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NUTRITIONAL CONDITION OF MICHIGAN ORCHARDS: A SURVEY OF SOIL ANALYSES AND LEAF COMPOSITION

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EAST LANSING

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SUMMARY

Soil and leaf samples were collected from 124 orchards in representative fruit-growing areas of Michigan. All orchards were in good vigor and without visible nutrient deficiencies. Soil samples were analyzed for phosphorus, potassium, calcium, magnesium, manganese and iron, and the pH was determined. Leaf samples were analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, copper and boron.

Peach orchards were generally highest, and apple orchards lowest in total soil nutrient content.

Surface soils of Michigan orchards contained more nutrients than did the subsoil. Phosphorus, potassium and manganese were particularly higher in the surface soils than in the subsoil. Soil pH was lowest in the surface soil beneath trees. The orchard soils were low in calcium, magnesium and manganese.

Peach leaves contained more nitrogen than did the cherry, and cherry leaves contained more nitrogen than did apple and pear. Peach and cherry leaves contained more magnesium than did apple or pear leaves. There was no difference in the potassium content of apple, cherry, peach and pear leaves.

According to soil and leaf analyses, the general practice of using complete fertilizers appeared to be unnecessary in certain areas. Various nutrient-elements were found to be critically short in some areas. Although these shortages of nutrient-elements were associated with trees not having deficiency symptoms, potential deficiencies are indicated.

Also discussed is the possibility of inducing deficiencies, which may result by altering the fertilizer program without due concern for other nutrients.

Nutritional Condition of Michigan Orchards: A Survey of Soil Analyses and Leaf Composition

By A. L. KENWORTHY

Soil management in early Michigan orchards was based upon clean cultivation. Today, however, growers are very conscious of the soil erosion and depletion that has been associated with clean cultivation. The use of cover crops or sods and mulch, as a means of preventing this soil erosion and depletion, has become widespread; consequently, clean cultivation without cover crops or sod covers has all but disappeared. There appears to be a general preference for a sod-mulch program of soil management in apple and pear orchards and for clean cultivation with cover crops in peach and cherry orchards.

The use of nitrogen has been, for many years, the standard fertilizer recommendation, and this element is still the one most widely needed. However, during recent years certain orchards have been found to be deficient in potassium, phosphorus, manganese, boron and magnesium. Applications of those elements to deficient soils have improved tree performance. Several growers have reported benefits from applications of complete fertilizers even though no defiiciencies were apparent. In many instances, there was a greater improvement in the growth of the cover crops or sods than observed for the trees.

Deficiencies of the nutrient-elements mentioned above have not been general but isolated occurrences. These occurrences have tended to cause many growers to consider the use of such fertilizers in their orchards. In many, perhaps most, instances the application of such fertilizers may be of no direct benefit to the fruit trees. If, however, there is an improvement in the growth of the cover crops or sods, the fruit trees should benefit, eventually, from the fertilizer application.

The nature of the origin of soils in Michigan would indicate that considerable variation should exist in different areas. The soils are glacial in origin and are comparable in type and composition only in limited areas. In addition to this initial soil variation, the previous management of the soils has tended to further complicate soil differences. Knowledge of this soil variation has made the use of generalized statewide fertilizer and soil management recommendations highly questionable.

A survey of Michigan orchards was made to determine the occurrence of nutrient-element shortages and the general nutritional conditions of orchards. This survey was designed, primarily, to locate areas of potential nutrient-element shortages and, in this manner, to provide information that would enable the prevention of the occurrence of deficiencies. If certain fruit-producing areas are known to have a shortage of certain nutrient-elements, then deficencies may be watched for and precautionary measures may be taken to prevent further occurrence of the deficiencies.

PROCEDURES

Soil and leaf samples were collected from orchards in representative fruit-growing areas of the state. A total of 124 orchards were studied and included 52 apple, 26 peach, 36 cherry and 10 pear orchards. All orchards were in good vigor and had no visible deficiencies of nutrient-elements. Four uniform trees representing the vigor of the orchard were used for sampling. The following varieties were used: apple—Jonathan and McIntosh; peach—Elberta and Halehaven; cherry—Montmorency; and pear—Bartlett.

Soil samples were taken during mid-summer from 1) surface soil beneath trees, 2) surface soil between trees, and 3) subsoil between trees. The subsoil sample was taken when either a definite change in soil horizons could be seen or a depth of 3 feet had been reached. The samples were air dried, screened and analyzed according to the reserve test of Spurway and Lawton.[1] Colorimeteric and turbidimetric determinations for phosphorus, potassium, calcium, magnesium, manganese and iron were made with a Lumitron colorimeter. Soil acidity or pH was also determined.

Leaf samples of approximately 100 leaves were obtained during mid-summer from the same orchards in which soil samples were taken. In addition, leaf samples were collected from 24 orchards in which soil samples were not taken. Leaves were selected from the middle of the current season's growth and were free of insect, disease or mechanical injury. The leaves were wiped free of visible spray residue with a moist cheesecloth and air dried. After the samples were ground and dried at 100°C. they were analyzed spectrographically[2] for phosphorus, potassium, calcium, magnesium, boron, copper and iron. Nitrogen was determined by the Kjeldahl method.

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[1]Spurway, C. H., and K. Lawton (1949). Soil testing, a practical system of soil fertility diagnosis. 4th rev. ed. Mich. Agr. Expt. Sta. Tech. Bul. 132. 39 pages.

[2]Spectrographic determinations made by the National Spectrographic Laboratories, Inc., Cleveland, Ohio.

In order to illustrate the relative balance of nutrient-elements the data were presented by a series of lines on a nutrient-element balance chart.[3] On such a chart (Figs. 20 to 39) the length of the lines indicates a shortage or an excess of nutrient-elements.

The length of the lines was determined in relation to the mean values of each variety and adjusted in regard to the coefficient of variation of each element.[4] All leaf samples from an area were combined after such calculations were made for each of the samples. In this manner, differences among varieties and species were eliminated and did not bias the results.

RESULTS

GENERAL OBSERVATIONS

Table 1 shows the soil management practices and fertilizer applications in relation to the different kinds of fruit. Approximately 70 percent of the apple and pear orchards were grown in accordance with the sod-mulch practice. Clean cultivation with cover crops was used in approximately 75 percent of the cherry orchards and 85 percent of the peach orchards. No orchards were found that were being grown with a soil management practice of clean cultivation alone.

