soils according to percent magnesium saturation within two broad soil textural groups and at two sampling depths.

Percent Mg saturation	0 - 6 inch depth		12 - 18 inch depth	
	Number of soils	Percent of total	Number of soils	Percent of total
	Coarse textured soils			
0 - 5	39	61	29	51
5.1 - 10	13	20	19	33
10.1 - 20	12	19	9	16
20.1 - 30	0	0	0	0
30.1 - 40	0	0	0	0
Total	64	100	57	100
	Fine textured soils			
0 - 5	10	19	7	17
5.1 - 10	16	30	6	15
10.1 - 20	21	40	22	54
20.1 - 30	5	9	6	14
30.1 - 40	1	2	0	0
Total	53	100	41	100

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Table 11. Distribution of experimental soils according to calcium-magnesium ratios within two broad soil textural groups and at two sampling depths.

Calcium magnesium ratio	0 - 6 inch depth Number of soils	Percent of total	12 - 18 inch depth Number of soils	Percent of total
		Coarse textured soils		
0.0 - 5	20	31.2	29	51.0
5.1 - 10	16	25.0	13	23.0
10.1 - 20	17	27.0	7	12.0
20.1 - 30	3	4.6	2	3.5
30.1 - 40	3	4.6	2	3.5
40.1 - 50	2	3.0	1	1.7
50.1 - 120	3	4.6	3	5.3
Total	64	100.0	57	100.0
		Fine textured soils		
0.0 - 5	23	43.0	24	58.0
5.1 - 10	18	34.0	9	22.0
10.1 - 20	9	17.0	6	15.0
20.1 - 30	1	2.0	2	5.0
30.1 - 40	0	0.0	0	0.0
40.1 - 50	0	0.0	0	0.0
50.1 - 120	2	4.0	0	0.0
Total	53	100.0	41	100.0

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Table 12. The degree of saturation of potassium and magnesium of the exchange complex and potassium-magnesium ratios in experimental soils within two broad soil textural groups and at two sampling depths.

Total number of soils	Depth Inches	Potassium saturation Percent	Magnesium saturation Percent	K-Mg saturation ratio
		Coarse textured soils		
64	0 - 6	1.3[1]	6.3	1 : 5.0
57	12 - 18	0.9	5.4	1 : 6.3
		Fine textured soils		
53	0 - 6	1.3	9.9	1 : 7.5
51	12 - 18	0.8	12.3	1 :16.0

[1]Average potassium and magnesium saturation and potassium-magnesium ratios of four composite samples for the number of soils designated.

VII. RELATION OF PERCENT MAGNESIUM SATURATION AND CALCIUM-MAGNESIUM RATIOS WITH CROP YIELD RESPONSE TO MAGNESIUM FERTILIZATION

The exchangeable magnesium and exchangeable calcium-magnesium ratios in the plow layer of the experimental soils were compared for crop locations showing a positive yield response to magnesium treatment and those experiments giving no response. A summary of this analysis is given in Table 13.

It may be seen that the average percent magnesium saturation was actually greater at most of the locations where some increased yield to magnesium was observed. Only in three wheat experiments, one field bean, and one soybean trial was the magnesium saturation lower where a response occurred.

Generally a large percentage of the soils from locations where a positive yield response to magnesium was observed contained less than six percent of the exchange complex saturated with magnesium for the crops of corn, wheat, and beans. In contrast, a large percentage of trials, where no magnesium response was noted, included soils with magnesium saturation values of less than six percent for the crops of oats, barley, hay, potatoes, and cantaloupe. For the other crops the magnesium saturation varied from a low of 2.5 percent for the soil on which sweet corn was grown to over 16 percent for the soils with soybean trials. This variation had no apparent effect on crop yield response to magnesium fertilization.

Neither the calcium-magnesium ratio or soil texture seemed to be important factors as to whether a soil did or did not respond to magnesium treatment. Generally, yields were normal even for the few soils having less than one percent magnesium on the exchange complex. Where yields were found to be low, this situation could usually be attributed to some other soil or climatic factor. Even for the 10 locations where the soil magnesium saturation amounted to less than one percent in either the subsoil or surface layer, less than one-half of the crops responded appreciably to magnesium fertilization.

From the data collected from this project, no logical explanation for the behavior of many of the crops to magnesium treatment was apparent. Even where extremely low quantities of supposedly available magnesium occurred in the soil, crop yields were neither depressed nor increased by added magnesium. Thus, it may be assumed from these tests that under Michigan conditions, most crops are tolerant of quite low magnesium levels and wide calcium-magnesium ratios in the soil.

Crop locations showing yield response	Crop locations showing no yield response to magnesium
	Number of Percent

Table 13. Relative response of various crops to two magnesium carriers as related to degree of magnesium saturation of the soil.

Crop	Crop locations showing yield response to magnesium[1]				Crop locations showing no yield response to magnesium			
	Number of locations	Average Mg saturation Percent	Number of locations with < 6% Mg saturation	Percent of locations with < 6% Mg saturation	Number of locations	Average Mg saturation Percent	Number of locations with < 6% Mg saturation	Percent of locations with < 6% Mg saturation
Hay	5	9.4	2	40	10	6.3	5	50
Corn	9	8.9	6	66	15	8.1	6	40
Oats and barley	10	8.8	2	20	13	5.1	9	69
Wheat	2	3.6	2	100	9	8.2	2	22
Potatoes	1[2]	-	-	-	15[2]	5.6	11	73
Field beans	1	4.9	1	100	5	14.4	1	20
Soybeans	1	16.2	0	-	1	16.8	0	-
Sugar beets	1	14.2	0	-	3[2]	12.6	0	-
Cantaloupe	0	-	-	-	3	3.3	3	100
Cauliflower	0	-	-	-	1	6.8	-	-
Sweet corn	1	2.5	1	100	1	2.6	1	100

[1]Yield increase of 10 percent or more.
[2]Some soil samples not available.

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VIII. ANALYTICAL RESULTS OF FRESH TISSUE TESTS

A. Magnesium Content in Plant Tissue

Samples were taken of the fresh tissue from most of the crops and analyzed for magnesium, potassium, and calcium in the cell sap. It was assumed that if the applied magnesium was being absorbed by the plant, it could be detected chemically in the conducting tissue. Information on mineral composition for specific crop locations is contained in Tables 28a to 44a of the Appendix.

As is shown in Table 14, a higher magnesium content in the fresh tissue of hay, corn, oats, and field beans was found in plants from the check treatment than in plants receiving fertilizer or fertilizer and magnesium. This was probably due to a dilution factor since increased vegetative growth was often noted as a result of fertilization. Comparisons were thus made between the plots receiving N-P-K only and those which received N-P-K plus Epsom salts or Sul-Po-Mag.

The magnesium composition of many crops was increased appreciably at several locations by one of the magnesium treatments. For example, in about one-third of the hay and one-half of the corn and potato trials a substantial increase in the magnesium content of the fresh tissue was noted for one or both of the magnesium treatments. A similar increase in composition of fresh tissue for all the soybean and cucumber crops and in plants at over one-half of the field bean experiments was found where either magnesium sulfate or Sul-Po-Mag was applied. The magnesium content in sweet corn in 1957 was more than doubled by the use of either magnesium source when compared with sweet corn from plots receiving only fertilizer.

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A statistical analysis of the magnesium composition of the fresh tissue from the various treatments showed that the magnesium content of the crop was significantly increased at a few of the locations. The magnesium content of potatoes was significantly increased by Epsom salts at the five percent level at location 16-F-10 and at the one percent level at location 16-F-11 in 1957. An increased magnesium content of potatoes at location 16-F-11 in 1957 and of corn at location 18 in 1956 by Sul-Po-Mag applications was highly significant.

The combining of crop locations for purposes of statistical analysis showed that the magnesium composition was increased significantly at the five percent level at four of the eight corn trials in 1956 by applications of Epsom salts (locations 18, 30, 69, and 75). Furthermore, the addition of Epsom salts on potatoes in 1957 increased the magnesium content an amount that was significant at the one percent level (see Table 35a of the Appendix). An analysis further showed that Sul-Po-Mag significantly increased the magnesium content of second cutting alfalfa grown on coarse textured soils in 1956.

From Table 15, it may be seen that applications of magnesium sulfate increased the magnesium contents on the average more than 20 percent in tissue of field corn, field beans, soybeans, cucumbers, cantaloupe, and sweet corn. Field beans, cucumbers, and sweet corn were the only crops in which the fresh tissue composition was affected by both magnesium carriers. It is of interest to note that soybean, sugar beet, and cauliflower tissue contained the largest concentration of magnesium.

B. Composition of Fresh Tissue as Affected by Various Rates of Magnesium Application

Because the treatments differed in 1958 from the two previous years and various rates of magnesium sulfate were applied, these data will be discussed separately.

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Definite increases in magnesium content were noted in all crops at the higher application rates of magnesium sulfate as may be seen in Table 16. A statistical analysis showed that the 200 and 400 pound rate of Epsom salts applied to corn and sweet corn significantly increased the magnesium composition at the five percent and one percent levels respectively (see Table 22). The average magnesium content of field corn from the two trials was closely related to the rate of magnesium applied as it increased from 100 to 400 pounds of magnesium per acre as the sulfate. The results of tests of the chemical composition of the oats and sweet corn were more erratic, but the heavy application of magnesium sulfate was definitely reflected in the magnesium content of the plant tissue. Generally, the Sul-Po-Mag, hydrated dolomite, and foliar applications were about equivalent to 100 and 200 pounds of magnesium per acre as the sulfate in respect to the composition of the fresh plant tissue.

Crop yields were not influenced by the variation in magnesium content. All three of the sandy soils had magnesium saturation values of six percent or less.

As was pointed out in the discussion of the yield data, an abnormal condition of the corn leaves was noted at all the corn trials in 1958. A yellow striping of the leaves characteristic of magnesium deficiency was apparent except that this condition occurred on the younger as well as the older leaves. Although the symptoms became less severe as the growing season progressed, some yellowing was observed right up to harvest time on some plants.

Fresh leaf tissue samples from plants showing these symptoms were analyzed and compared with the average magnesium content of normal leaves taken from all the treatments. Likewise, dry plant samples of the entire corn plant showing the symptoms were analyzed

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and compared in a like manner. The results of these tests may be seen in Table 17.

Although only one-half to two-thirds as much magnesium was found in the fresh tissue of the abnormal plant as in the normal appearing plants, this difference was not apparent when the dry tissue of the whole plant was analyzed. To the author's knowledge, no critical value for corn has been established and hence it is difficult to determine if the plants were bordering on a condition of magnesium deficiency.

The data for the surface soils in Appendix Tables 26a and 27a reveal that the degree of saturation of exchangeable magnesium varied between two and three percent in the corn field in Mecosta county and in the sweet corn field in Ottawa county. In contrast, about 12 percent of the exchange complex of the soil from the corn field in Clinton county was taken up with exchangeable magnesium. In spite of the fact that the level of soil magnesium was low at two of the three locations, sufficient magnesium should have been present in the treatments to correct this condition. On the other hand, studies by Johnson et al. (22) have shown that 500 pounds of magnesium applied on Utah 10-B celery was insufficient to prevent magnesium deficiency symptoms.

C. Relation of Exchangeable Magnesium and Magnesium Applications with Chemical Composition and Crop Yield 1956 and 1957

In about one-fourth of the trials where the magnesium content was appreciably increased by one of the soil applications of that nutrient, there were also responses in yields. However, both magnesium treatments were not equally effective in changing the mineral composition or the yield. For the magnesium sulfate treatment, the percentage increase in magnesium content varied from 20 to 146 percent. These changes in composition were accompanied by a range of 13 to 28 percent increase

in yield. With the Sul-Po-Mag treatment, a 40 to 153 percent change in composition was accompanied by a range of 10 to 31 percent increase in yield.

It may be observed from Table 18 that all of the soils from locations where responses to magnesium occurred in both composition and yield, less than six percent of the exchange complex of these soils contained magnesium. From this information it is conceivable that these soils could be on the verge of magnesium deficiency for the growth of most crops, and applications of magnesium in some form might be beneficial.

D. Interrelationships of Magnesium, Potassium, and Calcium

Chemical analyses of the fresh tissue showed little or no relationship generally between the content of magnesium and potassium in the crops grown the first two years. Graphs of percent magnesium plotted against percent potassium content in the tissue revealed that only in sugar beets was there a fair negative correlation between the two elements. A comparison of Tables 14 and 20 indicates that the average magnesium and potassium contents of hay, corn, oats and barley, potatoes, and field beans varied concurrently. On the other hand, the composition of these two elements varied inversely for cucumber and sweet corn.

Results of analyses from crops grown in 1958 where magnesium sulfate was applied at various rates disclosed no definite relationship between potassium and magnesium in any of the three crops raised. Although the higher rates of application of Epsom salts increased the magnesium composition, the potassium content was not affected as may be seen in Table 22. As it is thought that soil potassium exerts a greater influence on magnesium than does magnesium on potassium, one might not expect to find a definite correlation in the above situation.

A frequency distribution of the potassium-magnesium ratios for the crops grown on the N-P-K plots is shown in Table 19. For the crops of hay, corn, and sugar beets, the potassium-magnesium ratios of the fresh tissue were about equally divided between 0 to 10 and 10 to 20 ranges. Potatoes, field beans, and the horticultural crops tended to have wider potassium-magnesium ratios. The potassium-magnesium ratios of the fresh plant tissue varied from a narrow range of 5.2:1 in sugar beets to over 20:1 in sweet corn.

The fact that the sample from a particular part of the plant was used for determination of all three elements, variations in moisture content of tissue at the time of sampling, and analytical errors in determining the individual elements may have been responsible for some of the inconsistencies of these results.

The potassium content of the respective crops varied greatly between locations and between treatments. The data presented in Table 20 show that the potassium content of corn and potatoes was generally higher when the crops were grown on coarse textured rather than on fine textured soils. The potassium content of the various crops appeared to have been little affected by either magnesium carrier except sweet corn and cucumber. With these two crops, the magnesium composition was definitely increased by magnesium applications while the potassium percentage was depressed. It is possible then that the magnesium applications did have an adverse effect upon the potassium uptake in these two crops. For the remainder of the crops, the potassium content of the crops generally was unchanged or increased by the application of either magnesium carrier.

The calcium content of the fresh tissue for the various crops is shown in Table 21. The calcium-magnesium ratios in the fresh tissue varied from about 1:1 in sugar beet to over 9:1 for cucumber from plants grown on the fertilized plots. For cantaloupe and cauliflower plants, this ratio was generally wider than for the field crops which varied from 2:1 to 4:1. Sugar beet petioles were relatively lower in calcium than the conducting tissue of other crops. On the other hand, cucumber, cantaloupe, and cauliflower were relatively high in calcium as compared with the field crops. There appeared to be little change in calcium content of the tissue as a result of the magnesium applications.

Table 14. The magnesium content of fresh tissue of various field crops for all years for specific fertilizer treatments.

Crop	Plant part	Soil textural group	Number of locations	Ppm. Magnesium[1] Check	N-P-K only[2]	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay (1st cut)	Petioles	coarse	5	778	598	541	602
Hay (1st cut)	Petioles	fine	3	881	629	555	864
Hay (2nd cut)	Petioles	coarse	5	1004	934	896	1190
Hay (2nd cut)	Petioles	fine	1	688	480	400	496
Average				874	716	693	862
Corn	Leaf sheath	coarse	11	694	558	603	659
		fine	12	906	607	817	635
Average				803	583	715	646
Oats and barley	Stems	coarse	8	786	898	854	863
		fine	3	725	629	651	635
Average				985	752	734	725
Potatoes	Petioles	coarse	10	721	707	853	768
		fine	2	872	968	1080	976
Average				746	750	690	803
Field beans	Petioles	fine	5	784	550	682	749
Soybeans	Petioles	coarse	2	1288	968	1268	1032
Sugar beets	Petioles	fine	7	1103	1206	1204	1209
Cucumber	Petioles	coarse	2	656	656	984	896
Canteloupe	Petioles	coarse	2	760	756	908	800
Cauliflower	Petioles	coarse	1	1168	1056	1136	1248
Sweet corn	Leaf sheath	coarse	2	1120	435	904	945

[1]Parts of magnesium per million parts of fresh tissue by weight; values represent average of two samples per treatment for the specified number of locations.

[2]A treatment for 1958 represents D plot (N-P-K only) for 1956-57.

Table 15. The percent increase in magnesium in fresh tissue of several crops as affected by magnesium applications.

Crop	Plant part tested	Percent increase of Mg in tissue from treatments[1]	
		Epsom salts	Sul-Po-Mag
Hay	Petioles	-3.0	+20.4
Corn	Leaf sheath	+22.0	+10.8
Oats and barley	Stems	-2.4	-3.7
Potatoes	Petioles	+18.6	+7.1
Field beans	Petioles	+24.0	+36.3
Soybeans	Petioles	+31.0	+6.6
Sugar beets	Petioles	0	0
Cucumbers	Petioles	+50.0	+36.6
Cantaloupe	Petioles	+20.1	+5.8
Cauliflower	Petioles	+7.5	+18.2
Sweet corn	Leaf sheath	+107.5	+117.7

[1]Treatment comparison is NPK + Mg - NPK.

Table 16. The magnesium content of fresh leaf tissue of various crops for individual magnesium treatments grown on specified soils, 1958.

Location number	Soil type	Treatment[1] A	B	C	D	E	F	G
					Ppm. magnesium[2]			
					Corn			
328-341	Montcalm sandy loam	768	992	864	1184	754	800	576
314-327	Chesaning loam	1144	1088	1440	1315	1298	1261	1398
	Average	957	1040	1152	1249	1026	1030	987
					Oats			
342-354	Montcalm sandy loam	736	672	960	1088	800	704	896
					Sweet Corn			
300-313	Plainfield sand	384	624	640	1008	678	480	736
	Average (all crops)	758	844	976	1149	882	811	901

[1]A - N-P-K only (1,000 lbs 5-20-20/acre)
B - N-P-K + 100 lbs Mg/A as Epsom salts
C - N-P-K + 200 lbs Mg/A as Epsom salts
D - N-P-K plus 400 lbs Mg/A as Epsom salts
E - N-P + 100 lbs Mg/A as Sul-Po-Mag
F - N-P-K + 36 lbs Mg/A as foliar spray
G - N-P-K + 200 lbs Mg/A as hydrated dolomitic limestone

[2]Parts of magnesium per million parts of fresh plant tissue by weight.

Table 17. The magnesium content of normal and abnormal appearing corn and sweet corn plants in fresh and dried plant tissue, 1958.

Crop and location	Appearance of plant	Magnesium content[1]
	Fresh leaf tissue	
Field corn - Clinton county	normal	1278
	abnormal	672[2]
Field corn - Mecosta county	normal	848
	abnormal	464[2]
Sweet corn - Ottawa county	normal	681
	abnormal	480[2]
Average	normal	935
	abnormal	538
	Total dried plant	
Field corn - Clinton county	normal	.22
	abnormal	--
Field corn - Mecosta county	normal	0.13
	abnormal	0.13[3]
Sweet corn - Ottawa county	normal	0.22
	abnormal	0.29[3]
Average	normal	0.19
	abnormal	0.21

[1]Parts of magnesium per million parts of fresh tissue by weight; percent magnesium in dried plant.
[2]Average of two samples (five plants per sample).
[3]One sample (five plants).

Table 18. Crop locations where magnesium applications increased magnesium composition of fresh plant tissue and crop yield.[1]

Crop	Soil textural group	Location number	Percent increase in Mg content		Percent increase in yield		Percent Mg saturation of soil complex
			Epsom salts	Sul-Po-Mag	Epsom salts	Sul-Po-Mag	
Hay	coarse	16	-	46	-	17[2]	5.52
Hay	coarse	48	64	-	17[3]	-	0.57
Corn	coarse	51	20	60	20	15	2.13
Corn	fine	64	80	-	13	-	0.56
Beans	fine	38	93	54	28	10	4.91
Cucumbers	coarse	3-J-2	-	40	-	17	2.59
Sweet corn	coarse	70-B-28	146	153	23	31	2.56

[1]Twenty percent or more increase in Mg content accompanied by 10 percent or more increase in yield with one of the Mg carriers.

[2]Includes two cuttings.

[3]Includes only 1st cutting.

Table 19. The distribution of the potassium-magnesium ratios of fresh plant tissue for specified crops.[1]

Crop	Total number	Potassium-magnesium ratios								
		0-10		10.1-20		20.1-30		30.1-40		Average K-Mg ratio[2]
		No.	Percent	No.	Percent	No.	Percent	No.	Percent	
Hay	13	6	46	6	46	1	8	0	0	11:1
Corn	22	8	36	8	36	1	5	5	23	16:1
Oats and barley	11	11	100	0	0	0	0	0	0	5.8:1
Potatoes	11	2	18	7	64	2	18	0	0	14.8:1
Field beans	5	1	20	3	60	1	20	0	0	14.4:1
Soybeans	2	2	100	0	0	0	0	0	0	6.9:1
Sugar beets	7	4	57	3	43	0	0	0	0	5.2:1
Cucumbers	2	0	0	2	100	0	0	0	0	15.4:1
Cantaloupe	2	0	0	2	100	0	0	0	0	12.2:1
Cauliflower	1	0	0	1	100	0	0	0	0	11.1:1
Sweet corn	2	0	0	1	50	1	50	0	0	20.2:1

[1]For plant tissue from N-P-K plots.

[2]Values represent average of two samples for N-P-K treatment for the specified number of locations.

Table 20. The potassium content of fresh tissue of various field crops for all years for specific fertilizer treatments.

Crop	Plant part	Soil textural group	Number of locations	Ppm. Potassium[1]			
				Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay (1st cut)	Petioles	coarse	5	9768	8028	7836	7408
(1st cut)	Petioles	fine	3	7320	5820	7840	7740
Hay (2nd cut)	Petioles	coarse	5	5640	10344	9314	12392
(2nd cut)	Petioles	fine	1	3720	6720	10200	12000
	Average			7071	7808	7805	8730
Corn	Leaf	coarse	11	11203	11549	11203	9920
	sheath	fine	12	8639	7311	8384	7390
	Average			9865	9337	9732	8600
Oats	Stems	coarse	8	4600	4463	4581	4593
		fine	3	4767	4233	4300	4250
	Average			4650	4394	4496	4490
Potatoes	Petioles	coarse	10	11359	11556	11235	11619
		fine	2	8510	9095	9015	9255
	Average			10884	11145	10855	11260
Field beans	Petioles	fine	5	9056	7510	8382	8210
Soybeans	Petioles	coarse	2	8700	6420	6720	7260
Sugar beets	Petioles	fine	7	7731	6348	7531	6715
Cucumber	Petioles	coarse	2	10425	10375	9350	9250
Cantaloupe	Petioles	coarse	2	9588	9212	9388	8175
Cauliflower	Petioles	coarse	1	11000	11700	11400	10450
Sweet corn	Leaf sheath	coarse	2	12150	8900	7420	7850

[1]Parts of potassium per million parts fresh tissue by weight; values represent average of two samples per treatment for the specified number of locations.

Table 21. The calcium content of fresh tissue of various field crops for all years for specific fertilizer treatments.

Crop	Plant part	Soil textural group	Number of locations	Ppm. Calcium[1]			
				Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay (1st cut)	Petioles	coarse	5	2464	1824	1716	1382
(1st cut)	Petioles	fine	3	2017	2347	2069	2347
Hay (2nd cut)	Petioles	coarse	5	3057	2841	2528	2653
(2nd cut)	Petioles	fine	1	2240	1400	1600	1190
	Average			2564	2269	2073	2029
Corn	Leaf	coarse	11	2092	2158	2105	2150
	sheath	fine	12	2174	2150	2112	2230
	Average			2134	2154	2108	2192
Oats	Stems	coarse	8	2566	2502	2504	2209
		fine	3	2907	3093	2307	2407
	Average			2659	2663	2450	2263
Potatoes	Petioles	coarse	10	2298	1959	2042	2274
		fine	2	2440	2840	2317	2730
	Average			2155	2105	2087	2350
Field beans	Petioles	fine	5	1955	1121	1620	1455
Soybeans	Petioles	coarse	2	2320	1905	1802	2140
Sugar beets	Petioles	fine	7	1326	1569	1428	1464
Cucumber	Petioles	coarse	2	5790	5700	5770	5810
Cantaloupe	Petioles	coarse	2	5745	5340	5810	5585
Cauliflower	Petioles	coarse	1	5820	5940	5880	5820
Sweet corn	Leaf sheath	coarse	2	5560	3705	3540	3840

[1]Parts of calcium per million parts of fresh tissue by weight; values represent average of two samples per treatment for the specified number of locations.

Table 22. The magnesium, potassium and calcium contents of fresh field corn and sweet corn tissue for specific magnesium treatments, 1958.