"Under-tree" applications of fertilizers were generally preferred. Complete fertilizers were more generally broadcast than were nitrogen fertilizers. Many growers preferred to apply phosphorus and potassium in the form of an 0-9-27 or 0-20-20 commercial fertilizer. Complete fertilizers were used in approximately 40 percent of the apple orchards and 60 percent of the peach and cherry orchards. Although not yet

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[3]Kenworthy, A. L. (1949). A nutrient-element balance chart. Mich. Agr. Expt. Sta. Quart. Bul. 32: 17-19.

[4]Method of calculation of length of lines for the nutrient-element balance chart:

1. Symbols:

S — sample value	I — influence of variability
M—mean value	L—line value
P — Percent of mean	C—chart scale
V — coefficient of variation	R—length of chart line

2. If S is larger than M:

Formulas	Example
a. $(S \div M) \times 100 = P$	a. $(112 \div 86) \times 100 = 130$
b. $(P - 100) \times (V \div 100) = I$	b. $(130 - 100) \times (73 \div 100) = 21.9$
c. $P - I = L$	c. $130 - 21.9 = 108.1$
d. $L \div C = R$	d. $108.1 \div 2 = 54$

3. If S is smaller than M:

Formulas	Example
a. $(S \div M) \times 100 = P$	a. $42 \div 86 = 49$
b. $(100 - P) \times (V \div 100) = I$	b. $(100 - 49) \times (73 \div 100) = 37$
c. $P + I = L$	c. $49 + 37 = 86$
d. $L \div C = R$	d. $86 \div 2 = 43$

TABLE 1—Soil management practices and fertilizer applications in relation to kind of fruit

Cultural practice	Apple	Cherry	Peach
Sod or sod mulch (% of orchards)	68.4	24.9	16.4
Cover crops plus clean cultivation (% of orchards)	31.6	75.1	83.6
Nitrogen fertilizers (% of orchards)	72.4	41.5	42.8
Complete fertilizers* (% of orchards)	27.6	58.5	57.2
Ammonium nitrate (% of orchards)	62.5	62.3	59.2
Rate of nitrogen applications†			
Average (pounds)	0.28	0.23	0.35
Range (pounds)	0.12-0.75	0.09-0.52	0.09-0.69

*"Complete fertilizers" implies applications of fertilizers other than nitrogen in addition to nitrogen.
†Rate of nitrogen applications expressed as pounds per tree per year of age.

widespread there seemed to be an increasing use of complete fertilizer, such as 8-8-8, with minor elements.

The amount of nitrogen applied to peach trees was greater than that which was applied to apple trees. Cherry trees received less nitrogen than did either apple or peach trees. The average rate of nitrogen application on all trees was equivalent to approximately 0.3 pound of ammonium nitrate per tree per year of age. The lowest amount was equivalent to 0.09 pound of ammonium nitrate per tree per year of age, and the highest was equivalent to 0.75 pound. Ammonium nitrate was used by over 60 percent of the growers.

SOIL ANALYSES

COMPARISON OF 1) SURFACE SOIL BENEATH TREES, 2) SURFACE SOIL BETWEEN TREES AND 3) SUBSOIL BETWEEN TREES

The average analyses of all soil samples are shown in Table 2. The surface soil beneath the trees contained the greatest amount of phosphorus, calcium, manganese and iron but the least amount of magnesium. Surface soil between the trees was highest in potassium and intermediate in composition for all other elements. The subsoil between the trees contained the least amount of phosphorus, potassium, calcium, manganese and iron but the greatest amount of magnesium.

The surface soil beneath the trees was the most acid (pH lowest), the subsoil between the trees was the least acid (pH highest), and the surface soil between the trees was intermediate between the two.

TABLE 2—Analyses of Michigan orchard soils, with samples taken from: surface soil beneath trees, surface soil between trees and subsoil between trees

	Surface soil beneath trees	Surface soil between trees	Subsoil between trees
	p.p.m.	p.p.m.	p.p.m.
Phosphorus	45.7 ± .6	39.3 ± .6	20.4 ± .4
Potassium	129.3 ± 7.5	133.5 ± 6.8	89.6 ± 4.1
Calcium	101.6 ± 5.6	98.4 ± 7.3	98.4 ± 14.4
Magnesium	7.8 ± .05	7.8 ± .10	8.1 ± .25
Manganese	12.6 ± .23	12.7 ± .24	5.3 ± .09
Iron	45.0 ± .86	35.9 ± .88	33.6 ± .79
pH	4.6	5.0	5.0

COMPARISON OF APPLE, CHERRY, PEACH AND PEAR ORCHARDS

Analysis of soil from the different kinds of fruit in relation to 1) surface soil beneath trees, 2) surface soil between trees and 3) subsoil between trees is shown in Fig. 1.

Apple orchard soils were lowest in phosphorus, potassium, magnesium, manganese, iron and total nutrients and in respect to pH. The soil in cherry and pear orchards was also low in manganese, while that in the peach and pear orchards was lowest in calcium.

The soil from cherry orchards was highest in phosphorus, calcium and magnesium and in pH. The apple orchard soils were high in calcium, while in peach orchard soils magnesium was high. Soil from peach and pear orchards was highest in potassium and total nutrients. Peach orchard soils were also highest in manganese.

COMPARISON OF GEOGRAPHIC AREAS WITHIN THE STATE

The different geographic areas showed considerable variation in soil analysis, as shown in Figures 2-7 inc.[5]

PHOSPHORUS—Figure 2 shows the geographic variation in soil phosphorus. Only the Leelanau and Antrim County areas were found to contain the same amount of phosphorus in all sampling positions. Most of the other areas had less phosphorus in the soil between the trees than in the soil beneath the trees. Antrim, Genesee, Oceana and Mason County areas were low in phosphorus. The soil in the Allegan and Cheboygan County areas contained moderate amounts of phosphorus, while other areas were relatively high in soil phosphorus.

[5]Although reference will be made to counties, the actual area in each county is shown by the circles.