Crop	Location number	Soil type	Treatment[1] A	B	C	D	E	F	G
			Ppm. Magnesium[2]						
Corn	328-341	Montcalm sandy loam	768	992**	864	1184**	754	800	576
Corn	314-327	Chesaning loam	1144	1088	1440	1315	1298	1261	1398
Sweet corn	300-313	Plainfield sand	384	624	640	1008	678	480	736
		Average	765	901	981*	1169**	910	847	903
			Ppm. Potassium						
Corn	328-341	Montcalm sandy loam	4600	3800	3600	4100	3800	4400	4600
Corn	314-327	Chesaning loam	3300	4100	4400	3700	3500	4000	3600
Sweet corn	300-313	Plainfield sand	4600	3700	4300	4700	4300	4100	3900
		Average	4166	3866	4100	4166	3866	4166	4033
			Ppm. Calcium						
Corn	328-341	Montcalm sandy loam	3100	3100	2700	2750	3000	3300	3500
Corn	314-327	Chesaning loam	2100	2250	2350	2450	2350	2550	3100
Sweet corn	300-313	Plainfield sand	1650	1400	1900	1650	1800	1750	1600
		Average	2266	2233	2300	2283	2383	2533	2733

[1]Treatments: A - N-P-K only (1,000 lbs 5-20-20/A)
B - N-P-K + 100 lbs Mg/A as Epsom salts
C - N-P-K + 200 lbs Mg/A as Epsom salts
D - N-P-K + 400 lbs Mg/A as Epsom salts
E - N-P + 100 lbs Mg/A as Sul-Po-Mag
F - N-P-K + 36 lbs Mg/A as foliar spray
G - N-P-K + 200 lbs Mg/A as hydrated dolomitic limestone

[2]Parts of magnesium, potassium, and calcium per million parts fresh tissue by weight.

**Significant at 1% level.

*Significant at 5% level.

IX. DISCUSSION OF DRY TISSUE ANALYSES

A. Magnesium Content of Crops

Total magnesium, calcium, potassium, and phosphorus were determined in the dried plant tissue from the several crops raised over the three year period. These data are presented in Tables 45a to 64a of the appendix.

In general, the magnesium content of the dry tissue was increased in plants receiving magnesium treatments at substantially more locations than was found for the fresh tissue. However, the magnesium composition of both the fresh and dry tissue of the various crops was not always increased by the same treatments or in the same proportion.

The average magnesium content of each of the crops in all experiments is presented in Table 23. Generally, the magnesium content was lower in plants which received fertilizer only (treatment D for 1956 and 1957) for all crops except the small grains and field beans. Again, it is believed this occurred because of a dilution factor resulting from increased growth where N-P-K fertilizer was applied. However, comparisons made between this fertilizer treatment and those treatments where fertilizer plus magnesium were applied showed that the magnesium content of most of the crops was affected by use of supplemental magnesium.

Magnesium sulfate applied to the soil appreciably increased the magnesium composition of all crops except corn, oats, wheat, and sugar beets, while Sul-Po-Mag caused a notable increase in all crops except oats, field beans, and sugar beets.

The data further show that the average magnesium content of the dry tissue for most crops was usually higher when these crops were grown on fine textured soils compared with those on coarse textured soils. Furthermore, the magnesium content of the small grains was usually only about one-third to one-half as high as other crops. Sugar beet and cucumber tissue contained the highest amount of magnesium compared with other crops, with sugar beet foliage containing up to 10 times more magnesium than the small grains.

The percent increase of magnesium in the dry tissue of the various crops for all years and all soil types is shown in Table 24. About two-thirds of the crops showed an appreciable increase in magnesium uptake by applications of both magnesium carriers.

In Table 25 the number and percentage of experiments are given where either magnesium sulfate or Sul-Po-Mag increased the magnesium content of the specific crop more than 20 percent. The percent of locations giving an increased magnesium composition as a result of both magnesium carriers is shown in Table 26. These values are essentially a summary of the information contained in Table 25.

At about one-half of the hay, one-third of the corn, oats and barley, two-thirds of the potato , and one-half of the truck crop locations, the magnesium content of the crops was increased by one of the two soluble magnesium sources.

From Table 26 it may be seen that one-half of the soybean, cucumber, and cantaloupe trials showed a 20 percent or more increase in magnesium uptake by the plants from applications of both magnesium carriers. Likewise, increases in magnesium uptake varying from 20 to 38 percent occurred in the remainder of the crops, except sugar beets and sweet corn, by applications of both magnesium treatments.

The magnesium composition was significantly increased at several individual crop locations by application of one or both of the magnesium carriers. The Epsom salt treatment significantly increased the magnesium composition of potato plants at two locations in 1957 (locations 9-F-5 and 59-F-23) and of cucumber vines at location 54-J-19. The Sul-Po-Mag treatment also increased the magnesium content of the crop plants significantly at one potato location in 1957 (location 69-F-27) and at one hay trial in 1956 (location 17). The increased uptake of magnesium by cucumber vines at location 54-J-19 in 1957 was highly significant (see Tables 45a, 56a, and 58a of Appendix).

A statistical analysis of combined crop locations showed that the magnesium content was increased significantly at four of the 11 oat and barley locations in 1957 (locations 7, 9, 12, and 32) by applications of Epsom salts. An increased magnesium composition of potato and cucumber vines at all locations in 1957 by applications of both magnesium carriers was highly significant (see Tables 56a and 58a of Appendix).

From the above discussion it may be concluded that, in many cases, the applied magnesium was absorbed by the plant which was reflected in the chemical composition of the plant part tested.

B. Composition of Dry Tissue as Affected by Various Rates of Magnesium Application

The results of the chemical determination of both the fresh and dry tissue with respect to the effect of various rates of magnesium sulfate applications were quite similar in 1958. Over a 20 percent increase in magnesium in the dry tissue was noted for all crops from plots where 400 pounds of elemental magnesium was applied as magnesium sulfate. The application of half as much magnesium increased this content in only one-half of the crops. The magnesium composition of crops from plots receiving Sul-Po-Mag, foliar spray, and dolomitic hydrated limestone treatments in 1958 was, in almost every case, lower than with any of the magnesium sulfate treatments (see Table 27).

A statistical evaluation of each of the field corn and sweet corn trials in 1958 for differences in magnesium composition showed no significant changes due to applications of either magnesium carrier. However, when the locations were combined, an analysis revealed that a significant increase at the five percent level of magnesium content occurred when the 400 pound rates of magnesium sulfate were made. However, these differences in composition did not affect crop yield (see Table 14a of the Appendix).

C. Correlation Between Magnesium Content of Crop Plant and Crop Yield

Generally, there was little relation between the uptake of magnesium and crop yield response to additions of this nutrient. Only in nine trials did applied magnesium in either carrier influence both the content of magnesium and crops yields (see Table 28). In addition, three experiments showed a response in yield and magnesium composition from applications of both magnesium carriers. Usually the yield increases were less than the changes in composition on a percentage basis. For example, the percent increase in magnesium of the crop comparing the magnesium sulfate treatment with fertilizer alone ranged from 20 to 95 percent, while increases in yield amounted to 22 and 19 percent respectively for the same comparison. The changes occurring when Sul-Po-Mag was used were of lower magnitude.

D. Correlation of Exchangeable magnesium in Soil and the Magnesium Content of the Plant

The magnesium content of the various crops grown with fertilizer alone at the various locations were plotted against the quantity of exchangeable magnesium in the soil.

No direct correlation between soil and plant magnesium was found with any of the crops except beans and potatoes. A correlation coefficient of 0.932 was obtained with the field beans at five locations and an r value of 0.667 was obtained with 12 potato trials in 1957. Both of these values were significant at the five percent level (see Figure 4). With the remaining crops no significant correlations were obtained; however, in some cases there appeared to be some relationship between soil and plant composition for certain crops. In many instances the points representing correlation for individual locations were too scattered to give a close relationship. There were not a sufficient number of experiments with vegetable crops to make it possible to draw any conclusions.

The average magnesium content of each crop was generally related to the content of exchangeable magnesium in the soil but the relationship was rather imperfect as may be seen in Table 29.

E. Interrelationships of Magnesium, Potassium, Calcium, and Phosphorus

As has already been stated earlier, a negative correlation is thought to occur between potassium and magnesium in the soil and plant. Although this experiment was not designed to show these relationships, there were a few cases where such a correlation existed.

For example, as may be seen in Figure 5, there was a highly significant negative correlation between magnesium and potassium in the plant tissue of potatoes for the treatment involving magnesium sulfate at 13 locations (r of -0.78). There was also some degree of negative correlation between the two elements in potato vines from plots treated with N-P-K and N-P plus Sul-Po-Mag, but it was not significant (r of -0.35 and -0.25 respectively). It may be recalled

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from the earlier discussion that the magnesium content of potato plants was significantly increased by both magnesium treatments. Hence, it appears that for this one crop, magnesium may have influenced the uptake of potassium.

Plotting of the percent magnesium versus percent potassium for each crop revealed, in most instances, either no relationship or a slightly positive, though non-significant, correlation. Generally, the points were too widely scattered to give a reliable correlation coefficient. As might be expected, when either the percent magnesium or potassium increased in plant tissue, the calcium content declined somewhat.

Even though relatively heavy rates of magnesium were applied as magnesium sulfate for the field corn and sweet corn in 1958, it appears that supplemental magnesium had little influence on the uptake of potassium, although the magnesium content of the corn was increased. An analysis indicates that the average magnesium content for the corn at the three locations was increased over 30 percent by the 400 pound application of magnesium in respect to that of the N-P-K treatment; but the potassium content was practically unchanged in these two treatments. This finding is in agreement with other workers who have reported that potassium exerts a greater influence on the magnesium content of the plant than does magnesium on the potassium content of the plant. If varying rates of potash had been applied along with the magnesium, the results might have been different.

The average potassium composition of the various crops may be seen in Table 30. In general, there was little difference between the potassium content of the crops grown on the two broad textural groups of soils except for legume-grass hay and potatoes. In these two cases, the potassium content of the crops was highest when grown on the

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coarse textured soils. Sugar beets contained the greatest amount of potassium followed by potatoes. The small grains and particularly wheat contained the least amount of potassium. In comparison with sugar beet tissue, the percent of potassium in small grains was only one-fifth to one-sixth of the former.

The distribution of the potassium-magnesium ratios for specific crops is shown in Table 31. It may be seen that a high percentage of the corn, small grain, bean, and potato tissue had relatively narrow ratios (0 to 10) whereas about one-half of the hay trials showed a wider range of potassium-magnesium ratios (10.1 to 20).

The data in Table 32 show the average calcium composition of specific crops grown on soils of various texture. Generally, the calcium-magnesium ratio varied from 2:1 for the crops of corn, sweet corn, field beans, soybeans, cucumbers, and cauliflower to about 3:1 for hay, potatoes, and cantaloupe. On the other hand, the plant tissue of small grains and sugar beets contained one to two times more magnesium than calcium. The calcium content of the dry tissue did not vary appreciably among the various treatments or between the crops grown on soils of different texture. The small grains contained relatively small amounts of calcium while the calcium composition of cantaloupe was relatively high being two to four times greater than the magnesium content.

The phosphorus composition of the various crops is shown in Table 33. In the particular cases of cucumber and sweet corn where magnesium applications definitely increased the magnesium content, the phosphorus composition was unaffected. In general, the small grains contained about 20 to 25 percent more phosphorus than most of the other crops. Thus, no consistent relationship of total phosphorus and total magnesium in the dry plant tissue was noted as some workers have reported.

Table 23. The magnesium content of dry tissue of various field crops for all years for specific fertilizer treatments.

Crop	Plant part	Soil textural group	Number of locations	Percent Magnesium[1] Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay (1st)	Whole	coarse	9	0.25	0.25	0.34	0.29
Hay	Whole	fine	4	0.30	0.28	0.33	0.32
Hay (2nd)	Whole	coarse	6	0.34	0.29	0.31	0.31
Hay	Whole	fine	4	0.44	0.28	0.32	0.40
	Average			0.31	0.27	0.33	0.32
Corn	Leaves	coarse	10	0.39	0.38	0.43	0.43
Corn	Leaves	fine	17	0.52	0.45	0.45	0.48
	Average			0.47	0.42	0.44	0.46
Oats and	Whole	coarse	17	0.16	0.17	0.16	0.17
barley	Whole	fine	7	0.24	0.23	0.19	0.23
	Average			0.18	0.18	0.17	0.18
Wheat	Whole	coarse	3	0.19	0.23	0.20	--
Wheat	Whole	fine	9	0.18	0.21	0.19	--
	Average			0.18	0.21	0.19	--
Potatoes	Vines	coarse	10	0.45	0.40	0.50	0.52
		fine	3	0.79	0.69	0.87	0.74
	Average			0.49	0.45	0.52	0.57
Field beans	Whole	fine	5	0.49	0.52	0.61	0.50
Soybeans	Whole	coarse	2	0.49	0.25	0.31	0.59
Sugar beets	Leaf and petiole	fine	2	1.84	1.80	1.95	1.72
Cucumber	Vine	coarse	2	0.92	0.88	1.28	1.33
Cantaloupe	Vine	coarse	2	0.68	0.60	0.90	0.76
Cauliflower	Leaves and petiole	coarse	1	0.35	0.30	0.41	0.35
Sweet corn	Leaves and stalks	coarse	2	0.25	0.21	0.24	0.27

[1]Values represent average of two samples per treatment for the specified number of locations.

Table 24. The percent increase of magnesium in dry tissue of several crops as affected by magnesium applications.[1]

Crop	Number of locations	Percent increase of Mg in plants[2]	
		Epsom salts	Sul-Po-Mag
Hay	13	22.2	18.5
Corn	27	4.7	9.5
Oats and barley	24	-5.9	0.0
Wheat	12	-10.5	-
Potatoes	13	15.6	15.6
Field beans	5	17.3	-4.0
Soybeans	2	24.0	136.0
Sugar beets	2	8.3	-4.6
Cucumbers	2	45.5	51.1
Cantaloupe	2	50.0	26.6
Cauliflower	1	36.7	16.7
Sweet corn	2	14.3	28.6

[1]Compared with plots receiving N-P-K only.

[2]Values represent average of two samples per treatment for the specified number of locations.

Table 25. The number and percent of crop locations showing increased magnesium content of dry plant tissue from specific magnesium treatments for all years.[1]

Crop	Soil textural group	Total number of locations	Number of locations showing increase of Mg for		Percent of locations showing increase of Mg for		Number of locations showing increase of Mg for both treatments	Percent of locations showing increase of Mg for both treatments
			Epsom salts	Sul-Po-Mag	Epsom salts	Sul-Po-Mag		
Hay (1st)	coarse	9	6	4	67	45	4	45
Hay (2nd)	coarse	6	0	1	0	17	0	0
Hay (1st)	fine	4	2	1	50	25	1	25
Hay (2nd)	fine	4	2	2	50	50	2	50
Corn	coarse	10	4	2	40	20	2	20
	fine	17	6	6	35	35	4	26
Oats and barley	coarse	17	6	5	35	29	5	29
Potatoes	coarse	10	6	5	60	50	4	40
		3	1	1	33	33	1	33
Field beans	fine	5	2	1	40	20	1	20
Soybeans	coarse	2	1	2	50	100	1	50
Sugar beets	fine	2	1	0	50	0	0	0
Cucumber	coarse	2	2	1	100	50	1	50
Cantaloupe	coarse	2	2	1	100	50	1	50
Sweet corn		2	0	1	00	50	0	0

[1]Increased magnesium composition of 20 percent or more compared with N-P-K only plots.

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Table 26. Percent of crop locations showing increased magnesium uptake in dry tissue.[1]

Crop	Number of locations	Epsom salts	Sul-Po-Mag	Both treatments
Hay	23[2]	43	35	30
Corn	27	37	30	24
Oats and barley	17	35	29	29
Potatoes	13	54	46	38
Field beans	5	40	20	20
Soybeans	2	50	100	50
Sugar beets	2	50	0	0
Cucumbers	2	100	50	50
Cantaloupe	2	100	50	50
Sweet corn	2	0	50	0

[1]Increase of 20 percent or more.

[2]Includes two cuttings.

Table 27. The magnesium, potassium, and calcium contents of dry corn and sweet corn plants for specific magnesium treatments, 1958.[1]

Crop	Location number	Soil type	Treatment[2] A	B	C	D	E	F	G
			Percent Magnesium						
Corn	428-441	Montcalm sandy loam	0.09	0.14	0.15	0.18	0.11	0.10	0.12
Corn	414-427	Chesaning loam	0.22	0.24	0.22	0.26	0.21	0.20	0.20
Sweet corn	400-413	Plainfield sand	0.22	0.24	0.22	0.26	0.22	0.16	0.20
		Average	0.18	0.21	0.20	0.23*	0.18	0.15	0.17
			Percent Potassium						
Corn	428-441	Montcalm sandy loam	1.74	1.81	1.66	1.58	1.51	1.55	1.57
Corn	414-427	Chesaning loam	1.54	1.52	1.61	1.78	1.55	1.81	1.66
Sweet corn	400-413	Plainfield sand	2.11	2.14	1.96	1.94	1.95	1.98	1.97
		Average	1.79	1.82	1.74	1.77	1.67	1.78	1.73
			Percent Calcium						
Corn	428-441	Montcalm sandy loam	0.38	0.36	0.36	0.31	0.39	0.39	0.44
Corn	414-427	Chesaning loam	0.28	0.25	0.24	0.26	0.38	0.30	0.32
Sweet corn	400-413	Plainfield sand	0.30	0.24	0.24	0.30	0.24	0.28	0.29
		Average	0.32	0.28	0.28	0.29	0.33	0.32	0.35

*Significant at the 5% level.

[1]Includes entire vegetative portion of plant except ears.

[2]A - N-P-K only (1,000 lbs 5-20-20/acre)
B - N-P-K + 100 lbs Mg/A as Epsom salts
C - N-P-K + 200 lbs Mg/A as Epsom salts
D - N-P-K + 400 lbs Mg/A as Epsom salts
E - N-P + 100 lbs Mg/A as Sul-Po-Mag
F - N-P-K + 36 lbs Mg/A as foliar spray
G - N-P-K + 200 lbs Mg/A as hydrated dolomitic limestone

Table 28. Crop locations where magnesium applications increased magnesium composition of dry tissue and crop yield.[1]

Crop	Soil textural group	Location number	Percent increase in Mg content		Percent increase in yield		Percent Mg saturation of surface soil
			Epsom salts	Sul-Po-Mag	Epsom salts	Sul-Po-Mag	
Hay (1st)	coarse	48	39	47	17	-	0.57
Hay (2nd)	fine	44	39	-	22	-	11.40
Corn	coarse	57	91	83	31	15	1.99
Corn	fine	8	-	78	-	13	20.80
Corn	fine	61	20	-	22	-	14.00
Corn	fine	64	28	-	13	-	0.56
Corn	fine	88	25	-	14	-	24.80
Soybean	coarse	68	95	-	19	-	16.20
Cantaloupe	coarse	70-I-31	73	-	27		4.66

[1]Twenty percent or more increase in magnesium content accompanied by 10 percent or more increase in yield with one of the magnesium carriers.

Table 29. The relation of exchangeable magnesium in soil to the magnesium content of crops.

Field crop	Number of experiments	Soil textural group	Exchangeable Mg in soil M.e./100 gms.	Mg saturation of soil Percent	Mg in crop[1] tissue Percent
Hay (1st and 2nd cut)	9	coarse	0.49	7.52	0.27
	4	fine	0.87	9.94	0.28
Corn	10	coarse	0.33	3.85	0.38
	17	fine	1.90	15.08	0.44
Oats and barley	16	coarse	0.63	6.14	0.16
	3	fine	0.91	9.47	0.23
Wheat	3	coarse	0.57	5.53	0.23
	6	fine	0.98	8.67	0.20
Potatoes	10	coarse	0.48	3.77	0.40
	3	fine	1.92	10.89	0.69
Field beans	5	fine	1.24	10.60	0.52
Soybeans	2	coarse	1.63	16.50	0.25
Cucumbers	2	coarse	0.31	2.83	0.88
Cantaloupe	2	coarse	0.37	4.02	0.62
Cauliflower	1	coarse	0.63	6.79	0.30
Sweet corn	2	coarse	0.24	2.59	0.22

[1]Values represent the magnesium content of varied plant parts as given in Table 23 for samples collected from plots receiving N-P-K only.

Table 30. The potassium content of dry tissue of various field crops for all years and for specific fertilizer treatments.

Crop	Plant part	Soil texture	Number of locations	Percent Potassium[1]			
				Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay (1st)	Whole	coarse	9	2.67	3.35	3.12	3.54
Hay	Whole	fine	4	1.92	2.86	3.03	2.89
Hay (2nd)	Whole	coarse	6	2.76	3.13	2.86	3.18
Hay	Whole	fine	4	2.18	2.58	2.71	2.30
	Average			2.48	3.07	2.96	3.11
Corn	Leaves	coarse	10	2.42	2.52	2.45	2.44
Corn	Leaves	fine	17	2.42	2.55	2.49	2.37
	Average			2.42	2.54	2.47	2.39
Oats and barley	Whole	coarse	17	1.35	1.35	1.37	1.37
	Whole	fine	7	1.29	1.24	1.37	1.38
	Average			1.33	1.32	1.37	1.37
Wheat	Whole	coarse	3	0.76	0.90	0.93	-
Wheat	Whole	fine	9	0.80	0.89	0.98	-
	Average			0.79	0.89	0.96	-
Potatoes	Vines	coarse	10	4.62	4.44	4.65	4.70
Potatoes	Vines	fine	3	3.73	3.61	3.38	3.95
	Average			4.41	4.25	4.35	4.53
Field beans	Whole	fine	5	2.25	3.00	2.51	2.55
Soybeans	Whole	coarse	2	1.86	1.90	2.45	2.08
Sugar beets	Leaves and petioles	fine	2	6.78	7.40	7.04	7.22
Cucumber	Vines	coarse	2	2.46	2.50	2.36	2.78
Cantaloupe	Vines	coarse	2	2.22	2.98	2.34	2.29
Cauliflower	Leaves and stems	coarse	1	3.50	3.23	3.65	3.70
Sweet corn	Leaves and stalks	coarse	2	2.30	2.15	2.24	2.17

[1]Values represent average of two samples per treatment for the specified number of locations.

Table 11. Distribution of the potassium-magnesium ratios of dry plant tissue for specific crops.[1]

Table 31. Distribution of the potassium-magnesium ratios of dry plant tissue for specific crops.[1]

Crop	Total number locations	Potassium-magnesium ratios 0-10		10.1-20		20.1-30		30.1-40		Average[2] K-Mg ratio
		No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	
Hay	22	9	41	11	50	0	0	2	9	11.4:1
Corn	27	23	85	3	11	1	4	0	0	6.0:1
Oats and barley	24	16	67	6	25	2	8	0	0	7.3:1
Wheat	10	10	100	0	0	0	0	0	0	4.8:1
Potatoes	12	8	67	3	25	1	8	0	0	9.4:1
Field beans	5	5	100	0	0	0	0	0	0	5.7:1
Soybeans	2	1	50	1	50	0	0	0	0	7.6:1
Sugar beets	2	1	50	1	50	0	0	0	0	4.1:1
Cucumbers	2	2	100	0	0	0	0	0	0	2.8:1
Cantaloupe	2	1	50	1	50	0	0	0	0	4.9:1
Cauliflower	1	0	0	1	100	0	0	0	0	10.7:1
Sweet corn	2	1	50	1	50	0	0	0	0	10.2:1

[1]For plant tissue from N-P-K plots.

[2]Values represent average of two samples for this particular treatment for the specified number of locations.

Table 32. The calcium content of dry tissue of various field crops for all years for specific fertilizer treatments.

Crop	Plant part	Soil texture	Number of locations	Percent Calcium[1]			
				Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Hay (1st)	Whole	coarse	9	1.14	0.91	0.89	0.94
Hay	Whole	fine	4	1.14	1.32	1.12	1.11
Hay (2nd)	Whole	coarse	6	1.29	1.33	1.30	1.25
Hay	Whole	fine	4	1.47	1.44	1.06	1.28
	Average			1.23	1.18	1.06	1.11
Corn	Leaves	coarse	10	0.99	0.96	0.88	0.91
Corn	Leaves	fine	17	0.78	0.79	0.77	0.77
	Average			0.86	0.85	0.81	0.82
Oats and barley	Whole	coarse	17	0.11	0.12	0.12	0.11
		fine	7	0.08	0.11	0.11	0.10
	Average			0.10	0.12	0.12	0.11
Wheat	Whole	coarse	3	0.10	0.14	0.10	-
Wheat	Whole	fine	9	0.08	0.09	0.08	-
	Average			0.08	0.10	0.08	-
Potatoes	Vines	coarse	10	1.66	1.68	1.68	1.72
Potatoes	Vines	fine	3	1.88	1.87	1.85	1.95
Field beans	Whole	fine	5	1.05	1.18	0.90	1.19
Soybeans	Whole	coarse	2	1.40	1.07	1.50	1.34
Sugar beets	Leaf and petiole	fine	2	1.49	1.31	1.38	1.46
Cucumber	Vines	coarse	2	1.92	2.02	2.07	2.26
Cantaloupe	Vines	coarse	2	2.41	2.32	2.45	2.49
Cauliflower	Leaves and stems	coarse	1	0.60	0.63	0.52	0.54
Sweet corn	Leaves and stalks	coarse	2	0.56	0.44	0.42	0.40

[1]Values represent average of two samples per treatment for the specified number of locations.

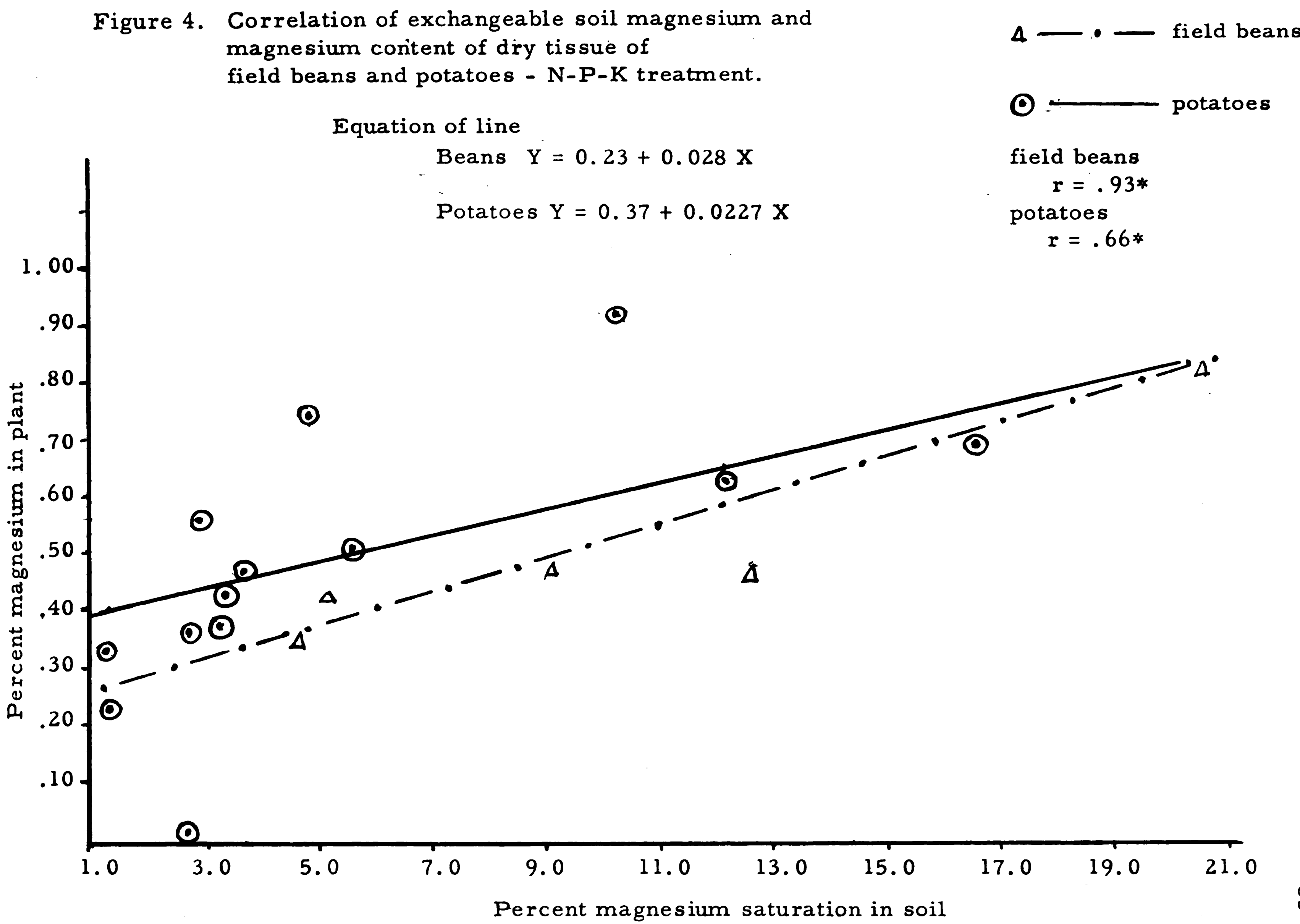
Table 33. The percent phosphorus in dry plant tissue of various crops as affected by magnesium fertilizer treatments in 1957 and 1958.

Crop	Plant part	Soil texture	Number of locations	Percent Phosphorus[1]			
				Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Corn	Leaves	coarse	3	0.24	0.24	0.23	0.21
		fine	4	0.32	0.29	0.33	0.30
	Average		7	0.28	0.27	0.28	0.26
Oats and barley	Whole	coarse	8	0.37	0.39	0.40	0.37
		fine	4	0.36	0.40	0.42	0.44
	Average		12	0.37	0.39	0.40	0.39
Potatoes	Vines	coarse	10	0.27	0.29	0.28	0.29
		fine	2	0.32	0.35	0.31	0.29
	Average		12	0.28	0.30	0.28	0.29
Cucumber	Vines	coarse	2	0.25	0.28	0.28	0.28
Cantaloupe	Vines	coarse	2	0.32	0.22	0.32	0.28
Cauliflower	Leaves and petioles	coarse	1	0.32	0.36	0.42	0.35
Sweet corn	Leaves and stalks	coarse	2	0.29	0.21	0.28	0.23

[1]Values represent average of two samples per treatment for the specified number of locations.

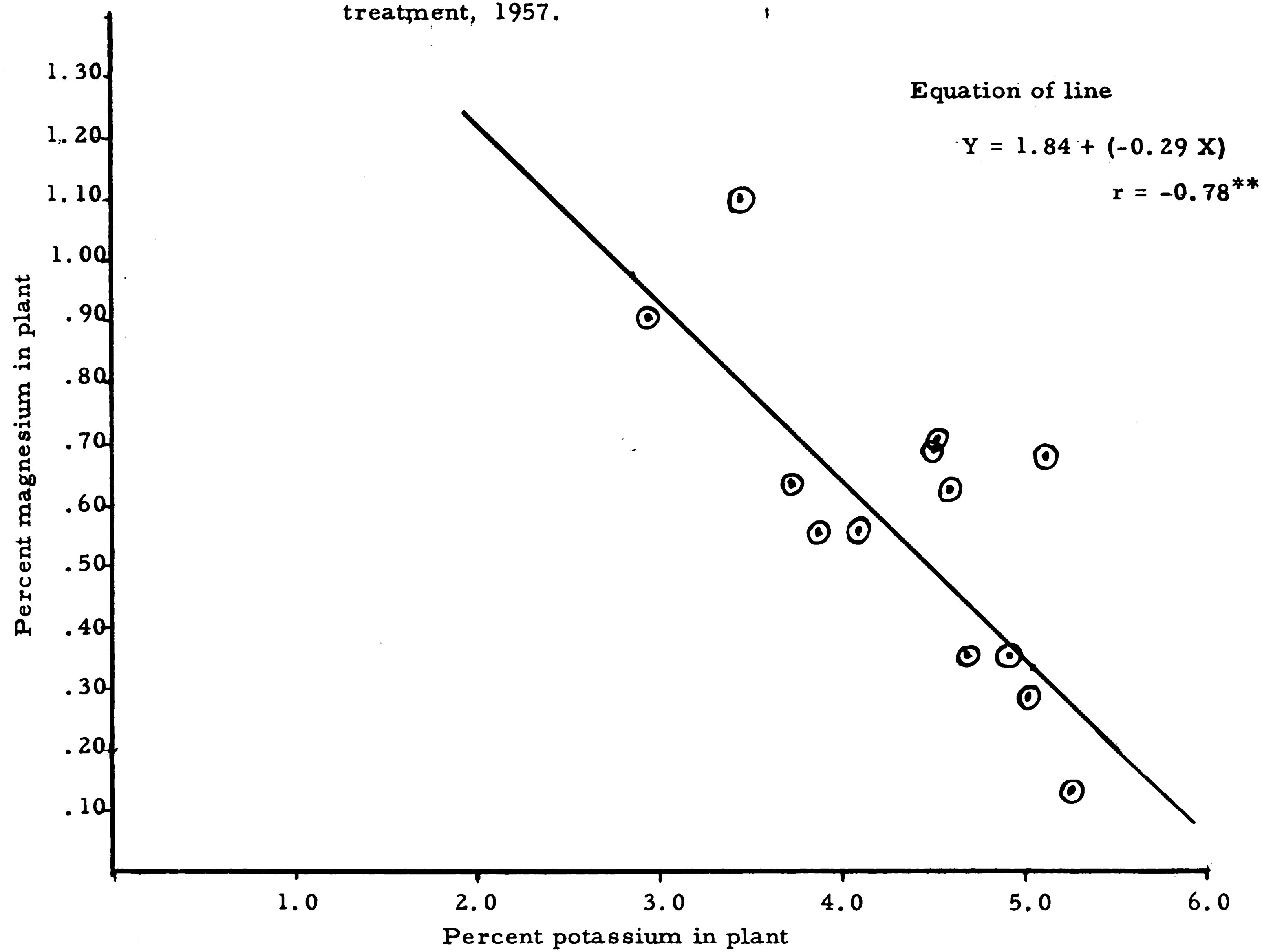
Figure 4. Correlation of exchangeable soil

Figure 4. Correlation of exchangeable soil magnesium and magnesium content of dry tissue of field beans and potatoes - N-P-K treatment.



treatment, 1957.

Figure 5. Correlation of magnesium and potassium in dry tissue of potato plants grown on all soils - magnesium sulfate treatment, 1957.



X. TOTAL REMOVAL OF NUTRIENTS FROM THE SOIL

The only crop for which it was possible to calculate total removal of magnesium was the legume-grass hay. The average quantity of magnesium, potassium, and calcium removed from the soil for the designated treatments for 13 locations was calculated and is shown in Table 34.

Table 34. The amount of magnesium, calcium, and potassium removed in legume-grass hay from various magnesium treatments.

Element	Pounds of each element removed per acre[1]			
	Check	N-P-K only	N-P-K + Epsom salts	N-P + Sul-Po-Mag
Magnesium	18.6	17.3	21.0	20.4
Calcium	73.8	75.5	67.8	71.0
Potassium	150.0	196.0	190.0	198.0

[1]Amount removed in two cuttings.

XI. SUMMARY AND CONCLUSIONS

Over a three year period, 125 field trials were conducted with different crops over the state of Michigan to evaluate the effect of magnesium fertilization on crop yield and mineral composition. Crops studied included legume hay, corn, oats, barley, wheat, field beans, soybeans, potatoes, sugar beets, cucumbers, cantaloupe, cauliflower, tomatoes, and sweet corn. Treatments consisted of two soluble magnesium carriers applied at rates varying from 100 to 400 pounds elemental magnesium per acre. Soil samples collected previous to fertilization of the experimental locations, fresh tissue plant samples taken during the growing season, and plant samples at harvest time were analyzed for magnesium as well as calcium and potassium.

The results of this project disclosed that the addition of fertilizer alone usually increased crop yields. In general, yields of most crops were little affected by magnesium treatments. Only two of approximately 125 trials gave a significant response to a soil treatment of magnesium. Although up to one-fourth of the corn, oats, and barley experiments resulted in a 10 percent or more yield increase with one or the other magnesium soil treatments, in only about one-half of these cases did the response occur from both magnesium carriers. Likewise, up to 50 percent of the soybeans and cantaloupe trials and both sweet corn experiments gave appreciable increases in yield with one of the magnesium carriers. There were, however, only a few trials involved with these latter crops.

Depressions in yield were noted from magnesium applications at over one-half of the potato and field bean locations. Considering all crops, there were about as many trials where yield depressions occurred as where yield increases were observed.

The exchange capacity varied widely among soil types, but the average exchange capacity of all soils varied little between the 0 to 6 inch and 12 to 18 inch depth. Over one-half of both surface and subsoils of coarse texture contained less than five percent magnesium on the exchange complex. The fine textured soils generally had a higher magnesium saturation, most of them lying within the range of 10 to 20 percent saturation.

About 15 percent of the coarse textured soils and five percent of the fine textured soils contained calcium-magnesium ratios exceeding 20:1. In spite of the fact that many of the soils were relatively low in exchangeable magnesium and a few had wide calcium-magnesium ratios, crop yields did not seem to be affected.

Chemical analyses of the fresh tissue and of the total dried plant did not always present the same absorption pattern insofar as magnesium composition was concerned. The magnesium content of the total dry plant was generally increased at more of the trials than the fresh tissue tests indicated. This fact can be related in part to the different time of sampling of these plant materials.

A comparison between the two plant tissue tests revealed that, in general, the magnesium content of most of the crops was appreciably increased at many of the locations by applications of one or both of the magnesium carriers. This increase was significant for the 1957 potato trials for both fresh and dry tissue. Furthermore, the 1958 experiments with corn and sweet corn showed that as the rate of magnesium fertilization increased to 400 pounds of magnesium per acre as magnesium sulfate, a significant increase in magnesium uptake occurred in both the fresh and total dried plant. There was generally little relation between magnesium uptake and crop yield.

A low negative correlation between potassium and magnesium as measured in fresh and dry plant tissue was noted except in the case of a few crops. As might be expected, there was a greater variation in the potassium-magnesium and calcium-magnesium ratios in the fresh tissue than in the dry tissue.

Considering all trials, the magnesium composition of the fresh tissue in about two-thirds of the crops was increased, on the average, up to 20 percent or more by either one or the other magnesium carrier, and up to this same amount by both magnesium sources in the case of field beans, cucumbers, and sweet corn.

A significant increase of magnesium content occurred at one-half of the corn trials in 1956 by applications of Epsom salts when these locations were combined for analysis. Likewise, considering all the potato locations in 1957, there was a highly significant increase of magnesium uptake by the plants when treated with Epsom salts. The study further revealed that as the rate of magnesium application was increased from 100 to 400 pounds as magnesium sulfate on the crops grown in 1958, the average magnesium composition increased almost proportionally.

There appeared to be little relation between the magnesium content of fresh tissue and crop yield. In the few cases where both yield and magnesium composition was increased appreciably by applications of either carrier, the magnesium saturation of the soil complex was generally low (below six percent saturation).

No consistent relationship of magnesium and potassium was noted in the fresh tissue of most crops. Wide potassium-magnesium ratios occurred among the crops varying from about 5:1 for sugar beets to 20:1 for sweet corn. Calcium-magnesium ratios in the tissue varied from 1:1 for sugar beets to 9:1 for cucumbers.

The total magnesium composition of the dry tissue was increased in a large percentage of the crops at many of the locations by one or the other of the magnesium soil treatments. A significant increase in uptake of magnesium occurred at four of the 11 oat locations in 1957 by addition of magnesium sulfate when locations were combined for analysis. Likewise, a highly significant increase of magnesium uptake occurred with potato and cucumber plants with both Epsom salt and Sul-Po-Mag treatments in 1957. The 400 pound rate of magnesium applied as magnesium sulfate significantly increased the magnesium composition of the corn and sweet corn crops grown in 1958 when all locations were considered. An increase of the magnesium composition of the crop by magnesium applications did not influence the yield appreciably in any of the trials.

In general, there was some relationship between exchangeable magnesium in the soil and magnesium composition of the plant. A significant correlation between soil and plant magnesium occurred in the case of field beans and with potatoes in 1957.

There appeared to be no definite relationship between magnesium and potassium in the dried plant. The only exception to this was in the case of potatoes where a significant negative correlation of these two elements occurred with the magnesium sulfate treatment. This was the only crop where there was an indication that magnesium might have influenced the uptake of potassium. The potassium-magnesium ratios varied from 3:1 in cucumbers to 11:1 for hay. The calcium-magnesium ratios of the crop plants varied only slightly, most of them lying in the range of 2:1 to 3:1.

These studies showed no consistent relationship of total phosphorus and total magnesium in the dry plant tissue as some workers have reported.

The results of these investigations were, to some degree, similar to findings reported at this same station recently by Satyapal (35) who found no definite correlation between dry matter production of crops and exchangeable magnesium content of the soil. Increased magnesium uptake by the plants was not accompanied by an increase in yield in all cases, and no cation constancy relationships occurred in the crops grown. However, only one of the 13 soils studied contained less than 10 percent exchangeable magnesium.

In summary, it appears that the application of magnesium containing fertilizers is not necessary on most soils of Michigan at this time. Although it is possible to increase the magnesium content of many crops by applications of substantial amounts of several magnesium carriers, this does not appear to affect crop yields. Yields of crops were not adversely affected by low exchangeable magnesium in the soil or by relatively wide calcium-magnesium ratios in the soil.

Although little or no yield response from magnesium applications occurred in these experiments, there is a possibility that magnesium deficiencies may occur in the future as cropping progresses, larger yields of crops are removed, and more highly refined fertilizers are employed. The application of dolomitic limestone on the coarser textured soils where lime is needed or use of fertilizer containing magnesium could be insurance against possible magnesium shortages occurring in the future.

Plate 1. Abnormal corn plants in Mecosta county, 1958.

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APPENDIX

Table 1a. Locations of experimental soils, 1956.

Location	County	Township	Range	Section	Soil type	Crop
1	Alcona	T26N	R9E	17	Nester loam	Oats
2	Alcona	T26N	R9E	18	Emmet sandy loam	Wheat
3	Antrim	T30N	R5W	1	Karlin loamy sand	Oats
4	Arenac	T20N	R5E	6	Nester loam	Corn
5	Bay	T16N	R4E	21	Sims loam	Field beans
6	Bay	T14N	R5E	7	Kawkawlin loam	Sugar beets
7	Bay	T14N	R5E	12	Thomas loam	Sugar beets
8	Bay	T14N	R4E	3	Kawkawlin loam	Corn
10	Bay	T13N	R5E	11	Brevort loamy sand	Potatoes
11	Bay	T13N	R5E	12	Kawkawlin loam	Potatoes
12	Berrien	T5S	R18W	10	Oshtemo loamy sand	Alfalfa
14	Berrien	T4S	R17W	35	Coloma loamy sand	Cantaloupe
16	Branch	T7S	R7W	33	Hillsdale sandy loam	Alfalfa
17	Branch	T6S	R7W	5	Coldwater loam	Ladino clover
18	Branch	T7S	R7W	34	Hillsdale sandy loam	Corn
19	Branch	T7S	R5W	14	Hillsdale sandy loam	Sudan grass
20	Branch	T7S	R5W	10	Coldwater loam	Wheat
21	Calhoun	T3S	R4W	26	Hillsdale sandy loam	Alfalfa
22	Calhoun	T3S	R4W	26	Hillsdale sandy loam	Winter barley
23	Calhoun	T3S	R4W	25	Hillsdale sandy loam	Corn
24	Calhoun	T3S	R4W	25	Hillsdale sandy loam	Oats
25	Calhoun	T3S	R4W	26	Hillsdale sandy loam	Wheat
26	Clare	T17N	R3N	8	Nester loam	Corn
27	Clinton	T7N	R2W	32	Conover loam	Alfalfa
28	Clinton	T5N	R1W	33	Fox sandy loam	Alfalfa
30	Clinton	T5N	R1W	33	Fox sandy loam	Corn
31	Clinton	T5N	R1W	33	Fox sandy loam	Oats
32	Eaton	T4N	R5W	17	Conover loam	Alfalfa

Continued

Table 1a - Continued

Location	County	Township	Range	Section	Soil type	Crop
34	Eaton	T4N	R5W	11	Conover loam	Wheat
36	Gratiot	T11N	R2W	20	Sims loam	Red Kidney beans
37	Gratiot	T10N	R2W	3	Sims loam	Corn
38	Huron	T15N	R9W	9	Sims clay loam	Field beans
39	Huron	T16N	R14E	24	Wisner loam	Field beans
40	Huron	T15N	R9E	9	Sims clay loam	Sugar beets
41	Huron	T16N	R14E	24	Wisner loam	Sugar beets
42	Huron	T16N	R14E	24	Wisner loam	Wheat
43	Huron	T15N	R9E	10	Sims clay loam	Wheat
44	Ingham	T13N	R2W	33	Conover loam	Alfalfa
45	Ingham	T13N	R2W	33	Miami loam	Corn
47	Jackson	T1S	R1E	19	Oshtemo sandy loam	Alfalfa
48	Jackson	T4S	R3W	34	Hillsdale sandy loam	Alfalfa
49	Jackson	T3S	R2E	3	Fox sandy loam	Alfalfa
50	Jackson	T1S	R1E	19	Oshtemo sandy loam	Corn
51	Jackson	T4S	R3W	34	Hillsdale sandy loam	Corn
53	Jackson	T4S	R3W	34	Oshtemo sandy loam	Oats
54	Jackson	T4S	R3W	34	Hillsdale sandy loam	Oats
55	Jackson	T2S	R1W	17	Fox sandy loam	Tomatoes
56	Kalamazoo	T1S	R9W	8	Fox sandy loam	Alfalfa
57	Kalamazoo	T1S	R9W	9	Fox sandy loam	Corn
58	Kalamazoo	T1S	R9W	8	Fox sandy loam	Oats
59	Kalamazoo	T1S	R9W	6	Fox sandy loam	Wheat
61	Lenawee	T6S	R3E	20	Miami loam	Corn
63	Lenawee	T6S	R3E	33	Miami loam	Wheat
64	Macomb	T5N	-	15	Blount silt loam	Corn
65	Marquette	-	-	-	Onaway loam	Alfalfa
66	Marquette	-	-	-	Onaway loam	Potatoes

Continued

Table 1a - Continued

Location	County	Township	Range	Section	Soil type	Crop
67	Monroe	T7S	R7E	35	Wauseon sandy loam	Soybeans
68	Monroe	T7S	R8E	18	Genesee sandy loam	Soybeans
69	Monroe	T6S	R7E	30	Wauseon sandy loam	Corn
70	Monroe	T5S	R9E	8	Miami loam	Corn
71	Monroe	T6S	R8E	--	Granby sandy loam	Oats
72	Monroe	T5S	R9E	7	Allendale loam	Wheat
73	Muskegon	T9N	R14W	3	Nester loam	Alfalfa
74	Muskegon	T9N	R14W	3	Nester loam	Corn
75	Muskegon	T12N	R17W	9	Montcalm loamy sand	Corn
76	Ogemaw	T23N	R3E	30	Nester loam	Corn
77	Oscoda	T27N	R3E	24	Montcalm loamy sand	Oats
78	Otsego	T31N	R4W	12	Kalkaska sandy loam	Oats
79	Otsego	T30N	R2W	15	Blue Lake sandy loam	Wheat
80	Saginaw	T9N	R3E	33	Sims clay loam	Barley
81	Saginaw	T9N	R3E	33	Sims clay loam	Corn
82	Saginaw	T9N	R3E	33	Sims clay loam	Wheat
83	Sanilac	T12N	R13E	32	Parkhill loam	Sugar beets
84	Shiawassee	T7N	R4E	33	Miami loam	Corn
85	Shiawassee	T7N	R3E	24	Blount loam	Corn
86	Shiawassee	T7N	R3E	23	Blount loam	Oats
87	Shiawassee	T7N	R3E	23	Blount loam	Wheat
88	St. Clair	T8N	R13E	13	Blount silt loam	Corn
89	St. Joseph	T7S	R11W	3	Oshtemo loamy sand	Alfalfa
90	St. Joseph	T7S	R11W	3	Oshtemo loamy sand	Corn
91	Tuscola	T14N	R8E	27	Conover loam	Barley
92	Tuscola	T14N	R8E	--	Sims loam	Barley
93	Tuscola	T14N	R8E	16	Thomas loam	Field beans
94	Tuscola	T12N	R7E	9	Sims loam	Field beans
95	Tuscola	T14N	R8E	16	Thomas loam	Wheat
96	Iosco	T21N	R6E	31	Selkirk loam	Corn
98	Iron	-	-		Munising sandy loam	Potatoes

Table 2a. Locations of experimental soils, 1957.

Location	County	Township	Range	Section	Soil type	Crop
3-K-1	Allegan	T1N	R16W	15	Newton sandy loam	Cauliflower
3-J-2	Allegan	T1N	R16W	22	Spinks loamy sand	Cucumber
5-F-3	Antrim	T30N	R5W	22	Mancelona sandy loam	Potatoes
9-F-4	Bay	T13N	R5E	11	Brevort loamy sand	Potatoes
9-F-5	Bay	T13N	R16E	14	Wisner loam	Potatoes
13-B-7	Calhoun	T3S	R4W	26	Hillsdale sandy loam	Corn
13-C-7	Calhoun	T3S	R4W	25	Hillsdale sandy loam	Oats
15-F-8	Charlevoix	T33N	R7W	2	Onaway loam	Potatoes
15-C-9	Charlevoix	T32N	R6W	1	Emmet sandy loam	Oats
16-F-10	Cheboygan	T35N	R2W	24	Onaway sandy loam	Potatoes
16-F-11	Cheboygan	T35N	R3W	20	Leelanau loamy sand	Potatoes
16-C-12	Cheboygan	T37N	R1W	29	Emmet sandy loam	Oats
19-B-13	Clinton	T8N	R1W	30	Chesaning loam	Corn
19-C-13	Clinton	T8N	R1W	30	Chesaning loam	Oats
19-B-14	Clinton	T5N	R3W	15	Miami loam	Corn
19-E-14	Clinton	T5N	R3W	15	Miami loam	Winter barley
24-F-15	Emmet	T36N	R4W	30	Emmet sandy loam	Potatoes
24-F-16	Emmet	T34N	R5W	30	Emmet loamy sand	Potatoes
24-C-17	Emmet	T34N	R5W	5	Emmet sandy loam	Oats
44-F-18	Lapeer	-	-	-	Bellefontaine loam	Potatoes
54-B-19	Mecosta	T13N	R7W	6	Montcalm sandy loam	Corn
54-J-19	Mecosta	T13N	R7W	6	McBride sandy loam	Cucumber
54-C-20	Mecosta	T14N	R7W	16	Isabella sandy loam	Oats
58-F-21	Monroe	T8S	R7E	4	Maumee sandy loam	Potatoes
59-C-22	Montcalm	T10N	R5W	30	Isabella loam	Oats
59-F-23	Montcalm	T11N	R6W	28	Montcalm sandy loam	Potatoes
59-F-24	Montcalm	T11N	R6W	21	McBride sandy loam	Potatoes
59-F-25	Montcalm	T11N	R7W	23	Montcalm sandy loam	Potatoes
68-C-26	Oscoda	T27N	R3E	2	Montcalm sandy loam	Oats

Continued

Table 2a - Continued

Location	County	Township	Range	Section	Soil type	Crop
69-F-27	Otsego	T31N	R4W	9	Mancelona loamy sand	Potatoes
70-B-28	Ottawa	T6N	R14W	13	Plainfield sand	Sweet corn
70-B-29	Ottawa	T5N	R13W	22	Napanee silt loam	Corn
70-I-30	Ottawa	T7N	R14W	28	Newton sand	Cantaloupe
70-I-31	Ottawa	T5N	R15W	13	Oshtemo sandy loam	Cantaloupe
70-C-32	Ottawa	T6N	R15W	24	Newton loamy sand	Oats
71-C-34	Presque Isle	T34N	R3E	22	Onaway loam	Oats
76-G-35	Sanilac	T12N	R12E	24	Parkhill loam	Sugar beets
76-G-36	Sanilac	T12N	R13E	19	Parkhill loam	Sugar beets
79-G-37	Tuscola	T14N	R8E	15	Sims loam	Sugar beets
79-G-38	Tuscola	T14N	R8E	23	Sims loam	Sugar beets
36-C-39	Iron	-	-	-	Iron River loam	Oats
31-F-40	Houghton	-	-	-	Munising sandy loam	Potatoes

Table 31. Locations of experimental soils, 1958.