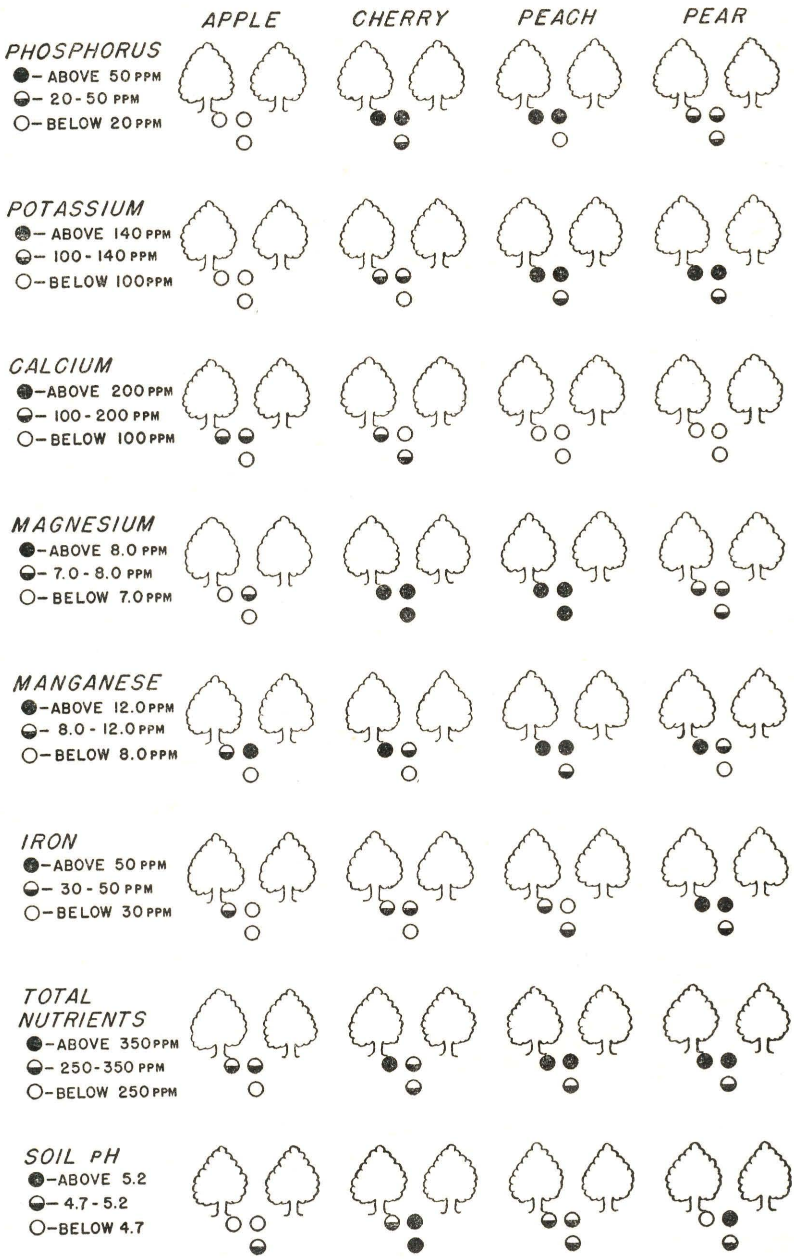


Fig. 1. Analysis of Michigan orchard soils in relation to kind of fruit and and position in the orchard. (Each group of three circles indicate different positions in the orchard: upper left–surface soil beneath tree, upper right–surface soil between trees, lower–subsoil between trees.)

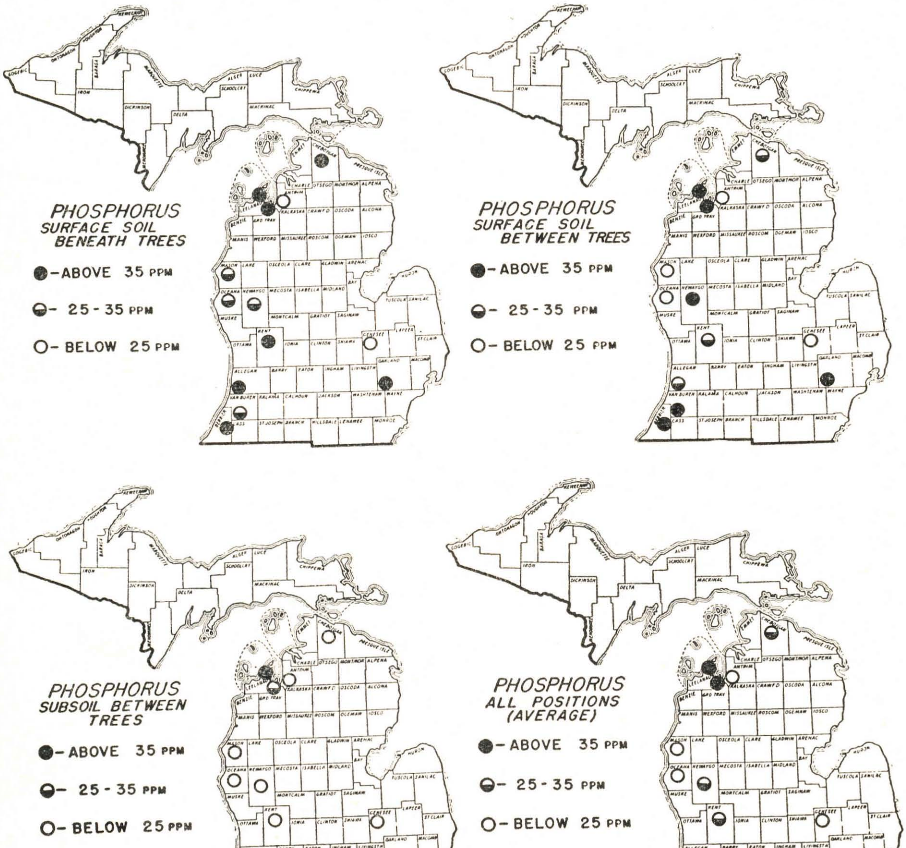


Fig. 2. Phosphorus content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between trees and 3) subsoil between trees.

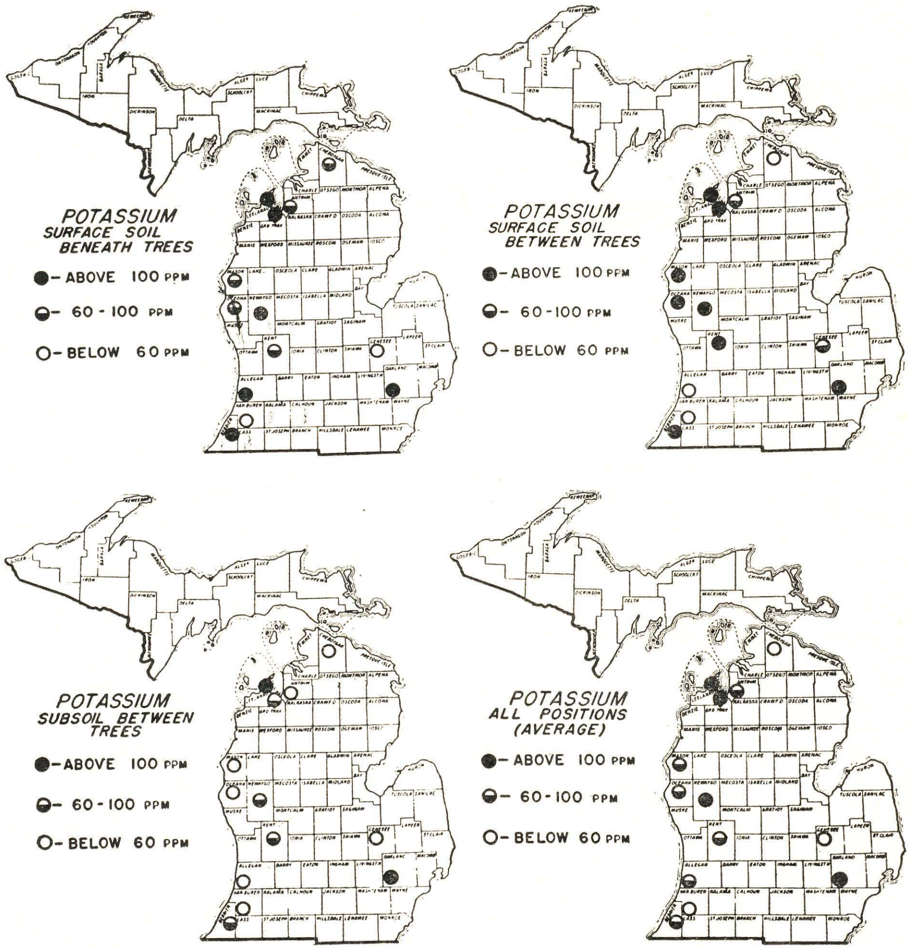


Fig. 3. Potassium content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between the trees.

POTASSIUM—Soil potassium in relation to geographic areas is shown in Fig. 3. Grand Traverse and Leelanau County areas were high in soil potassium. The Van Buren County area was low in soil potassium. The subsoil generally contained less potassium than the surface soil. The average values showed that the Allegan, Cheboygan and Genesee County areas were lowest in soil potassium while the Oakland, Newaygo, Grand Traverse and Leelanau County areas were highest.

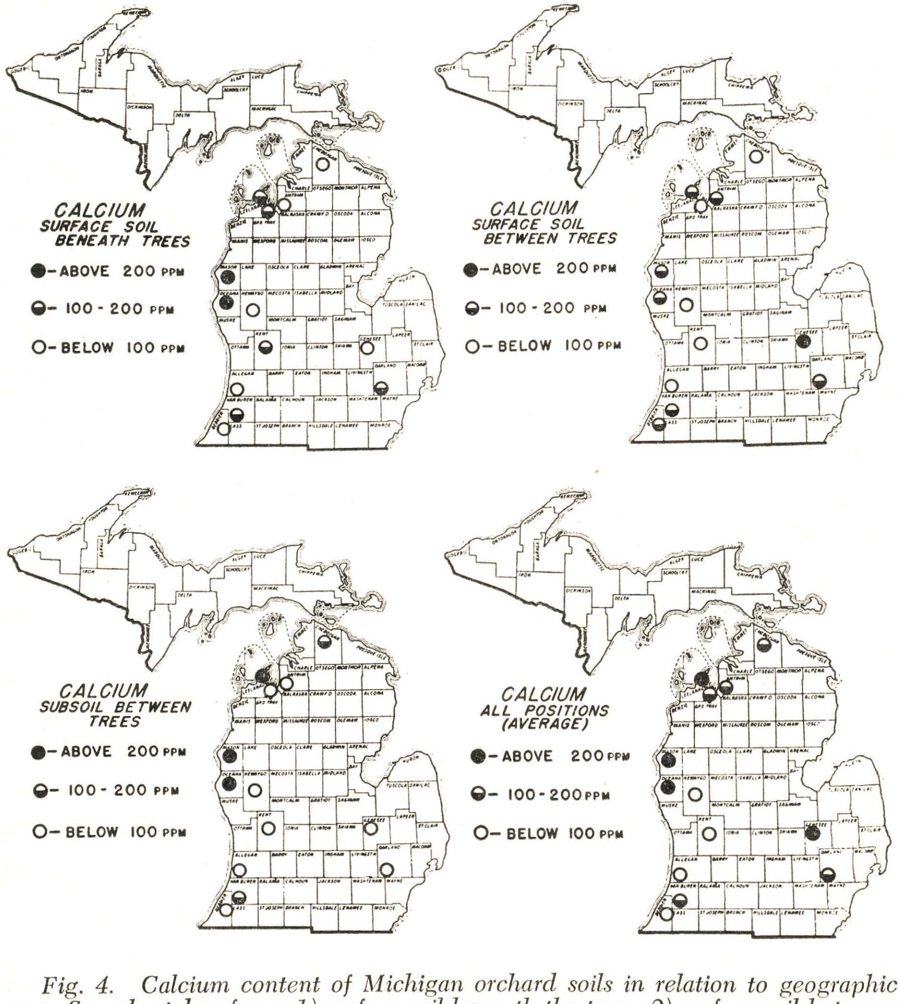


Fig. 4. Calcium content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between the trees.

CALCIUM—Less calcium was present in the surface soil between trees than in the surface soil beneath trees (Fig. 4). There was, generally, less calcium in the subsoil than in the surface soil. The average calcium content showed that the Berrien, Allegan, Kent and Newaygo County areas were lowest in calcium. Genesee, Oceana, Mason and Leelanau County areas were highest in soil calcium.