Table 3a. Locations of experimental soils, 1958.

Location	County	Township	Range	Section	Soil type	Crop
200-202 (soils) 300-313 (green tissue) 400-413 (dry tissue)	Ottawa	T6N	R14W	13	Plainfield sand	Sweet corn
203-205 (CEC soils) 314-327 (green tissue) 414-427 (dry tissue)	Clinton	T8N	R1W	30	Chesaning loam	Corn
206-208 (soils) 328-341 (green tissue) 428-441 (dry tissue)	Mecosta	T13N	R7W	6	Montcalm sandy loam	Corn
209-211 (soils) 342-355 (green tissue) 442-455 (dry tissue)	Mecosta	T13N	R7W	6	Montcalm sandy loam	Oats

Table [illegible]. The yield response of legume-grass hay to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Table 4a. The yield response of legume-grass hay to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Location	County	Soil type	Yield in tons per acre[1]									
			Treatment[2] First cutting					Treatment[2] Second cutting				
			A	B	C	D	E	A	B	C	D	E
12	Berrien	Oshtemo loamy sand	2.0	2.1	2.0	2.1	1.9	0.5	0.4	0.4	0.5	0.5
16	Branch	Hillsdale sandy loam	0.9	1.5	1.7	1.3	1.4	1.3	1.3	1.5	1.0	1.3
17	Branch	Coldwater loam	2.0	2.0	1.8	2.0	1.9	0.9	1.1	1.3	1.1	1.2
21	Calhoun	Hillsdale sandy loam	3.3	3.0	3.0	3.2	3.2	1.8	1.6	1.9	1.8	1.7
27	Clinton	Conover loam	2.1	2.5	2.4	2.5	2.6	1.2	1.0	1.2	1.2	1.1
28	Clinton	Fox sandy loam	2.3	2.7	2.3	2.8	2.9	1.4	1.7	1.5	1.7	1.7
32	Eaton	Conover loam	-	-	-	-	-	0.6	0.7	0.7	0.8	0.6
44	Ingham	Conover loam	1.9	2.2	2.1	2.0	2.2	0.7	1.1	0.8	0.9	0.6
47	Jackson	Oshtemo sandy loam	1.3	1.9	1.8	1.8	1.9	0.5	0.9	0.8	0.7	0.7
48	Jackson	Hillsdale sandy loam	2.7	2.8	2.9	2.4	2.5	1.7	1.7	1.7	1.7	1.6
49	Jackson	Fox sandy loam	2.1	1.8	1.8	2.1	2.2	0.5	0.5	0.5	0.6	0.6
56	Kalamazoo	Fox sandy loam	3.4	2.8	3.1	3.2	3.3	-	-	-	-	-
65	Marquette	Onaway loam	.7	.8	.7	.8	.6	-	-	-	-	-
73	Muskegon	Nester loam	1.6	1.7	1.6	1.7	1.3	1.6	1.8	1.7	2.0	2.1
89	St. Joseph	Oshtemo loamy sand	1.7	1.2	1.2	2.3	1.6	0.8	1.0	0.8	0.8	0.8
Average			2.0	2.1	2.0	2.1	2.1	1.0	1.1	1.1	1.1	1.1

[1]Average of 2 replications.
[2]Treatments are listed in Table 2, page 22; treatments applied as a topdress on the hay.

Table [illegible] The yield response of corn to N, P, K and magnesium [illegible]
Mich[illegible]

Table 5a. The yield response of corn to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Location	County	Soil type	Yield in bushels per acre[1] Treatment A	B	C	D	E	Remarks[2]
8	Bay	Kawkawlin loam	52.2	60.8	67.0	61.0	68.7	
18	Branch	Hillsdale sandy loam	59.1	77.6	76.2	77.0	68.8	
23	Calhoun	Hillsdale sandy loam	105.3	101.3	101.3	105.3	124.6*	
37	Gratiot	Sims loam	47.3	54.8	48.9	52.8	56.7	
45	Ingham	Miami loam	63.9	63.9	64.7	61.7	68.0	
50	Jackson	Oshtemo sandy loam	70.2	81.2	69.1	78.6	80.9	
51	Jackson	Hillsdale sandy loam	83.1	92.3	71.2	77.2	88.9	
57	Kalamazoo	Fox sandy loam	51.6	58.2	53.3	44.4	51.2	
61	Lenawee	Miami loam	37.0	41.5	28.9	33.9	31.6	
64	Macomb	Blount silt loam	62.5	74.6	65.4	66.3	71.3	
69	Monroe	Wauseon sandy loam	45.2	53.2	47.3	52.6	51.5	
70	Monroe	Miami loam	40.6	43.1	40.8	41.2	42.4	
74	Muskegon	Nester loam	61.7	61.2	64.0	72.4	67.2	
75	Muskegon	Montcalm loamy sand	32.9	52.6	49.2	49.7	48.8	
81	Saginaw	Sims clay loam	109.8	97.7	111.6	111.4	91.0	
85	Shiawassee	Blount loam	71.1	67.0	68.9	71.6	72.9	
88	St. Clair	Blount silt loam	65.3	69.9	60.9	61.5	67.6	
90	St. Joseph	Oshtemo loamy sand	70.9	67.5	60.3	61.0	70.0	
Average			62.7	67.6	63.8	65.5	67.8	

[1] Average of 2 replications.

[2] Unless otherwise stated, the magnesium treatments were applied before plowing and planting of crop. In most cases, the cooperator made his regular application of fertilizer at planting time over the plot areas.

* Significantly greater than yield of D plot.

Table 6a. The yield response of oats and barley to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Location	County	Soil type	Yield in bushels per acre[1] Treatment A	B	C	D	E	Remarks
					Oats			
1	Alcona	Nester loam	42.8	33.1	43.8*	38.9	40.8	
3	Antrim	Karlin loamy sand	17.2	31.0	33.6	31.9	33.6	
24	Calhoun	Hillsdale sandy loam	54.5	65.8	63.6	55.6	54.9	
31	Clinton	Fox sandy loam	14.6	14.6	11.7	21.4	19.5	
53	Jackson	Fox sandy loam	8.5	19.2	22.7	22.0	24.1	
54	Jackson	Hillsdale sandy loam	37.5	68.1	53.3	60.3	27.2	
58	Kalamazoo	Fox sandy loam	13.8	21.6	13.8	13.8	14.7	
71	Monroe	Granby sandy loam	71.5	74.9	44.2	54.0	62.4	
77	Oscoda	Montcalm loamy sand	83.8	109.9	107.3	104.7	100.8	
78	Otsego	Kalkaska sandy loam	52.4	78.6	74.6	72.0	74.6	
86	Shiawassee	Blount loam	40.6	47.1	41.9	-	39.3	Plots C and E only 1 repl.
Average			39.7	51.3	46.4	47.5	44.7	
					Barley			
22	Calhoun	Hillsdale sandy loam	42.9	38.7	43.7	42.9	-	Winter barley N applied on B, C, D.
80	Saginaw	Sims clay loam	27.2	49.2	41.6	43.1	50.0	Spring barley
91	Tuscola	Conover loam	37.1	40.1	34.8	42.4	52.9*	Spring barley-No N
92	Tuscola	Sims loam	28.0	19.7	18.2	21.2	24.2	Spring barley-No N
Average			33.8	36.9	34.6	37.4	42.3	

[1]Average of 2 replications.
*Significantly greater than yield of D plot.

Table 7a. The yield response of wheat to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Location	County	Soil type	Yield in bushels per acre[1] Treatment A	B	C	D	Remarks[2]
2	Alcona	Emmet sandy loam	15.1	18.2	14.0	15.6	D plots down
20	Branch	Coldwater loam	39.3	42.3	38.8	36.9	
25	Calhoun	Hillsdale sandy loam	41.8	30.3	37.5	38.5	
34	Eaton	Conover loam	43.6	46.0	42.4	43.6	
42	Huron	Wisner loam	58.6	62.8	65.6	63.5	
43	Huron	Sims clay loam	50.3	63.5	70.5	59.3	
59	Kalamazoo	Fox sandy loam	50.6	44.1	43.5	48.0	
63	Lenawee	Miami loam	46.0	66.8	63.0	-	No nitrogen applied-No D plots
72	Monroe	Allendale loam	3.0	19.4	20.6	-	No nitrogen applied-No D plots
79	Otsego	Blue Lake sandy loam	26.0	27.5	27.5	28.6	
82	Saginaw	Sims clay loam	45.4	44.8	45.4	47.8	
87	Shiawassee	Blount loam	45.4	49.6	44.2	47.8	B and D plots received nitrogen-C did not.
95	Tuscola	Thomas loam	37.5	34.5	34.5	37.5	
Average			38.6	42.7	42.1	42.4	

[1]Average of 2 replications.
[2]Treatments applied on wheat as top dress.

at various locations in Michigan

Table 8a. The yield response of several bean crops and sugar beets to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Location	County	Soil type	Yield in bushels per acre[1] Treatment A	B	C	D	E	Remarks
					Beans			
5	Bay	Sims loam	34.4	33.6	31.7	33.3	35.2	
38	Huron	Sims clay loam	25.5	24.5	23.1	19.1	21.1	
39	Huron	Wisner loam	24.2	20.9	17.2	26.3	20.4	
93	Tuscola	Thomas loam	23.3	25.5	26.9	28.7	24.9	
94	Tuscola	Sims loam	33.9	33.9	33.6	33.2	32.9	
36	Gratiot	Sims loam	36.0	33.8	39.4	36.5	37.5	Red kidney
Average			29.5	28.7	28.6	29.5	28.6	
					Soybeans			
67	Monroe	Wauseon sandy loam	21.1	17.3	19.5	23.1	25.2	
68	Monroe	Genesee sandy loam	25.0	28.0	27.4	23.6	24.6	
Average			23.0	22.6	23.4	23.3	24.9	
					Yield in tons per acre[1] Sugar Beets			
6	Bay	Kawkawlin loam	13.9	18.4	16.3	17.7	18.5	
7	Bay	Thomas loam	16.4	19.5	17.6	18.1	19.2	
40	Huron	Sims clay loam	29.1	32.3	29.7	29.5	34.3	
41	Huron	Wisner loam	25.3	26.4	21.4	26.9	27.8	
83	Sanilac	Parkhill loam	6.4	5.1	5.1	7.9	6.1	
Average			18.2	20.3	18.0	20.0	21.2	

[1]Average of 2 replications.

Table 9a. The yield response of potatoes, tomatoes and cantaloupes to N-P-K and magnesium fertilizers at various locations in Michigan, 1956.

Location	County	Soil type	Yield in cwt. per acre[1] Treatment A Market	A Culls	B Market	B Culls	C Market	C Culls	D Market	D Culls	E Market	E Culls
							Potatoes					
10	Bay	Brevort loamy sand	201.0	13.2	187.2	10.8	222.0	12.0	186.6	10.8	177.6	13.2
11	Bay	Kawkawlin loam	270.0	21.6	270.0	27.0	302.4	25.8	323.4	22.8	265.2	19.2
66	Marquette	Onaway loam	67.2	-	123.0	-	159.0	-	168.6	-	95.4	-
98	Marquette	Munising sandy loam	292.8	15.6	231.0	12.0	235.8	4.2	210.5	13.2	231.0	9.6
Average			207.7	16.8	202.7	16.5	204.8	14.0	222.3	15.6	192.3	14.0
							Cantaloupe					
14	Berrien	Coloma loamy sand	307.0	75.5	305.1	116.2	356.6	66.8	347.8	92.7	223.2	89.8

Location	County	Soil type	Yield in tons per acre[1] A #1	A #2	A #3	B #1	B #2	B #3	C #1	C #2	C #3	D #1	D #2	D #3	E #1	E #2	E #3
									Tomatoes								
55	Jackson	Fox sandy loam	10.5	2.5	0.2	13.3	4.9	0.3	9.5	5.0	0.2	6.6	4.0	0.2	5.9	4.2	0.1

[1]Average of two replications.

Table 10a. The yield response of oats to N-P-K and magnesium fertilizers at various locations in Michigan, 1957.

Location number	County	Soil type	Bushels per acre[1] Treatment[2] A	B	D	E	Remarks[3]
13-C-7	Calhoun	Hillsdale sandy loam	27.6	27.2	24.1	32.3	Cooperator applied 200# 5-20-20/A.; Kent variety.
15-C-9	Charlevoix	Emmet sandy loam	61.4	70.0	70.9	70.0	Cooperator applied 300# 4-16-16/A. at planting time; planted Moore barley 25% and Jackson oats 75% by weight.
16-C-12	Cheboygan	Emmet sandy loam	70.4	73.9	69.8	82.2	Cooperator applied 300# 4-16-16/A. at planting time; Van Gard variety.
19-C-13	Clinton	Chesaning loam	16.2	25.9	20.7	20.3	Cooperator applied 200# 5-20-20. Abegweit variety; plots harvested prematurely; test weights very low.
24-C-17	Emmet	Emmet sandy loam	92.4	97.7	93.8	94.8	Cooperator applied no fertilizer on plot areas; Gary variety.
36-C-39	Iron	Iron River loam	53.2	62.6	68.1	65.8	Cooperator applied 10 T./A. manure; Bonham variety; Mg fert. applied on plowed soil before disking; yields average of 3 replications.

Continued

Table 10a - Continued

Location number	County	Soil type	Bushels per acre Treatment A	B	D	E	Remarks
54-C-20	Mecosta	Isabella sandy loam	35.3	46.2	45.0	39.7	Cooperator applied no fert. on plot areas; Bonda variety.
59-C-22	Montcalm	Isabella loam	34.4	40.5	34.0	40.1	Cooperator applied 300# 5-20-20/A.; Jackson variety.
68-C-26	Oscoda	Montcalm sandy loam	23.5	40.8	40.1*	26.3	Cooperator applied no fert. to plot areas, Branch variety.
70-C-32	Ottawa	Newton loamy sand	26.7	39.4	44.3	39.4	Cooperator applied 175# 3-12-12/A; Eaton variety; Mg fert. applied on oats just emerging.
71-C-34	Presque Isle	Onaway loam	54.0	62.2	57.4	59.3	Cooperator applied 200# 5-20-20/A.; Huron variety.
19-E-14	Clinton	Miami loam	38.6	39.4	38.6	34.4	Winter barley; Hudson variety; Cooperator applied 200# 5-20-20/A; Mg applied as topdress in early spring treatment.
		Average	44.4	52.1	50.5	50.4	

[1]Yields are average of four replications.
[2]Treatments are listed in table 2, page 22.
[3]Unless otherwise stated. the Mg treatment was applied before plowing and planting of crop. In most cases the cooperator made his regular application of fertilizer at planting time over the plot areas.
*Significant at 5% level.

Table 11a. The yield response of potatoes to N-P-K and magnesium fertilizers at various locations in Michigan, 1957

Location number	County	Soil type	Yield in Cwt/A.[1] Treatment A	B	D	E	Remarks
5-F-3	Antrim	Mancelona sandy loam	162.3	164.6	163.4	180.4	Cooperator applied 750# 4-16-16/A.;Katahdin variety.
9-F-4	Bay	Brevort loamy sand	317.8	339.4	329.2	340.5	Cooperator applied 1,000# 4-16-16/A.; Katahdin variety.
9-F-5	Bay	Wisner loam	273.9	273.9	295.1	299.6	Cooperator applied about 1200# 3-12-12/A.; Onaway variety. Yields-average 3 replications.
15-F-8	Charlevoix	Onaway loam	200.9	202.0	212.2	215.7	Cooperator applied 500# 10-10-10/A.; R. Rural variety.
16-F-10	Cheboygan	Onaway sandy loam	326.9	383.6	382.5	407.5	Cooperator applied 1000# 5-20-20/A.; R. Rural variety; Irrigated 3X.
16-F-11	Cheboygan	Leelanau loamy sand	229.3	224.7	227.0	231.5	Cooperator applied 500# 5-20-20/A.; R. Rural variety.
24-F-15	Emmet	Emmet sandy loam	208.8	199.8	190.7	199.8	Cooperator applied 750# 4-16-16/A.; R.Rural variety.
24-F-16	Emmet	Emmet loamy sand	149.8	145.3	145.3	140.7	Cooperator applied 400# 5-20-20/A.; Onaway variety; Drought damaged.
31-F-40	Houghton	Munising sandy loam	122.4	144.0	151.2	143.4	Cooperator applied no fert. on plot area; White Rural variety; late planted; dry summer.

Continued

Table 11a - Continued

Location number	County	Soil type	Yield in Cwt/A.[1] Treatment A	B	D	E	Remarks
44-F-18	Lapeer	Bellfountaine loam	156.6	149.8	169.1	171.4	Cooperator applied 1000# 5-20-20/A.; Cherokee variety.
58-F-21	Monroe	Maumee sandy loam	208.8	149.8	190.7	190.7	Cooperator applied 1500# 5-10-10/A. at planting; side-dressed with 800# 5-10-10/A.; Russet Rural variety; field irrigated.
59-F-23	Montcalm	Montcalm sandy loam	254.2	272.4	276.9	249.7	Yields are average of 3 replications.
59-F-24	Montcalm	McBride sandy loam	385.9	381.4	408.6	408.6	Cooperator applied about 1200# 5-20-20/A.; Katahdin variety; Irrigated 5x.
59-F-25	Montcalm	Montcalm sandy loam	354.1	390.4	395.0	376.8	Cooperator applied 1000# 5-20-20/A.; Katahdin variety.
69-F-27	Otsego	Mancelona loamy sand	271.5	269.5	261.0	220.2	Cooperator applied 500# 5-20-20/A.; Sebago variety.
	Average		241.5	246.0	253.2	251.7	

[1]Average of four replications.

Table 12a. The yield response of corn and sugar beets to N-P-K and magnesium fertilizers at various locations in Michigan, 1957.

Location number	County	Soil type	Corn Yield in Bu./A.[1] Treatment A	B	D	E	Remarks
13-B-7	Calhoun	Hillsdale sandy loam	89.6	98.9	96.4	87.2	Cooperator applied 80# N. plowed down plus 125# 5-20-10/A. in row; DeKalb 406 variety.
19-B-13	Clinton	Chesaning loam	60.7	64.0	64.6	62.8	Cooperator applied 200# 5-20-20/A.; Supercross 85A variety; Mg deficiency symptoms apparent in field and on all plots.
19-B-14	Clinton	Miami loam	64.6	69.7	73.9	77.1	Cooperator applied 100# 5-20-20/A.; Pfister # 57 var.
54-B-19	Mecosta	Montcalm sandy loam	24.5	34.2	25.9	23.9	Cooperator applied 100# 5-20-10/A.; Funks variety G-6; Mg deficiency symptoms apparent in parts of field and on plot areas.
70-B-29	Ottawa	Napanee silt loam	36.9	35.9	36.6	36.9	Cooperator applied 180# 12-12-12/A.; Pioneer 373 variety.; Mg treatment applied on top of soil just after planting.
	Average		55.2	60.5	69.5	57.6	

Table 12a. - Continued

Location number	County	Soil type	Sugar Beets Yield in Tons/A.[1] Treatment A	B	D	E	Remarks
76-G-35	Sanilac	Parkhill loam	14.5	19.9	18.8*	20.3	Cooperator applied 560# 5-20-20/A. containing 2% manganese-$\frac{1}{4}$% boron; % sugar 12.8-14.4; % purity 81.2-82.7.
76-G-36	Sanilac	Parkhill loam	18.3	20.4	20.3	20.7	Cooperator applied 500# 6-24-12/A. Mg fert. applied after plowing before disking; % sugar 13.1-13.7; % purity 79.5-81.3.
79-G-37	Tuscola	Sims loam	16.8	18.3	18.5	17.6	Cooperator applied 300# 5-20-20/A.; % sugar 13.8-14.6; % purity 81.8-84.2.
79-G-38	Tuscola	Sims loam	12.3	14.1	15.1	15.2	Cooperator applied 400# 3-11-11/A. (liquid); % sugar 13.4-15.0; % purity 85.0-91.8.
	Average		14.2	18.2	17.5	17.8	

[1]Average of four replications.
*Significant at 5% level.

Table 13a. The yield response of several truck crops to N-P-K and magnesium fertilizers at various locations in Michigan, 1957.

Location number	County	Soil type	Yields in Cwt./A.[1] Treatment A	B	D	E	Remarks
				Cucumbers			
3-J-2	Allegan	Spinks loamy sand	35.2	55.6	54.4	63.5	Cooperator applied 100# dolomitic spray lime and 500# 5-20-20/A.; sidedressed with 150# ammonium sulfate and 80# ammonium nitrate applied in first irrigation; irrigated 2x. Marketeer slicing cucumber; Mg fert. applied on top of soil; data from 2 pickings.
54-J-19	Mecosta	McBride sandy loam	79.2	96.0	105.0	108.0	Cooperator applied fert. only to previous green manure crop. S-R-6 pickling cucumber; total wt. for ungraded cucumbers; total of 12 pickings.
				Cauliflower			
3-K-1	Allegan	Newton sandy loam	337.7	230.1	315.0	301.0	Cooperator plowed down 500-600# 5-20-20/A. Ferry Morse Y & Gunnison #25 varieties.

[1]Average of 4 replications.

Continued

Table 13a - Continued

Location number	County	Soil type	Yields in Cwt./A. Treatment A	B	D	E	Remarks
				Sweet Corn			
70-B-28	Ottawa	Plainfield sand	53.4	90.3	73.6	96.6	Cooperator applied no fert. on plot area at planting time; sidedressed with 400# 6-12-12 plus 200# ammonium nitrate; Nor-cross var.; Mg. fert. applied after plowing; Irrigated; Yields are averages of only 2 replications.
				Cantaloupes			
70-I-30	Ottawa	Newton sand	4.7	7.0	9.3	9.3	Mg treatment applied after plowing; Pride of Wisconsin variety; practically complete crop failure--dry weather, etc.
70-I-31	Ottawa	Oshtemo sandy loam	256.7	281.8	221.8	234.4	Cooperator applied 500# 5-20-20/A.; Harvest Queen variety; Mg treatment applied after plowing, but before planting.

Table 14a. The yield response of various crops to N-P-K and fertilizers containing magnesium at various rates, 1958.

Crop	County	Soil type	Yields by treatment[1]						
			A	B	C	D	E	F	G
Corn	Clinton	Chesaning loam	40.7	33.2	37.8	34.3	38.3	36.4	30.7
Oats	Mecosta	Montcalm sandy loam	36.0	35.3	41.2	37.3	36.8	37.1	27.7
Sweet corn	Ottawa	Plainfield sand	114.1	107.5	105.6	108.6	108.1	140.9	111.8

[1]Yields are in bushels per acre for corn and oats, average of five replications; yields are in cwt. per acre for sweet corn, average of three replications; treatments are listed in table 2, page 22.

Table 15a. The pH, available phosphorus, and potassium contents of experimental soils (sands, loamy sands, and sandy loams), 1956.

Location number	County	Soil type	pH		Pounds per acre[1]			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
2	Alcona	Emmet sandy loam	5.8		22		108	
3	Antrim	Karlin loamy sand	5.7		65		144	
10	Bay	Brevort loamy sand	7.0	7.2	156	123	84	65
12	Berrien	Oshtemo loamy sand	6.6	6.5	49	15	172	67
14	Berrien	Coloma loamy sand	7.0	6.3	151	30	169	94
16	Branch	Hillsdale sandy loam	6.5	6.5	28	20	87	49
18	Branch	Hillsdale sandy loam	6.2	6.4	24	16	94	82
19	Branch	Hillsdale sandy loam	6.2	6.5	11	7	124	48
21	Calhoun	Hillsdale sandy loam	6.8	6.2	20	26	105	136
22	Calhoun	Hillsdale sandy loam	6.1	5.9	36	17	176	84
23	Calhoun	Hillsdale sandy loam	6.4	6.1	11	8	156	144

[1] .135N HCl extractant, soil-acid dilution 1:4.