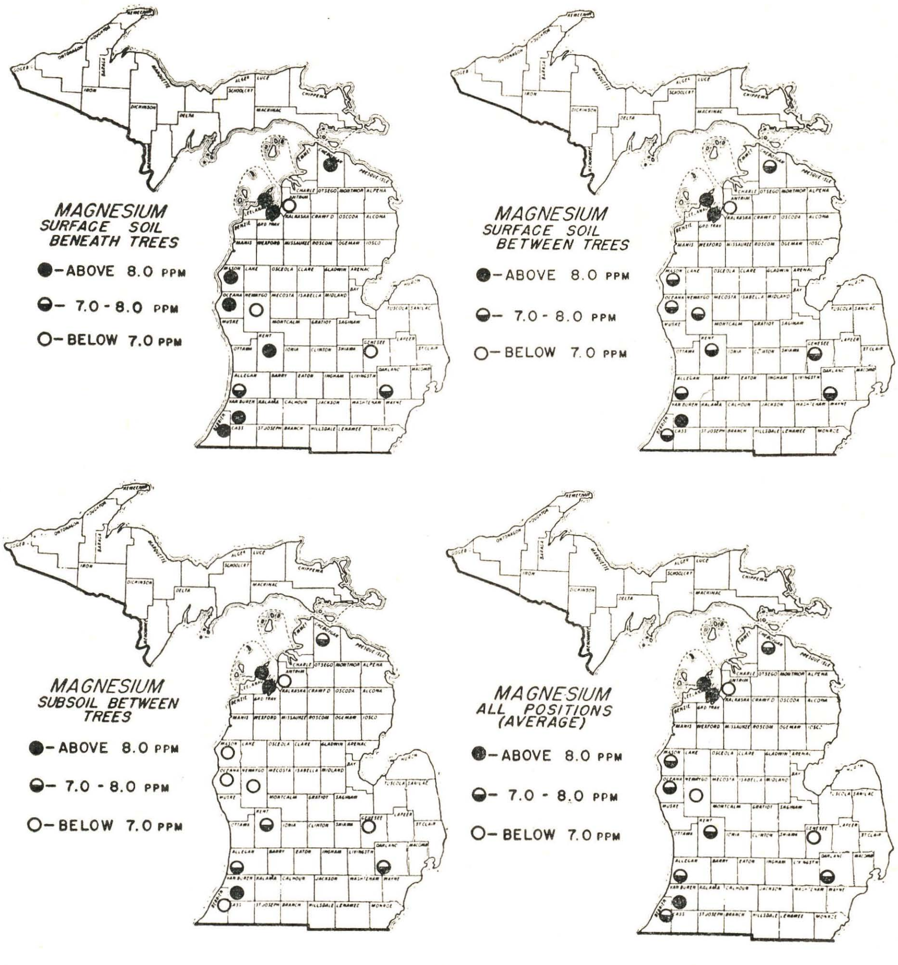


Fig. 5. Magnesium content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between trees.

MAGNESIUM—The surface soil beneath trees contained as much or more magnesium than the surface soil between the trees (Fig. 5) except in the Genesee and Newaygo County areas. The surface soil between the trees contained as much or more magnesium than did the subsoil in all areas. The average magnesium content showed that the Genesee, Newaygo and Antrim County areas were lowest in soil magnesium. Van Buren, Leelanau and Grand Traverse County areas were highest in soil magnesium.

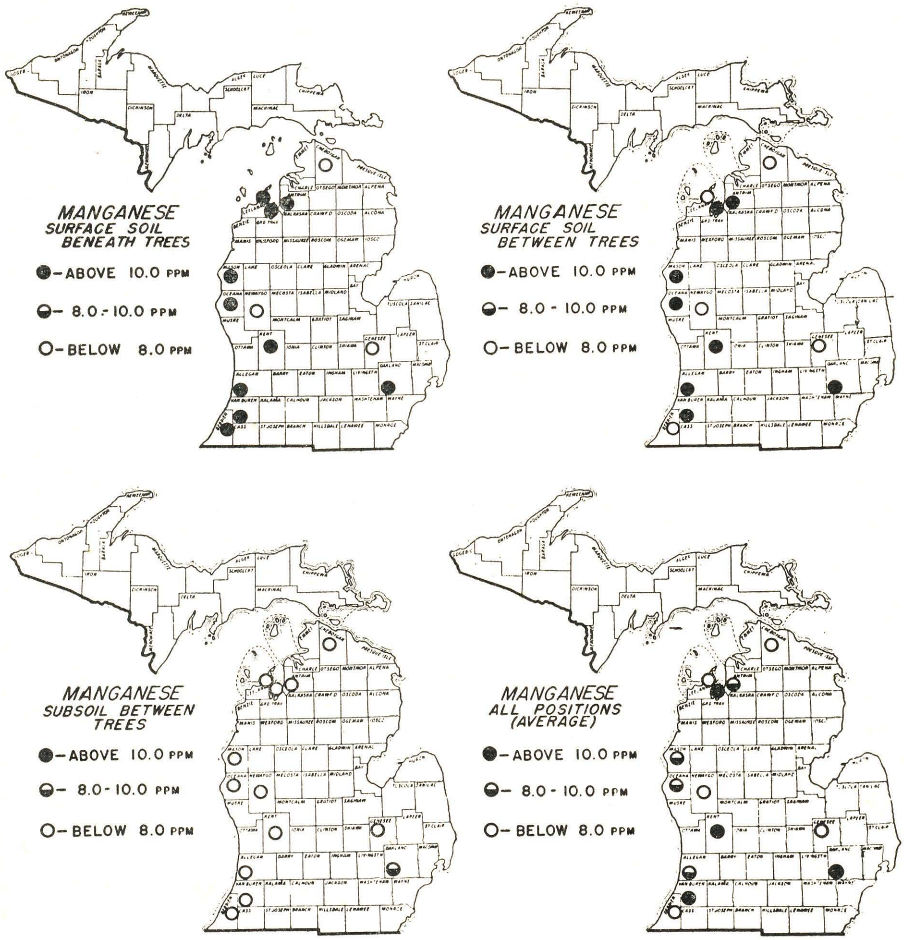


Fig. 6. Manganese content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between the trees.

MANGANESE—The manganese analyses (Fig. 6) showed that the subsoil contained lower amounts of manganese than found in the surface soil beneath or between the trees. In general, the soils in Berrien, Genesee, Newaygo, Leelanau and Cheboygan Counties were lowest in manganese. The soils in Van Buren, Oakland, Kent and Grand Traverse Counties appeared to contain relatively large amounts of manganese.

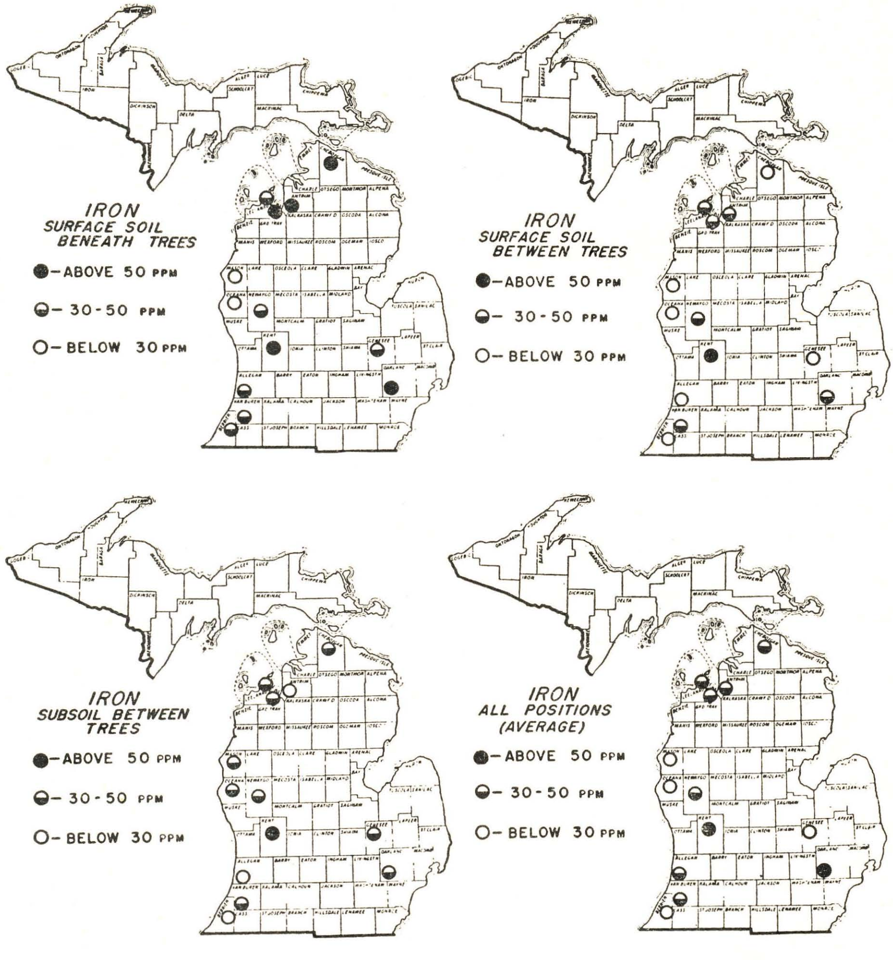


Fig. 7. Iron content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between the trees.

IRON—The surface soil between trees contained less iron than either the surface soil beneath trees or the subsoil (Fig. 7). The iron content of the surface soil beneath trees was lowest in Oceana and Mason Counties. The surface soil between the trees was lowest in iron content in Berrien, Allegan, Genesee, Oceana, Mason and Cheboygan Counties. The average iron content was lowest in Berrien, Genesee, Oceana and Mason Counties and highest in Oakland and Kent Counties.

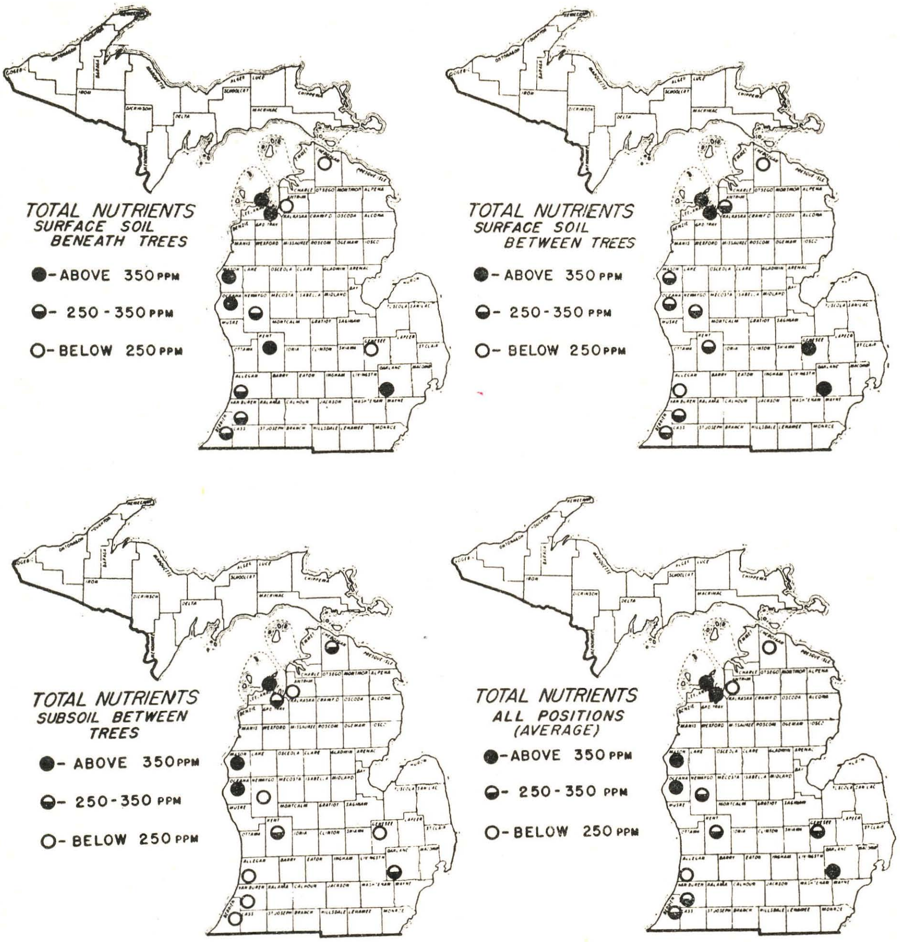


Fig. 8. Total nutrient content of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between the trees. (Total nutrients calculated as a total of phosphorus, potassium, calcium, magnesium, manganese and iron.)

When all nutrients were added together, the subsoil was found to have a generally lower total nutrient content than the surface soils (Fig. 8). The surface soil beneath trees had the lowest total nutrient supply in Genesee, Antrim and Cheboygan Counties and the highest in Oakland, Kent, Oceana, Mason, Grand Traverse and Leelanau Counties. The surface soil between trees had the lowest total nutrient content in Allegan and Cheboygan Counties and the highest in Oakland, Genesee, Grand Traverse and Leelanau Counties. The subsoil