Continued

Table 15a - Continued

Location number	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
24	Calhoun	Hillsdale sandy loam	5.7	5.8	27	8	97	56
25	Calhoun	Hillsdale sandy loam	6.1	5.4	31	15	240	144
28	Clinton	Fox sandy loam	6.6	5.6	15	22	80	77
30	Clinton	Fox sandy loam	7.0	6.5	31	16	80	48
31	Clinton	Fox sandy loam	6.9	6.3	27	14	85	52
47	Jackson	Oshtemo sandy loam	7.3	7.2	16	11	36	9
48	Jackson	Hillsdale sandy loam	7.0	6.1	28	15	110	64
49	Jackson	Fox sandy loam	6.9	6.9	14	6	64	40
50	Jackson	Oshtemo sandy loam	6.6	7.1	26	16	105	28
51	Jackson	Hillsdale sandy loam	6.5	5.4	24	13	138	40
54	Jackson	Hillsdale sandy loam	7.1	7.1	43	33	115	96
56	Kalamazoo	Fox sandy loam	6.5	5.2	62	26	176	95
57	Kalamazoo	Fox sandy loam	6.7	5.4	19	14	75	76
58	Kalamazoo	Fox sandy loam	6.2	6.5	37	13	152	54
59	Kalamazoo	Fox sandy loam	6.7	6.0	46	45	72	78

Continued

Table 15a - Continued

Location number	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
67	Monroe	Wauseon sandy loam	7.2	6.9	62	22	69	48
68	Monroe	Genesee sandy loam	6.6	7.0	55	108	59	66
69	Monroe	Wauseon sandy loam	5.4	5.6	33	31	73	42
71	Monroe	Granby sandy loam	6.6		69		69	
75	Muskegon	Montcalm loamy sand	7.0	7.1	46	37	98	68
77	Oscoda	Montcalm loamy sand	5.8		23		156	
78	Otsego	Kalkaska sandy loam	6.6		38		86	
79	Otsego	Blue Lake sandy loam	5.9		33		145	
89	St. Joseph	Oshtemo loamy sand	6.7	6.5	63	30	108	74
90	St. Joseph	Oshtemo loamy sand	6.4	6.5	66	31	172	49
		Ranges	5.4 - 7.3	5.2 - 7.2	11 - 156	6 - 123	36 - 240	9 - 144
		Averages	--	--	42	26	113	69
		Total number soils	36	30				

Table 16a. The pH, available phosphorus, and potassium contents of experimental soils (loams, silt loams, and clay loams), 1956.

Location number	County	Soil type	pH		Pounds per acre[1]			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
1	Alcona	Nester loam	5.9	--	34	--	234	--
4	Arenac	Nester loam	6.2	--	20	--	79	--
5	Bay	Sims loam	7.3	7.5	82	132	78	63
6	Bay	Kawkawlin loam	7.5	7.4	150	67	144	36
7	Bay	Thomas loam	7.6	7.5	102	4	98	26
8	Bay	Kawkawlin loam	7.2	7.5	31	108	74	73
11	Bay	Kawkawlin loam	7.6	7.7	216	147	160	82
17	Branch	Coldwater loam	6.0	6.3	13	3	102	104
20	Branch	Coldwater loam	6.8	6.9	71	3	117	62
26	Clare	Nester loam	6.2	--	32	--	124	--
27	Clinton	Conover loam	7.0	7.2	13	8	48	44
32	Eaton	Conover loam	7.0	7.0	40	66	84	84

[1]Extractant- .135N HCl, soil-acid dilution 1:4.

Continued

Table 16a - Continued

Location number	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
34	Eaton	Conover loam	6.9	7.1	90	54	332	192
36	Gratiot	Sims loam	6.9	7.0	102	19	150	90
37	Gratiot	Sims loam	7.1	7.0	34	22	101	48
38	Huron	Sims clay loam	6.9	7.4	47	46	62	45
39	Huron	Wisner loam	7.6	7.7	137	162	110	38
40	Huron	Sims clay loam	7.5	7.9	129	98	90	67
41	Huron	Wisner loam	7.2	7.7	249	150	79	41
42	Huron	Wisner loam	7.7	7.6	66	80	82	62
43	Huron	Sims clay loam	7.5	7.6	72	84	90	40
44	Ingham	Conover loam	7.1	7.4	34	108	67	52
45	Ingham	Miami loam	7.3	6.5	24	17	87	52
61	Lenawee	Miami loam	6.3	--	84	--	281	--
63	Lenawee	Miami loam	5.5	--	46	--	130	--
64	Macomb	Blount silt loam	6.4	6.5	22	12	69	45
65	Marquette	Onaway loam	6.1	6.2	14	66	64	56

Continued

Table 16a - Continued

Location number	County	Soil type	pH 0-6 inch	pH 12-18 inch	Pounds per acre P 0-6 inch	P 12-18 inch	K 0-6 inch	K 12-18 inch
66	Marquette	Onaway loam	6.5	6.3	10	32	44	16
70	Monroe	Miami loam	6.5	6.9	40	72	90	55
72	Monroe	Allendale loam	6.3	--	43	--	131	--
73	Muskegon	Nester loam	7.3	7.0	21	9	72	70
74	Muskegon	Nester loam	6.9	6.0	29	19	72	98
80	Saginaw	Sims clay loam	6.4	7.2	104	102	166	101
81	Saginaw	Sims clay loam	6.6	7.1	66	84	154	86
82	Saginaw	Sims clay loam	6.4	6.9	78	84	60	62
84	Shiawassee	Miami loam	7.0	7.5	47	29	134	73
85	Shiawassee	Blount loam	6.7	6.8	18	10	141	55
88	St. Clair	Blount silt loam	6.7	--	26	--	69	--
92	Tuscola	Sims loam	6.6	--	99	--	215	--
93	Tuscola	Thomas loam	7.6	--	112	--	75	--
94	Tuscola	Sims loam	7.1	7.6	114	126	72	110

Continued

Table 16a - Continued

Location number	County	Soil type	pH 0-6 inch	pH 12-18 inch	Pounds per acre P 0-6 inch	P 12-18 inch	K 0-6 inch	K 12-18 inch
95	Tuscola	Thomas loam	7.6	--	138	--	96	--
96	Iosco	Selkirk loam	7.6	--	156	--	89	--
		Ranges	5.5 - 7.6	6.0 - 7.9	10 - 249	3 - 162	48 - 332	16 - 192
		Averages	--	--	71	63	116	66
		Total number soils	43	32					

Table 17a. The pH, available phosphorus, and potassium contents of experimental soils (sands, loamy sands, and sandy loams), 1957.

Location	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
3-K-1	Allegan	Newton sandy loam	6.3	6.9	39	22	114	34
3-J-2	Allegan	Spinks loamy sand	5.2	5.7	29	24	76	50
5-F-3	Antrim	Mancelona sandy loam	5.7	5.7	12	6	66	31
9-F-4	Bay	Brevort loamy sand	7.2	7.4	23	89	185	50
13-B-7	Calhoun	Hillsdale sandy loam	6.1	5.5	23	24	96	62
13-C-7	Calhoun	Hillsdale sandy loam	6.3	5.4	14	12	60	57
15-C-9	Charlevoix	Emmet sandy loam	7.3	7.8	30	11	62	30
16-F-10	Cheboygan	Onaway sandy loam	6.2	6.2	31	22	71	50
16-F-11	Cheboygan	Leelanau loamy sand	5.6	5.8	17	13	67	45
16-C-12	Cheboygan	Emmet sandy loam	6.1	6.0	42	45	146	99
24-F-15	Emmet	Emmet sandy loam	5.8	6.5	77	21	115	66
24-F-16	Emmet	Emmet loamy sand	6.1	6.6	69	15	141	34
24-C-17	Emmet	Emmet sandy loam	7.6	7.8	28	11	90	29
54-B-19	Mecosta	Montcalm sandy loam	5.9	5.9	43	45	84	34
54-J-19	Mecosta	McBride sandy loam	6.1	5.7	52	31	57	45
54-C-20	Mecosta	Isabella sandy loam	7.2	7.0	30	15	194	94
58-F-21	Monroe	Maumee sandy loam	5.8		103		183	
59-F-23	Montcalm	Montcalm sandy loam	5.7	5.6	71	77	131	57
59-F-24	Montcalm	McBride sandy loam	5.3	5.5	73	66	94	95
59-F-25	Montcalm	Montcalm sandy loam	5.6	6.0	66	72	110	55
68-C-26	Oscoda	Montcalm sandy loam	7.0	6.8	32	13	60	59
69-F-27	Otsego	Mancelona loamy sand	6.1	5.7	79	27	148	126

Continued

Table 17a - Continued

Location	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
70-B-28	Ottawa	Plainfield sand	5.8	5.4	62	23	65	50
70-I-30	Ottawa	Newton sand	6.6	6.0	41	15	162	45
70-I-31	Ottawa	Oshtemo sandy loam	5.9	5.8	74	23	88	74
70-C-32	Ottawa	Newton loamy sand	5.7	5.6	23	14	69	29
		Ranges	5.2 - 7.6	5.4 - 7.8	12 - 103	6 - 89	60 - 194	29 - 126
		Averages	--	--	45.8	29.4	105.1	56.0
		Total number soils	26	25				

Table 18a. The pH, available phosphorus, and potassium contents of experimental soils (loams and silt loams), 1957.

Location	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
9-F-5	Bay	Wisner loam	6.9	7.2	189	132	160	60
15-F-8	Charlevoix	Onaway loam	6.2	6.0	22	16	53	24
19-B-13	Clinton	Chesaning loam	6.7	6.3	37	17	70	29
19-C-13	Clinton	Chesaning loam	6.7	7.0	27	20	63	50
19-B-14	Clinton	Miami loam	6.6	6.5	17	9	76	53
19-E-14	Clinton	Miami loam	5.5	5.7	19	10	86	55
44-F-18	Lapeer	Bellefontaine loam	5.5	5.6	33	25	71	41
59-C-22	Montcalm	Isabella loam	6.2	7.2	20	46	64	66
70-B-29	Ottawa	Napanee silt loam	6.7	5.8	17	19	110	67
71-C-34	Presque Isle	Onaway loam	7.3	7.2	38	34	52	49
36-C-39	Iron	Iron River loam	5.8	5.6	11	40	55	27
		Ranges	5.5 - 7.3	5.6 - 7.2	11 - 189	9 - 132	52 - 160	27 - 67
		Averages	--	--	39.1	33.4	78.2	47.4
		Total number soils	11	11				

Table 19a. The pH, available phosphorus, and potassium contents of experimental soils (sands and sandy loams), 1958.

Location	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
100-107	Ottawa	Plainfield sand	6.2	6.0	185	102	131	115
116-123	Mecosta	Montcalm sandy loam	6.8	6.5	103	92	170	64
124-131	Mecosta	Montcalm sandy loam	6.6	6.1	91	96	162	76
		Ranges	6.2 - 6.8	6.0 - 6.5	91 - 185	92 - 102	131 - 170	64 - 115
		Averages	--	--	126	97	154	85

Table 20a. The pH, available phosphorus, and potassium contents of experimental soils (loams), 1958.

Location	County	Soil type	pH		Pounds per acre			
					P		K	
			0-6 inch	12-18 inch	0-6 inch	12-18 inch	0-6 inch	12-18 inch
108-115	Clinton	Chesaning loam	6.6	6.9	99	35	117	62

Table 21a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (sands, loamy sands, and sandy loams), 1956.

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./ 100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
2	Alcona	Emmet sandy loam	0-6	5.8	8.55	46.8	42.1	2.34	1.80	7.01	18.0
3	Antrim	Karlin loamy sand	0-6	6.0	7.61	65.7	30.2	0.87	2.48	0.68	34.8
10	Bay	Brevort loamy sand	0-6	7.0	14.63	00.0	82.7	16.40	0.61	0.27	5.0
			12-18	7.2	18.32	00.0	84.6	14.60	0.28	0.59	5.8
12	Berrien	Oshtemo loamy sand	0-6	6.3	8.27	48.4	38.7	10.50	1.23	1.21	3.7
			12-18	6.4	5.63	53.2	37.3	2.36	4.29	2.84	15.8
14	Berrien	Coloma loamy sand	0-6	7.0	6.16	00.0	92.4	2.16	3.41	1.98	42.9
			12-18	6.3	8.97	33.4	61.3	3.71	1.02	0.48	16.5
16	Branch	Hillsdale sandy loam	0-6	6.5	7.22	55.4	36.0	5.52	1.30	1.80	6.5
			12-18	6.6	5.29	75.6	19.8	1.24	0.86	2.46	15.9
18	Branch	Hillsdale sandy loam	0-6	6.3	6.94	72.0	24.5	0.95	1.11	1.37	25.8
			12-18	6.3	4.38	68.4	26.2	1.50	1.05	2.78	17.4
19	Branch	Hillsdale sandy loam	0-6	6.0	8.43	59.3	35.6	2.37	1.21	1.54	15.0
			12-18	6.2	7.89	50.7	45.0	--	2.66	1.65	--
21	Calhoun	Hillsdale sandy loam	0-6	6.5	7.28	54.9	38.4	2.75	2.10	1.78	14.0
			12-18	5.8	8.24	48.6	37.0	11.30	0.47	2.36	3.3
22	Calhoun	Hillsdale sandy loam	0-6	5.8	9.21	54.2	28.2	13.70	1.77	1.97	2.0
			12-18	5.6	7.09	70.6	18.3	6.57	0.86	3.68	2.8
23	Calhoun	Hillsdale sandy loam	0-6	6.3	9.10	55.0	36.3	5.86	1.01	1.91	6.2
			12-18	5.7	10.83	64.6	16.6	16.60	0.94	1.20	1.0
24	Calhoun	Hillsdale sandy loam	0-6	5.6	10.84	64.5	31.4	1.84	0.82	1.40	17.0
			12-18	5.5	7.42	67.4	28.3	0.89	1.44	2.05	31.8

Continued

Table 21a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms.soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
25	Calhoun	Hillsdale sandy	0-6	5.9	13.02	61.4	26.1	9.72	1.69	1.07	2.7
		loam	12-18	5.1	12.67	63.1	26.8	7.36	1.13	1.54	3.6
28	Clinton	Fox sandy loam	0-6	6.3	6.21	80.6	6.4	10.70	1.06	1.19	0.6
			12-18	5.3	12.67	63.2	25.6	10.00	0.48	0.58	2.6
30	Clinton	Fox sandy loam	0-6	6.8	9.94	30.2	66.1	1.34	1.34	1.22	49.4
			12-18	6.4	10.05	49.8	41.8	6.62	0.91	0.94	6.3
31	Clinton	Fox sandy loam	0-6	6.5	9.45	52.9	44.4	0.70	0.92	1.00	63.6
			12-18	6.1	11.04	63.4	25.4	9.66	0.60	0.98	2.6
47	Jackson	Oshtemo sandy	0-6	7.1	4.74	00.0	81.2	15.50	1.29	2.00	5.2
		loam	12-18	6.1	6.62	75.5	21.1	1.00	1.09	1.30	21.2
48	Jackson	Hillsdale sandy	0-6	6.8	11.48	43.6	53.6	0.57	1.56	0.75	93.2
		loam	12-18	5.7	7.34	54.5	34.1	9.08	1.19	1.17	3.8
49	Jackson	Fox sandy loam	0-6	6.8	7.85	38.2	57.3	2.55	0.78	1.09	22.5
			12-18	6.2	13.77	29.0	57.0	12.60	0.48	0.88	4.5
50	Jackson	Oshtemo sandy	0-6	6.6	7.49	53.4	43.1	2.55	0.68	0.23	16.9
		loam	12-18	6.8	6.71	59.6	37.2	2.47	0.52	0.19	15.1
51	Jackson	Hillsdale sandy	0-6	6.2	9.39	53.2	42.6	2.13	1.31	0.69	20.0
		loam	12-18	5.5	11.26	62.2	32.8	4.13	0.45	0.38	7.9
54	Jackson	Hillsdale sandy	0-6	7.0	7.69	00.0	96.2	0.86	1.39	1.52	112.1
		loam	12-18	7.0	6.53	00.0	96.4	1.01	1.88	0.66	95.4
56	Kalamazoo	Fox sandy loam	0-6	6.3	10.16	49.2	43.3	5.57	1.26	0.64	7.8
			12-18	4.8	14.81	47.2	45.2	6.29	0.96	0.23	7.2
57	Kalamazoo	Fox sandy loam	0-6	6.2	9.96	45.2	50.7	1.99	1.30	0.86	25.4
			12-18	4.4	14.62	54.7	34.2	9.58	0.77	0.71	3.6

Continued

Table 21a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
58	Kalamazoo	Fox sandy loam	0-6	6.0	7.61	52.5	38.1	6.12	2.35	0.91	6.2
			12-18	6.0	8.52	47.0	43.4	7.82	0.72	0.11	5.6
59	Kalamazoo	Fox sandy loam	0-6	6.5	9.63	31.1	64.4	3.46	0.79	0.23	18.6
			12-18	5.7	10.99	36.4	56.4	6.06	0.69	0.47	9.3
67	Monroe	Wauseon sandy loam	0-6	7.1	6.75	00.0	81.5	16.80	0.90	0.77	4.8
			12-18	7.1	3.86	00.0	80.2	1.72	0.13	0.12	4.6
68	Monroe	Genesee sandy loam	0-6	6.8	13.21	22.7	59.8	16.20	0.54	0.82	3.7
			12-18	6.5	16.86	41.5	46.2	11.90	0.36	0.02	3.9
69	Monroe	Wauseon sandy loam	0-6	5.5	4.28	70.1	19.9	8.56	1.43	--	2.3
			12-18	5.8	8.60	93.0	5.2	0.58	0.36	0.80	9.0
71	Monroe	Granby sandy loam	0-6	6.6	12.83	23.4	61.2	14.00	0.56	0.84	4.4
75	Muskegon	Montcalm sandy loam	0-6	6.7	8.22	36.5	57.2	4.05	1.12	1.11	14.1
			12-18	6.8	5.51	54.4	36.3	6.95	0.83	1.48	5.2
77	Oscoda	Montcalm loamy sand	0-6	5.7	11.99	41.7	52.5	3.88	1.49	0.42	13.5
78	Otsego	Kalkaska sandy loam	0-6	6.6	9.12	32.9	59.2	5.84	0.67	1.38	10.1
79	Otsego	Blue Lake sandy loam	0-6	5.8	11.08	45.2	38.8	10.80	1.29	3.92	3.6
89	St. Joseph	Oshtemo loamy sand	0-6	6.9	5.08	16.0	64.0	15.80	1.91	0.51	4.1
			12-18	6.6	5.21	57.5	32.6	8.30	0.98	0.57	3.9

Continued

Table 21a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
90	St. Joseph	Oshtemo loamy	0-6	6.1	13.88	36.0	59.0	3.35	1.47	0.09	17.6
		sand	12-18	6.2	5.62	53.4	33.8	6.82	1.08	4.86	5.0
		Ranges	0-6	5.5	4.28	00.0	6.4	0.57	0.54	0.09	0.6
				-	-	-	-	-	-	-	-
				7.1	14.63	80.6	96.2	16.80	3.41	7.01	112.1
			12-18	4.4	3.86	00.0	5.2	0.58	0.13	0.02	1.0
				-	-	-	-	-	-	-	-
				7-2	18.32	93.0	96.4	16.60	4.28	4.86	95.4
		Averages	0-6	--	9.05	41.8	49.3	8.15	1.32	1.32	6.1
			12-18	--	9.24	51.3	39.5	6.14	.98	1.27	6.4
		Total number soils	0-6	36							
		Total number soils	12-18	30							

Table 22a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (loams, silt loams, and clay loams), 1956

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
1	Alcona	Nester loam	0-6	6.1	10.08	39.7	51.6	3.30	2.59	2.80	15.6
4	Arenac	Nester loam	0-6	6.2	8.00	50.0	33.8	9.16	4.61	2.44	3.7
5	Bay	Sims loam	0-6	7.1	9.64	00.0	75.8	20.80	1.91	1.58	3.6
			12-18	7.4	10.71	00.0	72.8	23.00	2.27	1.90	3.2
6	Bay	Kawkawlin loam	0-6	7.4	6.79	00.0	78.0	17.70	1.74	2.56	4.4
			12-18	7.2	5.57	00.0	70.0	25.10	1.00	3.89	2.8
7	Bay	Thomas loam	0-6	7.6	18.01	00.0	86.0	11.50	1.02	1.45	7.5
			12-18	7.9	15.76	00.0	86.2	11.40	0.65	1.65	7.6
8	Bay	Kawkawlin loam	0-6	7.6	7.67	00.0	76.9	20.80	0.86	1.40	3.7
			12-18	7.3	7.74	00.0	67.2	29.30	1.31	2.25	2.3
11	Bay	Kawkawlin loam	0-6	7.2	16.34	00.0	86.6	10.50	1.85	1.16	8.3
			12-18	7.1	11.26	00.0	96.7	--	1.54	1.73	--
17	Branch	Coldwater loam	0-6	6.2	13.00	38.4	51.5	6.92	0.91	2.14	7.4
			12-18	6.6	13.95	38.6	44.0	15.40	0.59	1.34	2.8
20	Branch	Coldwater loam	0-6	6.8	12.64	23.7	68.8	5.50	1.01	0.92	12.4
			12-18	6.8	9.94	30.2	55.3	13.10	0.61	0.78	4.2
26	Clare	Nester loam	0-6	6.0	19.10	47.2	38.2	11.50	1.99	1.14	3.3
27	Clinton	Conover loam	0-6	6.6	10.03	39.9	44.9	12.60	1.28	1.39	3.6
			12-18	6.8	9.97	50.2	36.1	10.70	1.74	1.30	3.4
32	Eaton	Conover loam	0-6	6.6	15.59	32.0	56.4	10.30	0.42	0.81	5.5
			12-18	6.6	14.03	35.6	52.0	10.70	0.73	0.90	4.9

Continued

Table 22a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
34	Eaton	Conover loam	0-6	6.5	19.54	20.5	70.7	6.61	1.68	0.60	10.6
			12-18	6.6	20.14	19.8	66.0	11.90	1.32	0.88	5.5
36	Gratiot	Sims loam	0-6	6.8	11.52	26.0	65.3	5.20	2.55	0.88	12.6
			12-18	7.0	6.85	00.0	86.1	10.70	1.56	1.57	8.0
37	Gratiot	Sims loam	0-6	6.8	9.15	21.9	67.8	8.01	1.45	0.94	8.5
			12-18	6.4	7.64	52.4	43.8	1.74	0.93	1.12	25.2
38	Huron	Sims clay loam	0-6	7.0	6.11	00.0	93.3	4.91	1.00	0.77	19.0
			12-18	7.6	5.96	00.0	85.6	13.40	0.59	0.37	6.4
39	Huron	Wisner loam	0-6	7.1	14.03	00.0	85.6	12.80	0.85	0.77	6.7
			12-18	7.1	12.93	00.0	92.1	6.59	0.36	1.00	14.0
40	Huron	Sims clay loam	0-6	7.3	12.89	00.0	84.2	14.20	0.79	0.82	5.9
			12-18	7.1	12.22	00.0	81.8	16.40	0.75	1.06	5.0
41	Huron	Wisner loam	0-6	7.0	13.75	00.0	90.2	8.73	0.60	0.47	10.3
			12-18	7.1	11.35	00.0	89.9	8.81	0.40	0.92	10.2
42	Huron	Wisner loam	0-6	7.2	8.10	00.0	90.1	6.58	0.63	2.72	13.7
			12-18	7.3	6.10	00.0	78.7	16.40	1.34	3.49	4.8
43	Huron	Sims clay loam	0-6	7.4	9.43	00.0	79.5	17.00	1.06	2.53	4.7
			12-18	7.3	13.51	00.0	89.5	8.88	0.45	1.12	10.1
44	Ingham	Conover loam	0-6	7.0	10.55	00.0	87.1	11.40	0.58	0.90	7.7
			12-18	6.4	15.79	31.6	55.1	12.70	0.32	0.27	4.4
45	Ingham	Miami loam	0-6	6.9	12.81	15.6	61.3	21.34	1.08	0.67	2.9
			12-18	6.2	15.22	32.8	50.6	15.30	0.60	0.62	3.3

Continued

Table 22a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
61	Lenawee	Miami loam	0-6	6.6	11.43	26.2	55.1	14.00	2.87	1.78	3.9
63	Lenawee	Miami loam	0-6	5.5	9.60	52.1	40.1	4.86	1.71	1.26	8.3
64	Macomb	Blount silt loam	0-6	6.4	11.69	42.8	54.8	0.56	0.56	1.34	97.0
			12-18	6.6	10.53	38.0	57.9	3.16	0.44	0.49	18.3
70	Monroe	Miami loam	0-6	6.6	13.50	29.6	56.7	11.80	0.64	1.18	4.8
			12-18	6.6	13.72	21.9	55.8	20.90	0.55	0.95	2.7
72	Monroe	Allendale loam	0-6	6.4	10.41	48.0	48.0	1.92	1.13	0.87	25.0
73	Muskegon	Nester loam	0-6	7.2	11.42	00.0	96.8	0.87	1.01	1.36	111.6
			12-18	7.0	4.91	00.0	91.6	4.07	1.04	3.26	22.5
74	Muskegon	Nester loam	0-6	6.5	11.28	26.6	66.5	4.73	0.90	1.27	14.1
			12-18	6.2	13.04	38.4	47.6	12.30	0.90	0.97	3.9
80	Saginaw	Sims clay loam	0-6	6.0	12.65	31.6	53.0	13.70	1.37	0.34	3.9
			12-18	6.7	18.51	21.6	65.3	11.90	0.99	0.12	5.5
81	Saginaw	Sims clay loam	0-6	6.0	14.60	34.2	51.4	12.30	1.61	0.44	4.2
			12-18	6.6	16.30	24.6	63.9	10.60	0.63	0.37	6.0
82	Saginaw	Sims clay loam	0-6	6.2	13.95	35.8	53.8	9.55	0.66	0.19	5.6
			12-18	6.7	12.64	23.7	68.8	6.33	0.52	0.55	10.9
84	Shiawassee	Miami loam	0-6	6.9	15.08	19.9	52.0	25.90	1.39	0.78	2.0
			12-18	6.5	16.61	24.1	47.3	27.10	0.77	0.84	1.7
85	Shiawassee	Blount loam	0-6	6.5	14.74	33.9	49.5	14.20	1.63	0.70	3.5
			12-18	6.5	11.51	34.8	46.9	16.50	1.02	0.79	2.8
88	St. Clair	Blount silt loam	0-6	6.6	12.91	23.2	50.3	24.80	0.59	1.08	2.0

Continued

Table 22a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
92	Tuscola	Sims loam	0-6	6.4	6.82	58.6	17.6	14.70	3.37	5.73	1.2
93	Tuscola	Thomas loam	0-6	7.0	9.63	00.0	72.7	24.20	1.86	1.21	3.0
94	Tuscola	Sims loam	0-6	7.2	17.97	00.0	89.0	9.27	0.94	0.77	9.6
			12-18	7.4	13.01	00.0	80.0	18.60	0.58	0.80	4.3
95	Tuscola	Thomas loam	0-6	7.4	9.98	00.0	78.2	17.40	1.89	2.56	4.5
96	Iosco	Selkirk loam	0-6	7.1	13.40	00.0	60.4	35.10	2.67	1.84	1.7
		Ranges	0-6	5.5	6.11	00.0	17.6	0.56	0.42	0.19	1.2
				-	-	-	-	-	-	-	-
				7.6	19.54	58.6	96.8	35.10	4.61	5.73	111.6
		Ranges	12-18	6.2	4.91	00.0	36.1	1.74	0.32	0.27	1.7
				-	-	-	-	-	-	-	-
				7.9	20.14	52.4	96.7	29.30	2.27	3.89	25.2
		Averages	0-6		12.09	19.9	65.1	10.51	1.45	1.40	6.2
			12-18		11.91	17.3	67.5	13.55	0.88	1.24	5.2
	Total number soils		0-6	41							
	Total number soils		12-18	30							

Table 23a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of ten experimental soils, 1956.

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
89	St. Joseph	Oshtemo loamy sand	0-6	6.9	7.16	41.9	46.1	10.20	1.42	0.42	4.5
			0-6	7.0	4.01	00.0	76.1	20.80	2.17	0.54	3.7
	Percent variability			1.4	35.0	32.0	29.6	33.7	24.0	9.3	17.8
50	Jackson	Oshtemo sandy loam	0-6	6.5	7.54	53.1	44.5	1.33	0.68	0.45	33.5
			0-6	6.6	7.43	53.8	41.7	3.81	0.69	0.00	11.0
	Percent variability			1.5	1.5	1.3	6.3	65.0	1.4	100.0	67.4
57	Kalamazoo	Fox sandy loam	0-6	6.3	9.30	43.0	51.0	3.58	1.48	0.88	14.3
			0-6	6.1	10.63	47.0	50.3	0.62	1.16	0.86	81.1
	Percent variability			3.2	12.5	8.5	1.3	83.0	21.6	2.3	82.0
16	Branch	Hillsdale sandy loam	0-6	6.6	7.56	52.9	34.4	9.69	1.35	1.72	3.6
			0-6	6.4	6.88	58.1	37.8	0.96	1.26	1.89	39.4
	Percent variability			3.1	9.0	9.0	9.0	90.0	6.6	9.0	91.0
11	Bay	Kawkawlin loam	0-6	7.2	14.68	00.0	85.8	10.90	2.23	1.04	7.9
			0-6	7.2	17.80	00.0	87.1	10.10	1.53	1.27	8.6
	Percent variability			00.0	17.4	00.0	1.5	7.3	31.2	18.1	8.1
73	Muskegon	Nester loam	0-6	7.3	8.38	00.0	95.5	0.79	1.84	1.92	121.2
			0-6	7.2	14.46	00.0	97.5	0.92	0.53	1.05	106.0
	Percent variability			1.3	42.0	00.0	2.0	14.1	71.2	45.3	12.5
30	Clinton	Fox sandy loam	0-6	6.9	8.76	22.8	73.7	0.75	1.35	1.38	97.7
			0-6	6.8	10.93	36.6	61.3	1.83	0.98	1.11	33.5
	Percent variability			1.3	19.8	37.7	16.8	59.0	27.4	19.6	65.7

Continued

Table 3.[illegible] – Continued

Table 23a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	H	Ca	Mg	K	Na	Ca-Mg ratio
36	Gratiot	Sims loam	0-6	6.8	13.49	37.1	53.4	6.42	2.35	0.80	8.3
			0-6	6.9	9.55	10.5	82.2	3.49	2.85	0.99	23.6
	Percent variability			1.4	29.2	71.6	35.0	45.6	17.5	19.2	64.8
39	Huron	Wisner loam	0-6	7.1	14.18	00.0	92.4	6.35	0.54	0.73	14.6
			0-6	7.2	13.88	00.0	78.6	19.50	1.18	0.81	4.0
	Percent variability			1.4	2.1	00.0	14.9	67.4	54.2	9.8	73.8
40	Huron	Sims clay loam	0-6	7.2	11.99	00.0	86.7	11.10	0.98	1.19	7.8
			0-6	7.5	13.79	00.0	81.9	16.90	0.63	0.50	4.8
	Percent variability			4.0	13.0	00.0	5.5	34.3	35.7	57.9	38.4

Table 24a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (sands, loamy sands and sandy loams), 1957.

Table 24a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (sands, loamy sands and sandy loams), 1957.

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
3-K-1	Allegan	Newton sandy loam	0-6	6.1	9.56	41.8	48.6	6.79	2.06	0.65	7.2
			12-18	6.1	6.90	43.5	43.5	11.10	0.88	1.06	3.9
3-J-2	Allegan	Spinks loamy sand	0-6	5.1	12.20	86.1	9.8	2.59	1.40	0.09	38.0
			12-18	5.1	13.41	74.6	24.2	0.86	0.34	0.00	28.0
5-F-3	Antrim	Emmet sandy loam	0-6	5.3	12.13	78.3	19.1	1.30	1.07	0.18	14.7
			12-18	5.3	17.30	57.8	41.0	0.58	0.59	0.00	71.0
9-F-4	Bay	Brevort loamy sand	0-6	6.5	15.62	22.4	63.4	12.40	1.60	0.22	5.1
			12-18	6.9	10.20	9.8	76.4	12.70	0.60	0.42	6.0
13-B-7	Calhoun	Hillsdale sandy loam	0-6	6.3	11.59	38.8	47.0	12.60	1.15	0.34	3.7
			12-18	5.5	14.10	70.9	21.3	7.09	0.43	0.30	3.0
13-C-7	Calhoun	Hillsdale sandy loam	0-6	6.0	11.98	50.0	39.4	9.72	0.70	0.12	4.0
			12-18	5.2	17.33	63.5	29.7	6.35	0.47	0.00	4.7
15-C-9	Charlevoix	Emmet sandy loam	0-6	6.9	12.68	11.8	82.7	3.81	0.60	0.98	2.2
			12-18	7.3	15.97	0.0	95.8	1.77	0.64	1.76	54.1
16-F-10	Cheboygan	Onaway sandy loam	0-6	5.7	13.14	72.3	24.4	2.78	0.35	0.20	8.7
			12-18	6.1	11.16	53.8	31.4	14.30	0.31	0.20	2.2
16-F-11	Cheboygan	Leelanau loamy sand	0-6	5.3	11.52	82.5	14.3	2.46	0.75	0.00	5.8
			12-18	5.4	9.88	81.0	16.2	2.36	0.52	0.00	6.9
16-C-12	Cheboygan	Emmet sandy loam	0-6	5.9	7.84	70.2	19.1	8.28	1.72	0.66	2.3
			12-18	6.0	7.37	67.8	19.0	11.30	1.38	0.53	1.7
24-F-15	Emmet	Emmet sandy loam	0-6	5.6	11.00	59.1	35.6	4.84	0.40	0.00	7.4
			12-18	6.1	7.64	65.4	26.2	7.41	0.67	0.29	3.5

Continued

Table 24a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
24-F-16	Emmet	Emmet loamy	0-6	5.8	11.03	63.4	32.6	2.79	1.04	0.10	11.7
		sand	12-18	6.0	7.11	56.3	38.0	4.68	0.86	0.18	8.1
24-C-17	Emmet	Emmet sandy	0-6	7.0	13.01	3.8	87.7	6.02	1.06	1.45	14.6
		loam	12-18	7.4	15.32	0.0	95.3	2.83	0.40	1.48	33.7
54-B-19	Mecosta	Montcalm sandy	0-6	6.2	7.72	77.8	18.1	2.15	1.49	0.48	8.4
		loam	12-18	5.7	8.08	86.7	8.6	3.71	0.60	0.37	2.3
54-J-19	Mecosta	McBride sandy	0-6	6.0	9.81	66.3	29.6	3.06	0.99	0.11	9.7
		loam	12-18	6.0	9.78	71.6	17.9	9.88	0.62	0.00	1.8
54-C-20	Mecosta	Isabella sandy	0-6	6.8	8.20	24.4	63.7	8.12	3.40	0.39	7.8
		loam	12-18	6.3	5.51	54.4	36.3	6.04	2.12	1.11	6.0
59-F-23	Montcalm	Montcalm sandy	0-6	5.4	12.11	82.6	12.4	3.29	1.45	0.26	3.8
		loam	12-18	5.4	11.12	89.9	7.2	2.39	0.50	0.00	3.0
59-F-24	Montcalm	McBride sandy	0-6	5.2	11.56	86.5	8.6	3.45	1.41	0.00	2.5
		loam	12-18	5.2	11.29	88.6	7.9	2.95	0.45	0.04	2.7
59-F-25	Montcalm	Montcalm sandy	0-6	5.5	11.25	80.0	15.7	3.18	1.06	0.00	4.9
		loam	12-18	5.5	9.35	85.6	12.8	1.07	0.49	0.00	12.0
68-C-26	Oscoda	Montcalm sandy	0-6	6.3	9.25	48.6	42.2	8.28	0.55	0.37	5.1
		loam	12-18	5.7	7.02	57.0	32.8	9.26	0.65	0.37	3.5
69-F-27	Otsego	Mancelona	0-6	5.9	8.89	50.6	46.4	1.26	1.70	0.09	36.8
		loamy sand	12-18	5.1	10.80	83.3	11.1	2.62	2.46	0.48	4.2
70-B-28	Ottawa	Plainfield sand	0-6	5.5	9.44	84.7	11.6	2.56	1.04	0.00	4.6
			12-18	5.4	10.83	92.3	5.1	2.15	0.47	0.00	2.4

Continued

Table 24a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
70-I-30	Ottawa	Newton sand	0-6	6.7	7.74	38.8	55.8	3.38	2.05	0.00	16.5
			12-18	6.2	6.53	76.6	21.4	0.50	1.16	0.34	42.4
70-I-31	Ottawa	Oshtemo sandy loam	0-6	5.7	10.55	80.7	14.0	4.66	0.78	0.00	3.0
			12-18	5.5	10.43	86.3	9.5	3.19	0.93	0.00	3.0
70-C-32	Ottawa	Newton loamy sand	0-6	5.4	12.10	74.3	23.1	1.92	0.54	0.00	12.0
			12-18	5.4	10.31	87.3	10.7	1.61	0.45	0.00	6.6
	Ranges		0-6	5.1 - 7.0	7.72 - 15.62	3.8 - 86.5	8.6 - 87.5	1.26 - 12.60	0.35 - 3.40	0.00 - 1.45	2.2 - 38.0
			12-18	5.1 - 7.4	6.53 - 15.97	0.0 - 92.3	5.0 - 95.8	0.50 - 14.30	0.31 - 2.46	0.00 - 1.76	1.7 - 54.1
	Averages		0-6		10.87	59.0	37.7	3.97	1.21	0.27	9.6
			12-18		10.58	64.2	29.6	5.15	0.76	0.36	12.6
	Total number soils		0-6	25							
	Total number soils		12-18	25							

Table 25a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (loams and silt loams), 1957.

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
9-F-5	Bay	Wisner loam	0-6	6.6	19.22	10.4	71.2	16.60	1.23	0.44	4.3
			12-18	6.7	18.04	16.6	64.8	17.70	0.51	0.24	3.7
15-F-8	Charlevoix	Onaway loam	0-6	6.0	10.79	55.6	38.0	5.56	0.73	0.06	6.8
			12-18	5.5	12.19	73.9	23.8	1.91	0.38	0.07	12.4
19-B-13	Clinton	Chesaning loam	0-6	6.6	8.02	43.6	47.4	6.74	2.07	0.14	7.0
			12-18	6.2	7.33	68.2	24.6	6.58	0.69	0.00	3.9
19-C-13	Clinton	Chesaning loam	0-6	6.8	8.24	12.1	74.0	12.90	0.76	0.16	5.7
			12-18	7.1	9.95	00.0	78.9	20.10	0.46	0.52	3.9
19-B-14	Clinton	Miami loam	0-6	6.0	12.18	41.0	48.8	8.34	1.55	0.18	5.9
			12-18	6.0	10.27	48.7	39.9	10.40	0.59	0.38	3.8
19-E-14	Clinton	Miami loam	0-6	5.4	13.87	64.9	29.6	4.92	0.59	0.06	6.0
			12-18	5.3	14.13	70.8	23.7	5.19	0.33	0.03	4.6
36-C-39	Iron	Iron River loam	0-6	5.6	19.08	52.4	37.7	9.25	0.29	0.30	4.1
			12-18	5.5	11.75	76.6	19.6	3.40	0.26	0.19	5.8
44-F-18	Lapeer	Bellefontaine loam	0-6	5.2	13.23	75.6	20.8	2.77	0.48	0.34	7.5
			12-18	5.3	12.83	85.7	11.7	1.82	0.51	0.26	6.4
59-C-22	Montcalm	Isabella loam	0-6	6.0	10.93	41.2	45.8	12.20	0.73	0.20	3.8
			12-18	6.8	12.31	16.2	65.0	17.30	0.71	0.71	3.8
70-B-29	Ottawa	Napanee silt loam	0-6	6.2	8.30	42.2	47.0	9.83	0.99	0.00	4.8
			12-18	5.6	11.11	72.0	22.5	4.80	0.46	0.20	4.7

Continued

Table 25a - Continued

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
71-C-34	Presque Isle	Onaway loam	0-6	6.8	13.79	14.5	75.4	8.70	0.57	0.78	8.7
			12-18	6.6	14.42	20.8	67.3	10.60	0.78	0.48	6.3
		Ranges	0-6	5.2	8.02	10.4	20.8	2.77	0.29	0.00	3.8
				-	-	-	-	-	-	-	-
				6.8	19.22	75.6	75.4	16.60	1.55	0.78	8.7
			12-18	5.3	7.33	00.0	11.7	1.82	0.26	0.00	3.7
				-	-	-	-	-	-	-	-
				6.8	18.04	85.7	78.9	20.10	0.78	0.71	12.4
		Averages	0-6		12.51	41.2	48.7	7.53	0.91	0.24	5.9
			12-18		12.21	49.9	40.2	9.07	0.52	0.28	5.4
	Total number soils		0-6	11							
	Total number soils		12-18	11							

Table 26a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (sands and sandy loams), 1958.

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
200-202	Ottawa	Plainfield sand	0-6	5.8	9.52	78.7	17.8	2.62	0.78	0.00	6.8
			12-18	5.3	10.90	91.7	6.4	1.38	0.47	0.00	4.6
206-208	Mecosta	Montcalm sandy	0-6	6.5	10.38	62.6	34.2	2.17	1.06	0.00	15.8
		loam	12-18	6.0	6.89	87.1	11.6	0.72	0.59	0.00	16.0
209-211	Mecosta	Montcalm sandy	0-6	6.7	10.61	32.9	59.6	6.12	1.28	0.00	9.7
		loam	12-18	5.8	8.70	91.9	5.7	1.72	0.59	0.00	3.3
		Ranges	0-6	5.8		32.9	17.8	2.17	0.78	0.00	6.8
				-		-	-	-	-	-	-
				6.7		78.7	59.6	6.12	1.28	0.00	9.7
			12-18	5.3		87.1	5.7	0.72	0.47	0.00	3.3
				-		-	-	-	-	-	-
				6.0		91.9	11.6	1.72	0.59	0.00	16.0
		Averages	0-6			58.1	37.2	3.64	1.04	0.00	10.2
			12-18			90.2	7.9	1.27	0.55	0.00	6.2
	Total number soils		0-6	3							
	Total number soils		12-18	3							

Table 27a. The pH, cation exchange capacity, cation saturation, and calcium-magnesium ratio of experimental soils (loams), 1958.

Location No.	County	Soil type	Depth Inches	pH	CEC. M.e./100 gms. soil	Percent saturation H	Ca	Mg	K	Na	Ca-Mg ratio
203-205	Clinton	Chesaning loam	0-6	6.4	11.69	42.7	44.5	11.9	0.70	0.09	3.7
			12-18	6.6	10.27	38.9	45.3	14.9	0.45	0.42	3.0

Table 28a. The effect of fertilizers containing magnesium on the chemical composition of fresh alfalfa leaf petioles from plants grown on soils of various textures, 1956.

Location No.	County	Soil type	Treatment[1]	Parts per million[2] K	Ca	Mg
		Loamy sands and sandy loams				
First cutting						
12	Berrien	Oshtemo loamy sand	A	8040	1720	384
			B	7740	1440	384
			C	9240	1280	336
			D	10320	1520	288
			E	7080	1690	472
48	Jackson	Hillsdale sandy loam	A	9720	4120	1024
			B	8640	2500	657
			C	11280	3900	422
			D	7200	3300	400
			E	7500	1300	672
49	Jackson	Fox sandy loam	A	19920	3400	1392
			B	9840	2480	448
			C	5760	2060	672
			D	11640	2580	1056
			E	8540	3000	648
56	Kalamazoo	Fox sandy loam	A	4800	1640	672
			B	7200	1400	672
			C	6960	920	800
			D	5340	320	688
			E	6360	240	640
89	St. Joseph	Oshtemo loamy sand	A	6360	1440	416
			B	5760	760	544
			C	5520	2080	576
			D	5640	1400	560
			E	7560	680	576
	Average of first cutting		A	9768	2464	778
			B	7836	1716	541
			C	7752	2048	561
			D	8028	1824	598
			E	7408	1382	602

[1]Treatments are given in Table 2, page 22.
[2]Values represent average of two samples per treatment.

Table 28a - Continued

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
		Loamy sands and sandy loams				
Second cutting						
16	Branch	Hillsdale sandy loam	A	13080	3400	1360
			B	18000	4400	960
			C	11040	3500	784
			D	16800	3700	896
			E	17760	3200	1312
21	Calhoun	Hillsdale sandy loam	A	3180	1760	686
			B	7200	1165	496
			C	8640	920	584
			D	12360	1320	752
			E	8460	1220	768
28	Clinton	Fox sandy loam	A	3300	2160	672
			B	10680	1040	510
			C	4560	1040	416
			D	4260	1720	640
			E	6240	1920	832
47	Jackson	Oshtemo sandy loam	A	3600	2720	1312
			B	4450	2360	1088
			C	3150	1780	1044
			D	3900	3120	1216
			E	4300	3080	1312
89	St. Joseph	Oshtemo loamy sand	A	5040	5247	992
			B	6240	3675	1424
			C	15240	3550	1248
			D	14400	4344	1168
			E	25200	3845	1728
	Average of second cutting		A	5640	3057	1004
			B	9314	2528	896
			C	8526	2158	815
			D	10344	2841	934
			E	12392	2653	1190*

*Significant at the 5% level with respect to D treatment.

Table 28a - Continued

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
		Loams				
First cutting						
17	Branch	Coldwater loam	A	8760	2400	1184
			B	9240	1480	624
			C	3720	1760	576
			D	4380	1720	656
			E	6660	2040	528
27	Clinton	Conover loam	A	6240	1410	608
			B	6600	2440	624
			C	7920	2040	528
			D	6960	1640	848
			E	6840	1440	800
73	Muskegon	Nester loam	A	6960	2240	850
			B	7680	2286	416
			C	--	--	--
			D	6120	3680	384
			E	9720	3560	1264
	Average of first cutting		A	7320	2017	881
			B	7840	2069	555
			C	5820	1900	552
			D	5820	2347	629
			E	7740	2347	864
Second cutting						
27	Clinton	Conover loam	A	3720	2240	688
			B	10200	1600	400
			C	5760	2240	336
			D	6720	1400	480
			E	12000	1190	496

Table 29a. The effect of fertilizers containing magnesium on the chemical composition of fresh corn leaf tissue from plants grown on soils of various textures, 1956.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
		Loamy sands and sandy loams				
18	Branch	Hillsdale sandy loam	A	13440	1480	552
			B	24000	1760	464
			C	15360	1680	368
			D	13920	1440	368
			E	21360	2280	872*
23	Calhoun	Hillsdale sandy loam	A	18720	1120	720
			B	17040	1040	480
			C	16080	840	480
			D	17760	1200	432
			E	9600	480	384
30	Clinton	Fox sandy loam	A	7400	1480	880
			B	6240	1440	880
			C	7440	1340	824
			D	8520	1800	824
			E	8880	1480	960
50	Jackson	Oshtemo sandy loam	A	18720	1120	720
			B	17040	1040	480
			C	16080	840	480
			D	17760	1200	432
			E	9600	480	384
51	Jackson	Hillsdale sandy loam	A	14280	1150	560
			B	8160	1040	384
			C	8400	940	352
			D	13200	960	320
			E	11520	2080	512
69	Monroe	Wauseon sandy loam	A	8760	900	560
			B	8520	1000	544
			C	9840	1000	504
			D	9240	940	448
			E	8400	820	768

*Significant at 5% level with respect to D treatment.

Table 29a - Continued

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
75	Muskegon	Montcalm loamy sand	A	4320	1760	556
			B	12960	820	548
			C	9000	1140	568
			D	10800	980	448
			E	7680	880	416
90	St. Joseph	Oshtemo loamy sand	A	8880	880	400
			B	10008	598	320
			C	--	--	--
			D	13440	676	376
			E	12240	775	432
		Average	A	11815	1236	618
			B	13005	1092	512
			C	11743	1111	511
			D	13080	1150	456
			E	11160	1159	591*
		Loam, silt loam, and clay loam				
45	Ingham	Miami loam	A	15840	1760	1136
			B	15360	1400	816
			C	21360	1340	1128
			D	12120	1760	688
			E	12000	1360	592
61	Lenawee	Miami loam	A	9840	1060	704
			B	6360	800	688
			C	6600	995	688
			D	6600	960	496
			E	9360	1000	320
64	Macomb	Blount silt loam	A	6840	660	736
			B	7200	240	704
			C	5400	520	589
			D	6480	650	392
			E	5520	600	552

*Significant at 5% level with respect to D treatment.

Table 29a - Continued

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
70	Monroe	Miami loam	A	11400	1120	496
			B	11040	1260	600
			C	8400	920	480
			D	8760	920	624
			E	6120	940	864
81	Saginaw	Sims clay loam	A	8040	860	416
			B	7080	760	384
			C	7080	900	464
			D	6380	700	480
			E	6480	800	576
84	Shiawassee	Miami loam	A	6480	640	540
			B	8280	285	488
			C	7400	440	448
			D	6600	515	472
			E	7320	560	404
85	Shiawassee	Blount loam	A	5520	900	660
			B	7680	720	672
			C	7680	940	556
			D	7680	1020	592
			E	7680	720	760
88	St. Clair	Blount silt loam	A	4920	400	352
			B	4920	580	400
			C	6360	500	264
			D	3840	600	512
			E	3960	1295	344
		Averages	A	8610	925	630
			B	8490	756	594
			C	8785	819	577
			D	7305	891	532
			E	7305	909	552

Table 30a. The effect of fertilizers containing magnesium on the chemical composition of fresh potato leaf petioles from plants grown on a loamy sand and a loam soil, 1956.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
10	Bay	Brevort loamy sand	A	4440	1200	800
			B	4000	1000	720
			C	4410	585	696
			D	4660	850	784
			E	5640	820	704
11	Bay	Kawkawlin loam	A	4420	820	720
			B	5030	995	944
			C	4250	1012	816
			D	5640	1020	912
			E	6360	940	768
		Average	A	4430	1010	760
			B	4515	998	832
			C	4330	798	756
			D	5150	935	848
			E	6000	880	736

Table 31a. **The effect of fertilizers containing magnesium on the chemical composition of fresh field bean leaf petioles from plants grown on loam soils, 1956.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
5	Bay	Sims loam	A	7920	1760	800
			B	6580	1582	992
			C	9600	1560	576
			D	5520	1305	800
			E	5640	1740	912
36	Gratiot	Sims loam[1]	A	3400	800	448
			B	3050	440	432
			C	4810	560	400
			D	4550	240	432
			E	4050	600	464
38	Huron	Sims clay loam	A	9840	2472	1120
			B	16800	1780	864
			C	6720	2032	928
			D	9960	842	448
			E	13920	1060	688
39	Huron	Wisner loam	A	7800	2329	592
			B	7680	2889	576
			C	9720	2258	672
			D	8400	1608	528
			E	7740	2000	496
93	Tuscola	Thomas loam	A	16320	2412	960
			B	7800	1407	544
			C	6360	1456	464
			D	9120	1608	544
			E	10080	1876	1184
		Average	A	9056	1955	784
			B	8382	1620	682
			C	7442	1573	608
			D	7510	1121	550
			E	8210	1455	749

[1]Red kidney beans.