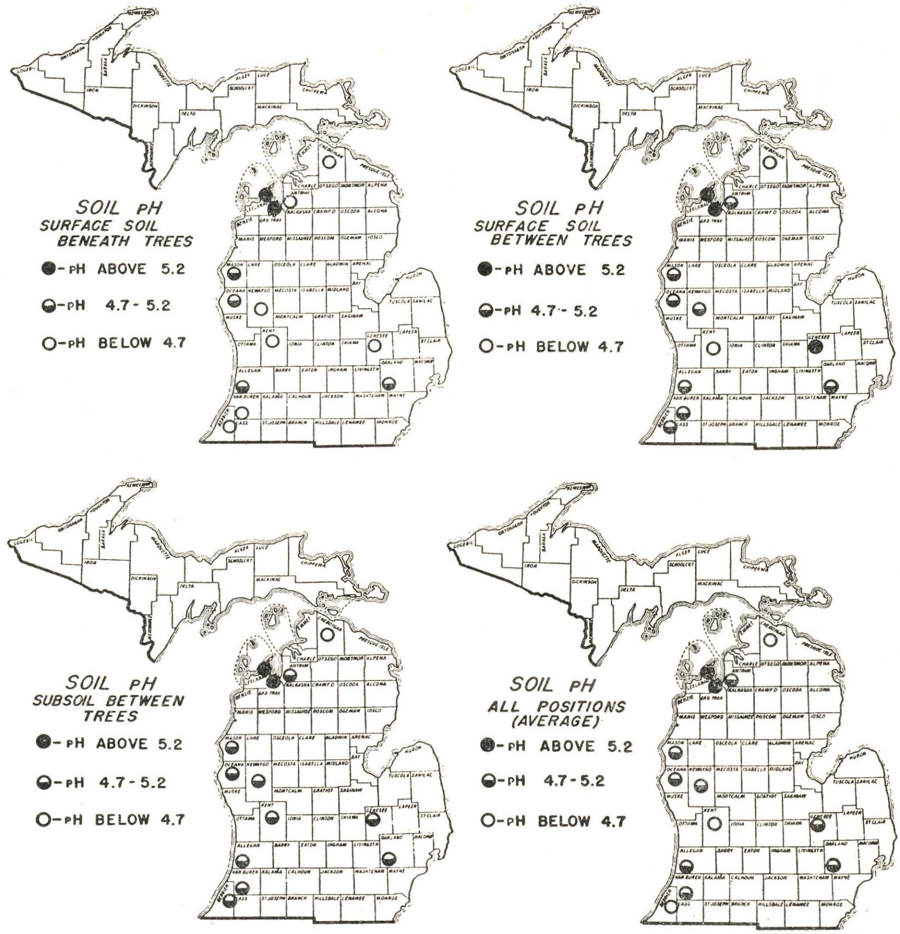


Fig. 9. The pH of Michigan orchard soils in relation to geographic area. Samples taken from: 1) surface soil beneath the trees, 2) surface soil between the trees, and 3) subsoil between the trees.

had the lowest total nutrient content in Berrien, Van Buren, Allegan, Genesee, Newaygo and Antrim Counties and the highest in Oceana, Mason, Grand Traverse and Leelanau Counties. When all soils were combined, the total nutrient content was lowest in Allegan, Antrim and Cheboygan Counties and highest in Oakland, Oceana, Mason, Grand Traverse and Leelanau Counties.

The soil pH was generally lowest in the surface soil beneath trees (Fig. 9). The pH for the three sampling locations was relatively uniform in Allegan, Oakland, Oceana, Mason, Grand Traverse, Leelanau, and Cheboygan Counties. The subsoil was usually higher in pH than the surface soil in other counties. The average soil pH[6] was lowest in Berrien, Kent and Cheboygan Counties and highest in Grand Traverse and Leelanau Counties.

LEAF ANALYSES

COMPARISON OF APPLE, CHERRY, PEACH AND PEAR LEAVES

Apple and pear leaves contained the least amount of nitrogen (Table 3). The greatest amount of nitrogen was found in peach leaves. Pear leaves contained less phosphorus than did apple, peach or cherry leaves. Less calcium and magnesium were found in apple leaves than in cherry, peach and pear. Pear leaves contained relatively low amounts of iron and boron and relatively large amounts of manganese and copper in comparison with apple, cherry and peach. Cherry and peach leaves contained more magnesium than apple and pear leaves. Larger amounts of copper and boron were also found in cherry leaves. There were no significant differences in the potassium content of leaves from different kinds of fruit.

TABLE 3—Composition of leaves from Michigan apple, cherry, peach and pear orchards

	Apple	Cherry	Peach	Pear
Nitrogen—%..........	2.41 ±.05	2.83 ±.07	3.98 ±.14	2.50 ±.08
Phosphorus—%.......	.266±.034	.267±.034	.238±.046	.135±.052
Potassium—%........	1.58 ±.12	1.54 ±.12	1.55 ±.14	1.45 ±.16
Calcium—%..........	1.48 ±.12	1.91 ±.13	1.95 ±.14	1.90 ±.13
Magnesium—%.......	.435±.022	.740±.044	.672±.061	.397±.054
Manganese—p.p.m.....	110±11	114±13	113±40	133±13
Iron—p.p.m...........	249±44	280±52	191±44	140±56
Copper—p.p.m.........	18±4	55±9	12±3	54±5
Boron—p.p.m..........	55±7	67±9	53±12	23±7

COMPARISON OF GEOGRAPHIC AREAS

Leaf analysis for almost all of the nutrient-elements were found to vary in the different geographic areas. Certain areas, however, were consistently high or low in the amount of some of the nutrient-elements contained in the leaves. The average leaf composition, expressed as relative values, for the geographic areas is shown in the following illustrations (Figs. 10-19).

[6]Average soil pH values were calculated by converting the individual pH values to H-ion concentrations. The average H-ion content was then converted into pH values.

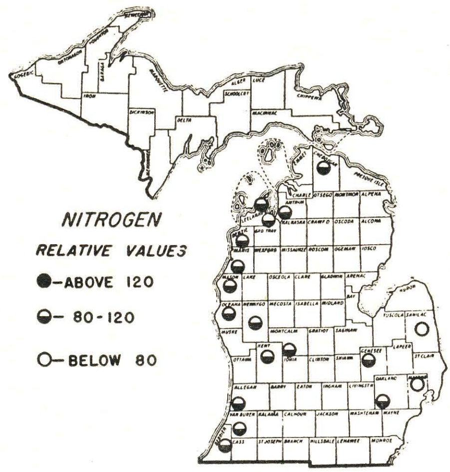


Fig. 10. Nitrogen content of fruit tree leaves in geographic areas of Michigan.

Above average—none.

Average—All counties except Sanilac and Macomb.

Below average – Sanilac and Macomb Counties.