Table 32a. **The effect of fertilizers containing magnesium on the chemical composition of fresh soybean leaf petioles from plants grown on sandy loam soils, 1956.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
67	Monroe	Wauseon sandy loam	A	8160	2280	1280
			B	7800	1925	1016
			C	8160	1965	880
			D	6600	1800	768
			E	9240	1880	944
68	Monroe	Genesee sandy loam	A	9240	2360	1296
			B	5640	1680	1520
			C	5760	2420	1312
			D	6240	2010	1168
			E	5280	2400	1120
		Average	A	8700	2320	1288
			B	6720	1802	1268
			C	6960	2192	1096
			D	6420	1905	968
			E	7260	2140	1032

Table 33a. **The effect of fertilizers containing magnesium on the chemical composition of fresh sugar beet leaf petioles from plants grown on loam soils, 1956.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
6	Bay	Kawkawlin loam	A	9120	160	704
			B	8400	160	784
			C	6650	140	976
			D	1080	140	776
			E	9000	120	800
7	Bay	Thomas loam	A	10080	220	512
			B	11160	100	512
			C	7080	180	472
			D	7370	140	624
			E	--	--	--
40	Huron	Sims clay loam	A	9120	211	672
			B	5640	90	720
			C	7800	194	552
			D	10440	144	856
			E	5760	191	664
		Average	A	9440	197	629
			B	8440	117	672
			C	7177	171	667
			D	6297	141	752
			E	7380	156	732

Table 34a. **The effect of fertilizers containing magnesium on the chemical composition of fresh oat plant tissue from plants grown on soils of different textures,** 1957.

Location No.	County	Soil type	Treatment[1]	Parts per million[2] K	Ca	Mg
		Loamy sands and sandy loams				
13-C-7	**Calhoun**	**Hillsdale sandy loam**	A	5250	2520	816
			B	5550	3320	816
			D	5000	2320	880
			E	5200	2460	640
15-C-9	**Charlevoix**	**Emmet sandy loam**	A	6150	2180	960
			B	5900	2300	720
			D	6250	2240	880
			E	6050	1820	656
16-C-12	**Cheboygan**	**Emmet sandy loam**	A	5000	2300	720
			B	4950	1660	672
			D	4400	1720	720
			E	4900	1660	672
24-C-17	**Emmet**	**Emmet sandy loam**	A	3800	2800	752
			B	3650	2800	640
			D	3550	3080	624
			E	4400	2220	816
54-C-20	**Mecosta**	**Isabella sandy loam**	A	4650	2300	1024
			B	5200	2440	976
			D	4450	2380	1104
			E	4500	2780	1088
68-C-26	**Oscoda**	**Montcalm sandy loam**	A	3850	2800	592
			B	3550	2460	800
			D	4650	2800	864
			E	4200	2460	816
70-C-32	**Ottawa**	**Newton loamy sand**	A	3500	3060	640
			B	4050	3000	768
			D	3800	3080	572
			E	3700	2320	656
		Average	A	4600	2566	786
			B	4693	2569	770
			D	4586	2517	806
			E	4707	2246	763

[1]**Treatments are given in Table 2, page 22.**

[2]**Values represent average of two samples per treatment.**

Table 34a - Continued

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
		Loams				
19-C-13	Clinton	Chesaning loam	A	4450	2260	624
			B	4750	1940	528
			D	4650	2460	672
			E	4450	2360	656
59-C-22	Montcalm	Isabella loam	A	4100	2500	1136
			B	4750	2460	1024
			D	4650	4220	752
			E	4650	2060	864
71-C-34	Presque Isle	Onaway loam	A	5750	3960	416
			B	3400	2520	400
			D	3400	2600	464
			E	3650	2800	384
		Average	A	4767	2907	725
			B	4300	2307	651
			D	4233	3093	629
			E	4250	2407	635

Table 35a. **The effect of fertilizers containing magnesium on the chemical composition of fresh potato plant tissue from plants grown on loamy sands, sandy loams, and loam soils, 1957.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
5-F-3	Antrim	Mancelona sandy loam	A	12300	3420	768
			B	12750	2860	768
			D	13200	3000	720
			E	12400	2940	800
15-F-8	Charlevoix	Onaway loam	A	12600	4060	1024
			B	13000	3640	1216
			D	12550	4660	1024
			E	12150	4520	1184
16-F-10	Cheboygan	Onaway sandy loam	A	12900	3000	816
			B	12550	2160	1424*
			D	12600	2720	1040
			E	12900	3000	1232
16-F-11	Cheboygan	Leelanau loamy sand	A	12100	3140	592
			B	11000	2660	912**
			D	12850	2640	608
			E	12000	3560	736**
24-F-15	Emmet	Emmet sandy loam	A	12900	1940	784
			B	13000	2220	912
			D	13450	1900	704
			E	12300	1980	864
24-F-16	Emmet	Emmet loamy sand	A	12300	1920	608
			B	13200	1280	768
			D	--	--	--
			E	13200	1920	512
59-F-23	Montcalm	Montcalm sandy loam	A	12450	2380	752
			B	11850	2320	768
			D	11850	2240	880
			E	12300	2260	720

*Significant at 5% level with respect to D treatment.

**Significant at 1% level with respect to D treatment.

Table 35a - Continued

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
59-F-24	Montcalm	McBride	A	11000	1820	816
		sandy loam	B	11150	1780	880
			D	11550	1960	608
			E	11600	1860	720
59-F-25	Montcalm	Montcalm	A	10300	2300	864
		sandy loam	B	10700	2320	768
			D	11150	2520	608
			E	11250	2180	848
69-F-27	Otsego	Mancelona	A	12900	1860	416
		loamy sand	B	12150	1820	608
			D	12700	1760	416
			E	12600	2220	544
		Average	A	12175	2584	744
			B	12135	2306	902**
			D	12433	2600	734
			E	12270	2644	816

**Significant at 1% level with respect to D treatment.

Table 36a. **The effect of fertilizers containing magnesium on the chemical composition of fresh corn leaf tissue from plants grown on soils of different textures, 1957.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
		Sandy loams				
13-B-7	Calhoun	Hillsdale sandy loam	A	7300	5080	1472
			B	7800	5560	896
			D	7500	5680	1120
			E	8250	5760	1120
54-B-19	Mecosta	Montcalm sandy loam	A	7450	5960	528
			B	7300	5760	653
			D	10300	5760	--
			E	7800	5620	653
		Average	A	7375	5520	1000
			B	7550	5660	774
			D	8900	5720	865
			E	8025	5690	886
		Loams				
19-B-13	Clinton	Chesaning loam	A	7600	5420	1408
			B	9050	5420	1264
			D	7750	5880	1136
			E	8400	5560	1312
19-B-14	Clinton	Miami loam	A	6550	5360	1408
			B	7550	5480	1328
			D	6950	5420	1344
			E	7500	5700	1392
70-B-29	Ottawa	Napanee silt loam	A	12000	5740	2112
			B	12000	6600	1376
			D	11300	5280	1952
			E	10850	5880	2144
		Average	A	8717	5506	1643
			B	9533	5683	1323
			D	8667	5527	1477
			E	8917	5713	1616

Table 37a. The effect of fertilizers containing magnesium on the chemical composition of fresh sugar beet leaf petioles from plants grown on loams and clay loam soils, 1957.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
76-G-35	Sanilac	Parkhill clay loam	A	4750	1960	1424
			B	6050	2720	1440
			D	5100	1860	1504
			E	5900	2520	1456
76-G-36	Sanilac	Parkhill clay loam	A	4700	2300	1488
			B	4550	2110	1766
			D	5100	3480	1248
			E	4100	2180	1520
79-G-37	Tuscola	Sims loam	A	6050	2060	1360
			B	6100	2260	1536
			D	5800	2640	1360
			E	5900	2360	1504
79-G-38	Tuscola	Sims loam	A	10300	2380	1568
			B	10700	2560	1666
			D	9550	2580	2080
			E	9050	2720	1792
		Average	A	6450	2175	1460
			B	6850	2412	1604
			D	6388	2640	1548
			E	6238	2445	1568

Table 38a. The effect of fertilizers containing magnesium on the chemical composition of fresh cucumber vine tissue from plants grown on a loamy sand and sandy loam soil, 1957.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
3-J-2	Allegan	Spinks loamy sand	A	10550	5820	896
			B	9400	5940	1264
			D	10450	5640	800
			E	8800	5620	1120
54-J-19	Mecosta	McBride sandy loam	A	10300	5760	416
			B	9300	5600	704
			D	10300	5760	512
			E	9700	6000	672
		Average	A	10425	5790	656
			B	9350	5770	984
			D	10375	5700	656
			E	9250	5810	896

Table 39a. The effect of fertilizers containing magnesium on the chemical composition of fresh cauliflower leaf petioles from plants grown on a sandy loam soil, 1957.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
3-K-1	Allegan	Newton sandy loam	A	11000	5820	1168
			B	11400	5880	1136
			D	11700	5940	1056
			E	10450	5820	1248

Table 40a. The effect of fertilizers containing magnesium on the chemical composition of fresh cantaloupe vine tissue from plants grown on a sand and sandy loam soil, 1957.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
70-I-30	Ottawa	Newton sand	A	10400	5940	832
			B	10300	6000	1088
			D	9500	5580	752
			E	7800	5900	896
70-I-31	Ottawa	Oshtemo sandy loam	A	8775	5550	688
			B	8475	5620	728
			D	8925	5100	760
			E	8550	5270	704
		Average	A	9588	5745	760
			B	9388	5810	908
			D	9212	5340	756
			E	8175	5585	800

Table 41a. The effect of fertilizers containing magnesium on the chemical composition of fresh sweet corn leaf tissue from plants grown on a sandy soil, 1957.

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
70-B-28	Ottawa	Plainfield sand	A	12150	5560	1120
			B	11150	5680	1184
			D	13200	5760	480
			E	11400	5880	1216

Table 42a. The effect of fertilizers containing magnesium on the chemical composition of fresh corn leaf tissue from plants grown on sandy loam and loam soils, 1958.

Location No.	County	Soil type	Treatment[1]	Parts per million[2] K	Ca	Mg
			Sandy loam			
328-341	Mecosta	Montcalm sandy loam	A	4600	3100	768
			B	3800	3100	992**
			C	3600	2700	864
			D	4100	2750	1184**
			E	3800	3000	754
			F	4400	3300	800
			G	4600	3500	576
			Loam			
314-327	Clinton	Chesaning loam	A	3300	2100	1144
			B	4100	2250	1088
			C	4400	2350	1440
			D	3700	2450	1315
			E	3500	2350	1298
			F	4000	2550	1261
			G	3600	3100	1398

[1]Treatments are given in table 2, page 22.

[2]Values represent average of two samples per treatment.

**Significant at 1% level with respect to A treatment.

Table 43a. **The effect of fertilizers containing magnesium on the chemical composition of fresh oat plant tissue from plants grown on a sandy loam soil, 1958.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
342-354	Mecosta	Montcalm sandy loam	A	3600	2400	736
			B	3800	2050	672
			C	3500	2050	960
			D	3700	2300	1088
			E	3800	1950	800
			F	3400	2700	704
			G	3600	2500	896

Table 44a. **The effect of fertilizers containing magnesium on the chemical composition of fresh sweet corn leaf tissue from plants grown on a sandy soil, 1958.**

Location No.	County	Soil type	Treatment	Parts per million K	Ca	Mg
300-313	Ottawa	Plainfield sand	A	4600	1650	384
			B	3700	1400	624
			C	4300	1900	640
			D	4700	1650	1008
			E	4300	1800	678
			F	4100	1750	480
			G	3900	1600	736

Table 45a. The effect of fertilizers containing magnesium on the chemical composition of dry alfalfa plants grown on soils of various textures, 1956.

Location No.	County	Soil type	Treatment[1]	Percent[2] K	Ca	Mg	Na
				Loamy sands and sandy loams			
First cutting							
12	Berrien	Oshtemo loamy sand	A	2.25	0.68	0.11	
			B	2.74	0.58	0.15	
			C	2.66	0.67	0.11	
			D	2.47	0.64	0.07	0.02
			E	2.40	0.56	0.09	
16	Branch	Hillsdale sandy loam	A	1.68	1.01	0.16	
			B	2.16	0.59	0.18	
			C	2.10	0.84	0.10	
			D	2.46	0.69	0.19	0.02
			E	2.78	0.72	0.18	
21	Calhoun	Hillsdale sandy loam	A	2.56	0.66	0.11	
			B	2.51	0.80	0.32	
			C	2.79	0.82	0.13	
			D	2.51	0.66	0.16	0.02
			E	2.25	0.70	0.20	
28	Clinton	Fox sandy loam	A	1.94	0.72	0.26	
			B	2.80	0.62	0.32	
			C	2.90	0.50	0.26	
			D	3.36	0.54	0.22	0.05
			E	3.11	0.94	0.29	
47	Jackson	Oshtemo sandy loam	A	1.65	1.33	0.32	
			B	3.52	0.94	0.47	
			C	2.96	0.80	0.36	
			D	2.62	1.04	0.25	0.05
			E	--	--	--	

[1]Treatments are given in table 2, page 22.

Continued

[2]Values represent average of two samples per treatment.

Table 45a - Continued

Location No.	County	Soil type	Treatment[1]	K (Percent[2])	Ca	Mg	Na
48	Jackson	Hillsdale sandy loam	A	2.86	1.90	0.30	
			B	2.88	1.32	0.50	
			C	3.98	1.46	0.33	
			D	4.82	1.72	0.36	0.02
			E	4.78	1.43	0.53	
49	Jackson	Fox sandy loam	A	3.68	1.12	0.39	
			B	2.53	0.96	0.38	
			C	2.58	0.88	0.25	
			D	3.14	0.84	0.39	0.04
			E	2.92	1.00	0.30	
56	Kalamazoo	Fox sandy loam	A	3.60	1.26	0.20	
			B	3.56	0.62	0.16	
			C	4.00	0.75	0.20	
			D	3.69	0.62	0.24	0.04
			E	4.44	0.75	0.26	
89	St. Joseph	Oshtemo loamy sand	A	3.80	1.62	0.37	
			B	5.34	1.54	0.56	
			C	5.06	1.15	0.37	
			D	5.12	1.42	0.36	0.02
			E	5.64	1.38	0.50	
	Average of first cutting		A	2.67	1.14	0.25	
			B	3.12	0.89	0.34	
			C	3.22	0.87	0.23	
			D	3.35	0.91	0.25	0.03
			E	3.54	0.94	0.29	
<u>Second cutting</u>							
12	Berrien	Oshtemo loamy sand	A	--	0.86	0.20	
			B	--	0.90	0.18	
			C	--	0.98	0.28	
			D	--	0.98	0.16	0.03
			E	--	0.97	0.18	

Continued

Table 45a - Continued

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
16	Branch	Hillsdale sandy loam	A	1.76	1.30	0.32	
			B	2.32	1.61	0.22	
			C	2.08	0.96	0.07	
			D	2.23	1.24	0.22	0.02
			E	2.40	1.12	0.26	
21	Calhoun	Hillsdale sandy loam	A	2.51	0.76	0.16	
			B	2.94	0.74	0.29	
			C	2.86	0.74	0.04	
			D	3.90	0.78	0.24	0.03
			E	4.22	0.80	0.28	
48	Jackson	Hillsdale sandy loam	A	3.50	1.73	0.44	
			B	3.72	1.66	0.41	
			C	4.35	--	0.37	
			D	4.24	1.75	0.37	0.05
			E	3.43	1.51	0.36	
49	Jackson	Fox sandy loam	A	3.97	1.12	0.49	
			B	2.36	1.18	0.38	
			C	3.00	1.06	0.32	
			D	2.81	1.28	0.41	0.04
			E	3.00	1.15	0.36	
89	St. Joseph	Oshtemo loamy sand	A	2.14	1.95	0.41	
			B	2.98	1.71	0.40	
			C	2.24	1.87	0.50	
			D	2.46	1.95	0.34	0.02
			E	2.84	1.97	0.41	
	Average of second cutting		A	2.78	1.29	0.34	
			B	2.86	1.30	0.31	
			C	2.91	1.12	0.26	
			D	3.13	1.33	0.29	0.03
			E	3.18	1.25	0.31	

Continued

Table 45a - Continued

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na
			Loams				
First cutting							
17	Branch (Ladino clover)	Coldwater loam	A	1.84	1.28	0.10	
			B	2.68	1.30	0.22	
			C	2.28	1.10	0.06	
			D	2.54	1.64	0.16	0.05
			E	2.40	1.44	0.27*	
27	Clinton	Conover loam	A	1.80	1.57	0.27	
			B	3.41	1.30	0.40	
			C	3.56	1.31	0.38	
			D	2.90	1.46	0.32	0.07
			E	2.81	1.07	0.34	
44	Ingham	Conover loam	A	2.19	1.28	0.57	
			B	3.20	1.32	0.57	
			C	3.03	1.11	0.54	
			D	3.16	1.28	0.41	0.06
			E	2.70	1.20	0.48	
73	Muskegon	Nester loam	A	1.84	0.43	0.24	
			B	2.83	0.56	0.15	
			C	3.02	0.60	0.18	
			D	2.86	0.88	0.22	0.02
			E	3.64	0.74	0.22	
	Average of first cutting		A	1.92	1.14	0.30	
			B	3.03	1.12	0.33	
			C	2.97	1.03	0.29	
			D	2.86	1.32	0.28	0.05
			E	2.89	1.11	0.32	

*Significant at 5% level with respect to D treatment.

Table 45a - Continued

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
Second cutting							
17	Branch (Ladino clover	Coldwater loam	A	1.34	0.87	0.11	
			B	2.06	0.75	0.12	
			C	1.94	0.87	0.07	
			D	2.54	0.88	0.07	0.07
			E	1.87	0.75	0.29	
27	Clinton	Conover loam	A	3.41	1.56	0.44	
			B	2.96	0.84	0.24	
			C	3.24	1.04	0.39	
			D	3.12	1.06	0.34	0.07
			E	2.58	1.06	0.38	
32	Eaton	Conover loam	A	2.16	1.42	0.54	
			B	2.74	1.12	0.38	
			C	2.88	1.62	0.29	
			D	2.83	1.70	0.27	0.04
			E	3.10	1.70	0.40	
44	Ingham	Conover loam	A	1.80	2.04	0.65	
			B	3.08	1.54	0.53	
			C	1.96	1.58	0.49	
			D	1.84	2.10	0.45	0.09
			E	1.67	1.62	0.53	
	Average of second cutting		A	2.18	1.47	0.44	
			B	2.71	1.06	0.32	
			C	2.50	1.28	0.31	
			D	2.58	1.44	0.28	0.07
			E	2.30	1.28	0.40	

Table 46a. The effect of fertilizers containing magnesium on the chemical composition of dry corn leaves from plants grown on soils of different textures, 1956.

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
		Sandy loams and loamy sands					
18	Branch	Hillsdale sandy loam	A	1.88	0.78	0.09	
			B	1.98	0.73	0.09	
			C	1.68	0.75	0.09	
			D	2.10	0.84	0.07	0.04
			E	2.40	0.70	0.11	
30	Clinton	Fox sandy loam	A	1.90	0.99	0.56	
			B	2.73	0.96	0.63	
			C	2.14	0.90	0.58	
			D	2.30	1.05	0.70	0.04
			E	2.19	1.06	0.66	
50	Jackson	Oshtemo sandy loam	A	2.81	1.01	0.41	
			B	2.40	1.00	0.62	
			C	3.28	0.88	0.72	
			D	4.33	0.94	0.64	0.06
			E	3.40	1.03	0.51	
51	Jackson	Hillsdale sandy loam	A	2.66	0.74	0.41	
			B	2.87	0.71	0.48	
			C	2.85	0.70	0.38	
			D	2.48	0.68	0.54	0.17
			E	2.92	9.76	0.48	
57	Kalamazoo	Fox sandy loam	A	3.54	2.26	0.38	
			B	3.07	2.21	0.67	
			C	3.32	2.24	0.44	
			D	3.32	2.50	0.35	0.26
			E	3.11	2.36	0.64	

Continued

Table 46a - Continued

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na
69	Monroe	Wauseon sandy loam	A	3.62	0.65	0.17	
			B	3.68	0.40	0.40	
			C	2.53	0.60	0.28	
			D	2.34	0.62	0.14	0.09
			E	3.72	0.58	0.58	
75	Muskegon	Montcalm loamy sand	A	1.53	1.15	0.61	
			B	2.08	1.14	0.56	
			C	2.14	1.15	0.46	
			D	2.38	1.08	0.60	0.05
			E	1.42	1.02	0.48	
		Average	A	2.56	1.08	0.38	
			B	2.69	1.02	0.49	
			C	2.56	1.03	0.42	
			D	2.75	1.10	0.43	0.10
			E	2.74	1.07	0.49	
		Loams, silt loams and clay loams					
8	Bay	Kawkawlin loam	A	1.91	--	0.20	
			B	1.35	--	0.15	
			C	1.54	--	0.16	
			D	1.33	--	0.09	0.04
			E	1.68	--	0.16	
26	Clare	Nester loam	A	2.60	0.73	0.41	
			B	2.00	0.71	0.34	
			C	2.14	0.73	0.38	
			D	3.11	0.64	0.47	--
			E	2.02	0.69	0.40	
37	Gratiot	Sims loam	A	5.32	1.00	0.72	
			B	3.69	0.92	0.62	
			C	3.67	0.94	0.60	
			D	5.08	0.96	0.74	0.06
			E	3.76	0.91	0.54	

Continued

Table 46a - Continued

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na
45	Ingham	Miami loam	A	1.97	1.13	1.02	
			B	1.80	1.14	0.64	
			C	1.61	1.12	0.74	
			D	2.24	1.11	0.86	0.06
			E	1.89	1.11	0.74	
61	Lenawee	Miami loam	A	3.47	0.98	0.56	
			B	4.16	0.98	0.72	
			C	3.26	1.00	0.67	
			D	3.45	0.98	0.60	0.05
			E	3.07	0.95	0.51	
64	Macomb	Blount silt loam	A	1.98	0.44	0.48	
			B	2.62	0.72	0.41	
			C	2.59	0.70	0.37	
			D	3.45	0.73	0.32	0.08
			E	3.82	0.71	0.46	
70	Monroe	Miami loam	A	2.38	0.93	0.54	
			B	2.42	0.92	0.47	
			C	2.06	0.90	0.48	
			D	3.00	0.95	0.49	0.04
			E	2.46	0.96	0.56	
74	Muskegon	Nester loam	A	1.36	0.72	0.42	
			B	1.80	0.70	0.28	
			C	1.58	0.72	0.34	
			D	1.93	0.79	0.41	0.04
			E	1.72	0.70	0.48	
81	Saginaw	Sims clay loam	A	2.44	0.96	0.42	
			B	4.57	0.98	0.55	
			C	3.07	0.94	0.62	
			D	2.66	1.02	0.40	0.04
			E	3.62	0.95	0.68	

Continued

Table 46a - Continued

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na
84	Shiawassee	Miami loam	A	2.28	0.49	0.52	
			B	2.56	0.48	0.58	
			C	2.59	0.54	0.61	
			D	2.86	0.48	0.36	0.05
			E	2.32	0.46	0.66	
85	Shiawassee	Blount loam	A	2.74	0.85	0.52	
			B	3.06	0.86	0.32	
			C	--	--	--	
			D	2.64	0.84	0.36	0.04
			E	2.64	0.90	0.45	
88	St. Clair	Blount silt loam	A	2.23	0.78	0.77	
			B	2.35	0.82	0.76	
			C	2.75	0.79	0.84	
			D	2.32	0.83	0.61	0.05
			E	1.84	0.79	0.69	
96	Iosco	Selkirk loam	A	2.42	0.87	0.44	
			B	2.54	0.78	0.47	
			C	2.25	0.88	0.40	
			D	2.23	0.86	0.44	0.05
			E	2.64	0.94	0.51	
		Average	A	2.55	0.82	0.54	
			B	2.69	0.83	0.49	
			C	2.43	0.84	0.52	
			D	2.79	0.85	0.47	0.05
			E	2.58	0.84	0.53	

Table 47a. The effect of fertilizers containing magnesium on the chemical composition of dry oat plants grown on soils of different textures, 1956.

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
		Sandy loams and loamy sand					
3	Antrim	Karlin loamy sand	A	0.86	0.12	0.18	
			B	0.88	0.13	0.10	
			C	0.92	0.10	0.18	
			D	0.97	0.13	0.26	0.02
			E	1.03	0.14	0.22	
51	Clinton	Fox sandy loam	A	1.68	0.16	0.25	
			B	1.50	0.14	0.20	
			C	1.98	0.22	0.31	
			D	1.40	0.16	0.30	0.12
			E	1.38	0.12	0.25	
53	Jackson	Oshtemo sandy loam	A	1.39	0.18	0.26	
			B	1.40	0.19	0.19	
			C	1.59	0.18	0.10	
			D	1.54	0.21	0.26	0.06
			E	1.80	0.18	0.15	
54	Jackson	Hillsdale sandy loam	A	1.46	0.13	0.18	
			B	1.63	0.13	0.22	
			C	1.65	0.13	0.20	
			D	1.42	0.12	0.26	0.04
			E	1.86	0.10	0.22	
58	Kalamazoo	Fox sandy loam	A	1.03	0.10	0.18	
			B	1.36	0.12	0.17	
			C	1.12	0.13	0.26	
			D	0.92	0.12	0.16	0.04
			E	1.14	0.11	0.25	
71	Monroe	Granby sandy loam	A	1.84	0.13	0.33	
			B	1.60	0.13	0.18	
			C	1.50	0.10	0.20	
			D	1.96	0.14	0.30	0.02
			E	1.42	0.10	0.16	

Continued

Table 47a - Continued

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
77	Oscoda	Montcalm loamy sand	A	1.02	0.15	0.21	
			B	1.65	0.14	0.13	
			C	1.93	0.18	0.09	
			D	1.72	0.18	0.25	0.02
			E	1.30	0.17	0.18	
78	Otsego	Kawkawlin sandy loam	A	0.98	0.14	0.08	
			B	1.42	0.12	0.19	
			C	1.42	0.18	0.20	
			D	1.18	0.17	0.06	0.03
			E	1.12	0.12	0.11	
		Average	A	1.28	0.14	0.21	
			B	1.43	0.14	0.17	
			C	1.51	0.15	0.19	
			D	1.39	0.15	0.23	0.04
			E	1.38	0.13	0.19	
		Loams					
1	Alcona	Nester loam	A	0.41	0.04	0.41	
			B	0.44	0.13	0.37	
			C	0.39	0.08	0.28	
			D	0.37	0.14	0.38	0.02
			E	0.37	0.10	0.42	
86	Shiawassee	Blount loam	A	1.90	0.12	0.28	
			B	1.86	0.14	0.18	
			C	1.82	0.12	0.20	
			D	1.72	0.09	0.28	0.04
			E	1.90	0.12	0.22	
		Average	A	1.16	0.08	0.34	
			B	1.15	0.14	0.28	
			C	1.10	0.10	0.24	
			D	1.04	0.12	0.33	0.03
			E	1.14	0.11	0.32	

Table 48a. The effect of fertilizers containing magnesium on the chemical composition of dry barley plants grown on soils of different textures, 1956.

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
		Sandy loam					
22[1]	Calhoun	Hillsdale sandy loam	A	0.98	0.07	--	
			B	0.78	0.08	0.04	
			C	0.92	0.08	0.06	
			D	0.80	0.07	0.07	0.05
			E	--	--	--	
		Clay loam					
80	Saginaw	Sims clay loam	A	1.22	0.14	0.23	
			B	1.44	0.12	0.27	
			C	--	--	--	
			D	1.18	0.15	0.34	0.04
			E	1.46	0.14	0.36	

[1]Winter barley

Table 49a. The effect of fertilizers containing magnesium on the chemical composition of dry wheat plants grown on soils of different textures, 1956.

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na
			Sandy loams				
2	Alcona	Emmet sandy loam	A	0.98	--	--	
			B	1.66	0.08	0.18	
			C	1.54	0.06	0.20	
			D	1.36	0.06	0.18	0.02
			E	--	--	--	
59	Kalamazoo	Fox sandy loam	A	0.80	0.12	0.14	
			B	0.62	0.12	0.14	
			C	0.79	0.10	0.12	
			D	0.82	0.12	0.17	0.05
79	Otsego	Blue Lake sandy loam	A	0.50	0.09	0.24	
			B	0.50	0.10	0.29	
			C	0.56	0.21	0.28	
			D	0.52	0.14	0.34	0.04
		Average	A	0.76	0.10	0.19	
			B	0.93	0.10	0.20	
			C	0.96	0.12	0.20	
			D	0.90	0.11	0.23	0.04
			E	--	--	--	
			Loams and clay loams				
20	Branch	Coldwater loam	A	0.46	0.07	0.06	
			B	0.60	0.04	0.09	
			C	0.56	0.07	0.07	
			D	0.56	0.07	0.06	0.09
34	Eaton	Conover loam	A	0.60	0.04	0.21	
			B	0.69	0.06	0.19	
			C	0.72	0.06	0.20	
			D	0.73	0.04	0.20	0.05

Continued

Table 49a - Continued

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
42	Huron	Wisner loam	A	1.31	0.10	0.35	
			B	1.57	0.21	0.30	
			C	--	0.16	0.34	
			D	1.12	0.10	0.30	--
43	Huron	Sims clay loam	A	0.71	0.07	0.17	
			B	1.24	0.07	0.28	
			C	1.20	0.07	0.28	
			D	0.98	0.08	0.24	0.06
63	Lenawee	Miami loam	A	0.62	0.06	0.09	
			B	0.58	0.06	0.12	
			C	0.73	0.06	0.22	
			D	--	--	--	--
72	Monroe	Allendale loam	A	0.82	0.07	0.09	
			B	0.75	0.04	0.09	
			C	0.92	0.06	0.20	
			D	--	--	--	--
82	Saginaw	Sims clay loam	A	0.56	0.10	0.23	
			B	0.64	0.10	0.18	
			C	0.72	0.10	0.20	
			D	0.64	0.09	0.20	0.09
87	Shiawassee	Blount loam	A	1.22	0.09	0.27	
			B	1.80	0.10	0.20	
			C	1.76	0.10	0.16	
			D	1.14	0.11	0.26	0.08
95	Tuscola	Thomas loam	A	0.90	0.11	0.18	
			B	0.95	0.07	0.22	
			C	0.74	0.10	0.07	
			D	1.03	0.11	0.20	
		Average	A	0.80	0.08	0.18	
			B	0.98	0.08	0.19	
			C	0.92	0.09	0.19	
			D	0.89	0.09	0.21	0.07

Table 50a. The effect of fertilizers containing magnesium on the chemical composition of dry field bean plants grown on loams and clay loam soils. 1956.

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
5	Bay	Sims loam	A	1.72	1.62	0.67	
			B	2.76	1.62	1.12	
			C	2.34	1.90	0.90	
			D	3.02	1.88	0.86	0.02
			E	2.17	1.62	0.78	
38	Huron	Sims clay loam	A	1.57	0.68	0.67	
			B	2.26	0.71	0.56	
			C	2.81	0.66	0.18	
			D	2.87	0.71	0.35	0.01
			E	2.32	0.95	0.45	
39	Huron	Wisner loam	A	3.06	0.72	0.58	
			B	2.66	0.50	0.48	
			C	3.67	0.94	0.45	
			D	3.24	0.73	0.48	0.01
			E	2.94	0.89	0.48	
94	Tuscola	Sims loam	A	1.82	0.82	0.34	
			B	1.38	0.53	0.41	
			C	2.46	1.09	0.54	
			D	2.42	0.88	0.50	0.01
			E	2.14	0.79	0.46	
36	Gratiot	Sims loam[1]	A	3.06	1.42	0.17	
			B	3.47	1.12	0.50	
			C	3.10	1.62	0.28	
			D	3.47	1.70	0.42	0.03
			E	3.20	1.70	0.32	
		Average	A	2.25	1.05	0.49	
			B	2.51	0.90	0.61	
			C	2.88	1.24	0.47	
			D	3.00	1.18	0.52	0.02
			E	2.55	1.19	0.50	

[1]Red kidney beans.

Table 51a. **The effect of fertilizers** containing magnesium on the chemical **composition of dry soybean plants** grown on sandy loam soils, **1956.**

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
67	Monroe	**Wauseon sandy loam**	A	1.61	1.08	0.34	
			B	2.08	1.05	0.24	
			C	1.70	1.02	0.24	
			D	1.76	1.05	0.30	0.01
			E	2.14	1.07	0.60	
68	Monroe	Genesee sandy **loam**	A	2.10	1.72	0.64	
			B	2.82	1.95	0.39	
			C	1.93	1.32	0.43	
			D	2.04	1.09	0.20	0.01
			E	2.02	1.61	0.58	
		Average	A	1.86	1.40	0.49	
			B	2.45	1.50	0.31	
			C	1.82	1.17	0.34	
			D	1.90	1.07	0.25	0.01
			E	2.08	1.34	0.59	

Table 52a. **The effect of fertilizers** containing magnesium on the chemical **composition of dry sugar** beet leaves and leaf petioles grown **on loam and clay loam** soils, 1956.

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
40	Huron	**Sims clay loam**	A	6.06	2.16	2.32	
			B	6.20	2.09	2.78	
			C	--	--	--	
			D	7.12	2.02	3.00	0.16
			E	6.56	2.20	2.85	
83	Sanilac	**Parkhill loam**	A	7.50	0.82	1.35	
			B	7.87	0.66	1.12	
			C	7.50	0.78	1.05	
			D	7.68	0.60	0.60	0.19
			E	7.87	0.72	0.60	
		Average	A	6.78	1.49	1.84	
			B	7.04	1.38	1.95	
			C	7.50	0.78	1.05	
			D	7.40	1.31	1.80	0.18
			E	7.22	1.46	1.72	

Table 53a. **The effect of fertilizers containing magnesium on the chemical composition of dry potato plants grown on a loam soil, 1956.**

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
11	Bay	Kawkawlin loam	A	3.32	2.26	0.71	
			B	2.88	2.32	0.90	
			C	3.73	2.38	1.27	
			D	3.20	2.36	0.90	0.28
			E	3.66	2.49	0.75	

Table 54a. **The effect of fertilizers containing magnesium on the chemical composition of dry sudan grass plants grown on a sandy loam soil, 1956.**

Location No.	County	Soil type	Treatment	Percent K	Percent Ca	Percent Mg	Percent Na
19	Branch	Hillsdale sandy loam	A	2.55	0.27	0.15	
			B	2.21	0.24	0.07	
			C	3.11	0.30	0.11	
			D	3.07	0.31	0.07	0.05
			E	2.59	0.31	0.26	

Table 55a. The effect of fertilizers containing magnesium on the chemical composition of dry oat and barley plants grown on soils of different textures, 1957.

Location No.	County	Soil type	Treatment[1]	Percent[2] K	Ca	Mg	Na	P
		Sandy loams and loamy sands						
13-C-7	Calhoun	Hillsdale sandy loam	A	1.80	0.08	0.16	0.029	0.37
			B	1.63	0.09	0.18	0.034	0.44
			D	1.55	0.07	0.07	0.037	0.46
			E	1.45	0.06	0.14	0.038	0.46
15-C-9	Charlevoix	Emmet sandy loam	A	1.28	0.08	0.16	0.030	0.37
			B	1.45	0.10	0.20	0.032	0.40
			D	1.39	0.09	0.13	0.031	0.41
			E	1.43	0.07	0.12	0.030	0.41
16-C-12	Cheboygan	Emmet sandy loam	A	1.38	0.08	0.09	0.038	0.36
			B	1.63	0.11	0.16	0.036	0.42
			D	1.45	0.09	0.10	0.041	0.40
			E	1.38	0.08	0.15	0.036	0.42
24-C-17	Emmet	Emmet sandy loam	A	1.49	0.11	0.11	0.033	0.31
			B	1.44	0.10	0.13	0.034	0.42
			D	1.40	0.10	0.16	0.036	0.33
			E	1.48	0.09	0.14	0.033	0.31
54-C-20	Mecosta	Isabella sandy loam	A	1.45	0.11	0.11	0.033	0.41
			B	1.45	0.09	0.11	0.031	0.43
			D	1.53	0.10	0.10	0.035	0.51
			E	1.45	0.10	0.12	0.033	0.43

[1]Treatments are given in table 2, page 22.
[2]Values represent average of two samples per treatment.

Continued

Table 55a - Continued

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na	P
68-C-26	Oscoda	Montcalm sandy loam	A	1.53	0.07	0.02	0.032	0.40
			B	1.42	0.08	0.21	0.031	0.41
			D	1.33	0.06	0.21	0.032	0.35
			E	1.40	0.06	0.25	0.032	0.34
70-C-32	Ottawa	Newton loamy sand	A	1.45	0.10	0.06	0.033	0.38
			B	1.48	0.10	0.15	0.032	0.32
			D	1.55	0.09	0.07	0.032	0.33
			E	1.65	0.07	0.07	0.035	0.28
		Average of treatments	A	1.48	0.09	0.10	0.033	0.37
			B	1.50	0.10	0.16	0.033	0.41
			D	1.46	0.09	0.12	0.035	0.40
			E	1.46	0.08	0.14	0.034	0.38
			Loams					
19-C-13	Clinton	Chesaning loam	A	1.53	0.09	0.33	0.034	0.34
			B	1.35	0.07	0.15	0.034	0.41
			D	1.40	0.09	0.15	0.035	0.36
			E	1.60	0.08	0.19	0.031	0.49
59-C-22	Montcalm	Isabella loam	A	1.55	0.08	0.13	0.032	0.32
			B	1.55	0.10	0.18	0.034	0.36
			D	1.38	0.10	0.16	0.033	0.32
			E	1.38	0.06	0.12	0.053	0.36

Continued

Table 55a - Continued

Location No.	County	Soil type	Treatment	Percent K	Ca	Mg	Na	P
71-C-34	Presque Isle	Onaway loam	A	1.38	0.09	0.25	0.033	0.39
			B	1.45	0.08	0.18	0.035	0.46
			D	1.40	0.07	0.20	0.034	0.49
			E	1.51	0.08	0.21	0.032	0.44
19-E-14	Clinton[3]	Miami loam	A	1.05	0.07	0.09	0.034	0.37
			B	1.48	0.10	0.08	0.032	0.44
			D	1.25	0.07	0.08	0.031	0.41
			E	1.43	0.09	0.11	0.035	0.45
		Average of treatments	A	1.38	0.08	0.20	0.033	0.36
			B	1.46	0.09	0.15	0.034	0.42
			D	1.36	0.08	0.15	0.033	0.40
			E	1.48	0.08	0.16	0.038	0.44

[3]Winter barley.

Table 56a. The effect of fertilizers containing magnesium on the chemical composition of dry potato plants grown on sands, loamy sands, sandy loams, and loam soils, 1957.

Location No.	County	Soil type	Treat-ment	Percent K	Percent Ca	Percent Mg	Percent Na	Percent P
5-F-3	Antrim	Mancelona sandy loam	A	5.10	1.75	0.34	0.033	0.33
			B	4.70	1.56	0.35	0.034	0.21
			D	5.10	1.83	0.33	0.032	0.27
			E	5.05	1.70	0.39	0.034	0.33
9-F-4	Bay	Brevort loamy sand	A	4.65	1.76	0.75	0.035	0.16
			B	4.45	1.79	0.71	0.033	0.18
			D	4.60	1.65	0.61	0.035	0.14
			E	4.75	1.68	0.81	0.035	0.13
9-F-5	Bay	Wisner loam	A	3.35	1.68	1.08	0.031	0.15
			B	3.45	1.65	1.15*	0.029	0.17
			D	4.13	1.73	0.68	0.030	0.28
			E	3.45	1.64	0.90	0.028	0.18
15-F-8	Charlevoix	Onaway loam	A	4.53	1.72	0.58	0.039	0.40
			B	3.80	1.58	0.55	0.039	0.45
			D	3.50	1.52	0.49	0.037	0.42
			E	4.75	1.74	0.57	0.037	0.40
16-F-10	Cheboygan	Onaway sandy loam	A	4.93	1.75	0.34	0.035	0.26
			B	4.93	1.62	0.35	0.034	0.28
			D	4.85	1.79	0.54	0.035	0.37
			E	4.95	1.63	0.34	0.034	0.26

*Significant at 5% level with respect to D treatment.

Table 56a - Continued

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
16-F-11	Cheboygan	Leelanau loamy sand	A	4.43	1.57	0.47	0.034	0.38
			B	4.10	1.69	0.55	0.031	0.48
			D	4.10	1.54	0.35	0.034	0.41
			E	5.05	1.72	0.68	0.035	0.44
24-F-15	Emmet	Emmet sandy loam	A	5.08	1.61	0.69	0.034	0.35
			B	5.10	1.64	0.69	0.033	0.34
			D	4.05	1.59	0.72	0.038	0.31
			E	5.08	1.57	0.76	0.036	0.39
24-F-16	Emmet	Emmet loamy sand	A	5.28	1.77	0.17	0.031	0.17
			B	5.33	1.77	0.13	0.031	0.25
			D	5.15	1.86	0.02	0.034	0.18
			E	5.35	1.77	0.13	0.033	0.30
59-F-23	Montcalm	Montcalm sandy loam	A	3.25	1.66	0.43	0.034	0.37
			B	4.62	1.64	0.63*	0.033	0.35
			D	3.57	1.66	0.41	0.037	0.44
			E	3.00	1.75	0.44	0.037	0.41
59-F-24	Montcalm	McBride sandy loam	A	3.83	1.59	0.45	0.033	0.24
			B	4.53	1.59	0.70	0.032	0.22
			D	4.00	1.58	0.45	0.035	0.21
			E	3.95	1.67	0.42	0.033	0.21
59-F-25	Montcalm	Montcalm sandy loam	A	4.55	1.70	0.69	0.034	0.16
			B	3.75	1.72	0.63	0.031	0.16
			D	4.05	1.74	0.37	0.030	0.21
			E	4.83	1.90	0.82	0.036	0.17

Continued

Table 56a - Continued

Location No.	County	Soil type	Treat-ment	Percent				
				K	Ca	Mg	Na	P
69-F-27	Otsego	Mancelona loamy sand	A	5.10	1.57	0.17	0.033	0.28
			B	5.05	1.76	0.29	0.034	0.36
			D	4.93	1.58	0.22	0.031	0.37
			E	5.00	1.79	0.41*	0.030	0.33
		Average of treatments	A	4.46	1.67	0.51	0.034	0.27
			B	4.48	1.67	0.56**	0.033	0.29
			D	4.34	1.67	0.43	0.034	0.30
			E	4.60	1.71	0.55**	0.034	0.30

*Significant at the 5% level in respect to D treatment.
**Significant at the 1% level in respect to D treatment.

Table 57a. The effect of fertilizers containing magnesium on the chemical composition of dry corn leaves from plants grown on soils of different textures, 1957.

Location No.	County	Soil type	Treatment[1]	Percent[2] K	Ca	Mg	Na	P
		Sands and sandy loams						
13-B-7	Calhoun	Hillsdale sandy loam	A	2.13	0.75	0.48	0.023	0.26
			B	1.70	0.63	0.49	0.027	0.23
			D	2.25	0.78	0.36	0.026	0.26
			E	2.05	0.64	0.40	0.026	0.20
54-B-19	Mecosta	Coloma sand	A	1.78	0.64	0.38	0.029	0.22
			B	2.15	0.63	0.26	0.028	0.21
			D	2.15	0.75	0.29	0.025	0.23
			E	1.68	0.56	0.35	0.026	0.22
		Average of treatments	A	1.96	0.70	0.43	0.026	0.24
			B	1.92	0.63	0.38	0.028	0.22
			D	2.20	0.76	0.32	0.026	0.24
			E	1.86	0.60	0.38	0.026	0.21
		Loams and silt loam						
19-B-13	Clinton	Chesaning loam	A	1.80	0.70	0.29	0.026	0.32
			B	1.88	0.62	0.30	0.026	0.42
			D	1.85	0.61	0.41	0.030	0.43
			E	1.68	0.63	0.29	0.028	0.38
19-B-14	Clinton	Miami loam	A	1.88	0.69	0.24	0.027	0.33
			B	1.98	0.69	0.35	0.029	0.32
			D	1.85	0.70	0.39	0.027	0.31
			E	1.98	0.72	0.37	0.028	0.33

Continued

Table 57a - Continued

Location No.	County	Soil type	Treatment[1]	Percent[2] K	Ca	Mg	Na	P
70-B-29	Ottawa	Napanee silt loam	A	1.85	0.68	0.72	0.028	0.30
			B	1.98	0.66	0.43	0.028	0.30
			D	1.90	0.72	0.38	0.025	0.19
			E	1.55	0.45	0.51	0.031	0.24
		Average of treatments	A	1.84	0.69	0.42	0.027	0.32
			B	1.95	0.64	0.36	0.028	0.35
			D	1.87	0.68	0.39	0.027	0.31
			E	1.74	0.60	0.36	0.029	0.32

Table 58a. The effect of fertilizers containing magnesium on the chemical composition of dry cucumber vines from plants grown on a loamy sand and sandy loam soil, 1957.

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
3-J-2	Allegan	Spinks loamy sand	A	2.43	1.81	0.74	0.047	0.20
			B	2.53	2.10	1.05	0.044	0.22
			D	2.75	2.00	0.84	0.045	0.25
			E	3.15	1.99	0.91	0.043	0.23
54-J-19	Mecosta	McBride sandy loam	A	2.50	2.04	1.11	0.046	0.30
			B	2.20	2.04	1.50**	0.043	0.35
			D	2.25	2.04	0.92	0.043	0.30
			E	2.40	2.54	1.75**	0.045	0.33
		Average of treatments	A	2.46	1.92	0.92	0.046	0.25
			B	2.36	2.07	1.28**	).044	0.28
			D	2.50	2.02	0.88	0.044	0.28
			E	2.78	2.26	1.33**	0.044	0.28

Table 59a. The effect of fertilizers containing magnesium on the chemical composition of dry cauliflower leaves and petioles from plants grown on a sandy loam soil, 1957

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
3-K-1	Allegan	Newton sandy loam	A	3.50	0.60	0.35	0.22	0.32
			B	3.65	0.52	0.41	0.23	0.42
			D	3.23	0.63	0.30	0.27	0.36
			E	3.70	0.54	0.35	0.19	0.35

Table 60a. The effect of fertilizers containing magnesium on the chemical composition of dry cantaloupe vines from plants grown on sandy and sandy loam soils, 1957.

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
70-I-30	Ottawa	Newton sand	A	2.20	2.42	0.25	0.040	0.24
			B	2.43	2.41	0.55	0.039	0.27
			D	3.80	2.19	0.21	0.036	0.21
			E	2.20	2.50	0.50	0.041	0.22
70-I-31	Ottawa	Oshtemo sandy loam	A	2.25	2.40	1.12	0.039	0.41
			B	2.25	2.50	1.25	0.041	0.38
			D	2.15	2.45	1.00	0.035	0.22
			E	2.38	2.48	1.02	0.038	0.33
		Average of	A	2.22	2.41	0.68	0.040	0.32
			B	2.34	2.45	0.90	0.040	0.32
			D	2.98	2.32	0.60	0.036	0.22
			E	2.29	2.49	0.76	0.040	0.28

Table 61a. The effect of fertilizers containing magnesium on the chemical composition of dry sweet corn leaves from plants grown on a sandy soil, 1957.

Location No.	County	Soil type	Treat-ment	K	Ca	Mg	Na	P
70-B-28	Ottawa	Plainfield sand	A	2.30	0.56	0.25	0.030	0.29
			B	2.35	0.60	0.24	0.031	0.37
			D	2.20	0.58	0.21	0.033	0.22
			E	2.40	0.56	0.33	0.032	0.23

Table 62a. The effect of fertilizer containing magnesium on the chemical composition of dry corn plants grown on sandy loam and loam soils, 1958.

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
			Sandy loam					
428-441	Mecosta	Montcalm sandy loam	A	1.74	0.38	0.09	0.012	0.24
			B	1.81	0.36	0.14	0.014	0.24
			C	1.66	0.36	0.15	0.013	0.22
			D	1.58	0.31	0.18	0.012	0.20
			E	1.51	0.39	0.11	0.012	0.22
			F	1.55	0.39	0.10	0.013	0.20
			G	1.57	0.44	0.12	0.012	0.20
			Loam					
414-427	Clinton	Chesaning loam	A	1.54	0.28	0.22	0.014	0.24
			B	1.52	0.25	0.24	0.014	0.25
			C	1.61	0.24	0.22	0.020	0.28
			D	1.78	0.26	0.26	0.014	0.26
			E	1.55	0.38	0.21	0.012	0.24
			F	1.81	0.30	0.20	0.014	0.26
			G	1.66	0.32	0.20	0.013	0.24

Table 63a. The effect of fertilizers containing magnesium on the chemical composition of dry oat plants grown on a sandy loam soil, 1958.

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
442-455	Mecosta	Montcalm sandy	A	0.90	0.14	0.09	0.013	0.35
			B	0.67	0.11	0.12	0.012	0.32
			C	0.92	0.12	0.14	0.012	0.34
			D	0.82	0.10	0.14	0.012	0.30
			E	0.71	0.10	0.10	0.012	0.31
			F	0.78	0.12	0.10	0.012	0.37
			G	0.74	0.10	0.10	0.012	0.32

Table 64a. The effect of fertilizers containing magnesium on the chemical composition of dry sweet corn plants grown on a sandy soil, 1958.

Location No.	County	Soil type	Treat-ment	Percent K	Ca	Mg	Na	P
400-413	Ottawa	Plainfield sand	A	2.11	0.30	0.22	0.020	0.20
			B	2.14	0.24	0.24	0.020	0.20
			C	1.96	0.24	0.22	0.018	0.22
			D	1.94	0.30	0.26	0.018	0.20
			E	1.95	0.24	0.22	0.020	0.23
			F	1.98	0.28	0.16	0.020	0.24
			G	1.97	0.29	0.20	0.019	0.23

Table 65a. **Instrumental conditions of the Beckman Spectrophotometer for the determination of potassium, calcium, and sodium.**

	Ca	K	Na
Wave length	422.7	766.5	589.3
Photo tube resistor	No. 2	No. 1	No. 2
Photo tube filter	blue	red	blue
Selector	0.1	0.1	0.1
Photo-multiplier sensitivity	4	off	2
Zero suppression	1.0	off	1.0
Oxygen pressure			
(a) tank	40	40	40
(b) instrument panel	11	12	11
Hydrogen pressure			
(a) tank	10	10	10
(b) instrument panel	5.75	5.75	5.75
Slit width	.01	.01-.02	.01