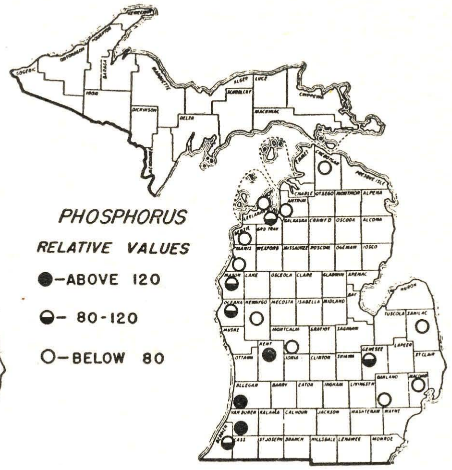


Fig. 11. Phosphorus content of fruit tree leaves in geographic areas of Michigan.

Above average—Van Buren, Allegan, and Kent counties.

Average—Berrien, Genesee, Oceana, Mason and Grand Traverse counties.

Below average—Montcalm, Macomb, Oakland, Sanilac, Newaygo, Manistee, Benzie, Leelanau, Antrim and Cheboygan Counties.

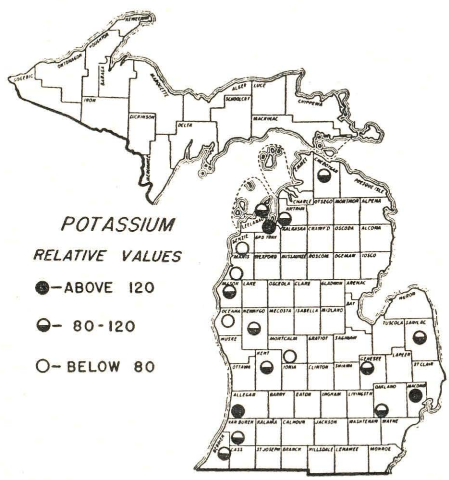


Fig. 12. Potassium content of fruit tree leaves in geographic areas of Michigan.

Above average—Allegan, Macomb, and Grand Traverse Counties.

Average—Berrien, Van Buren, Oakland, Genesee, Sanilac, Newaygo, Mason, Leelanau, Antrim and Cheboygan Counties.

Below average—Montcalm, Oceana, Manistee, and Benzie Counties.

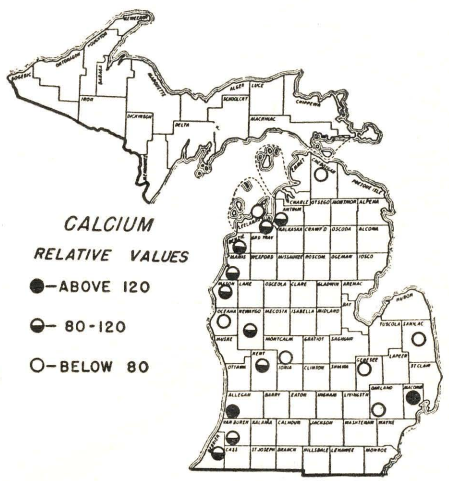


Fig. 13. Calcium content of fruit tree leaves in geographic areas of Michigan.

Above average—Allegan and Macomb Counties.

Average—Berrien, Kent, Newaygo, Mason, Manistee, Benzie, Grand Traverse and Antrim Counties

Below average—Oakland, Genesee, Sanilac, Montcalm, Oceana, Leelanau, and Cheboygan Counties.

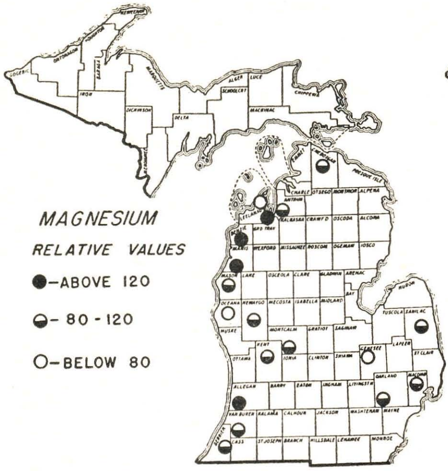


Fig. 14. Magnesium content of fruit tree leaves in geographic areas of Michigan.

Above average–Allegan, Manistee, Benzie and Grand Traverse Counties.

Average–Berrien, Van Buren, Oakland, Macomb, Sanilac, Montcalm, Kent, Newaygo, Mason, Antrim and Cheboygan Counties.

Below average – Genesee, Oceana and Leelanau Counties.

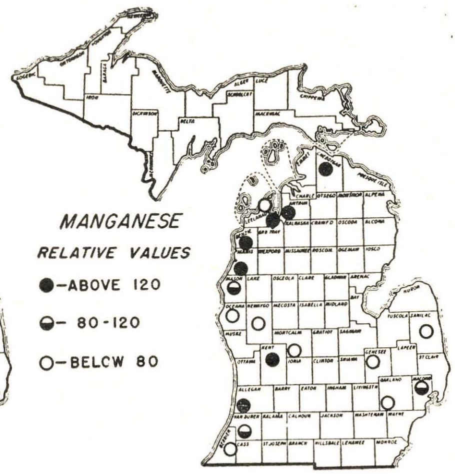


Fig. 15. Manganese content of fruit tree leaves in geographic areas of Michigan.

Above average–Allegan, Kent, Manistee, Benzie, Grand Traverse, Antrim and Cheboygan Counties.

Average–Van Buren, Macomb and Mason Counties.

Below average–Berrien, Oakland, Genesee, Sanilac, Montcalm, Newaygo, Oceana and Leelanau Counties.

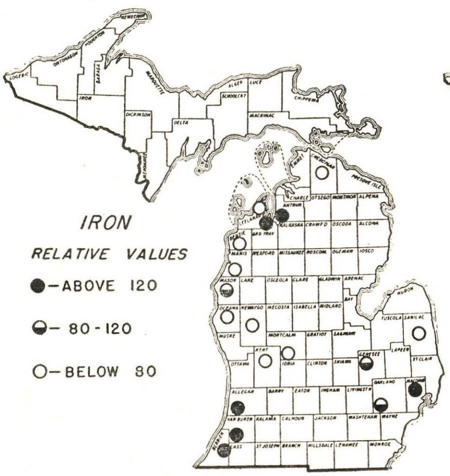


Fig. 16. Iron content of fruit tree leaves in geographic areas of Michigan.

Above average–Berrien, Van Buren, Allegan, Macomb, Grand Traverse and Antrim Counties.

Average – Oakland, Genesee and Mason Counties.

Below average–Sanilac, Montcalm, Kent, Newaygo, Oceana, Manistee, Benzie, Leelanau and Cheboygan Counties.

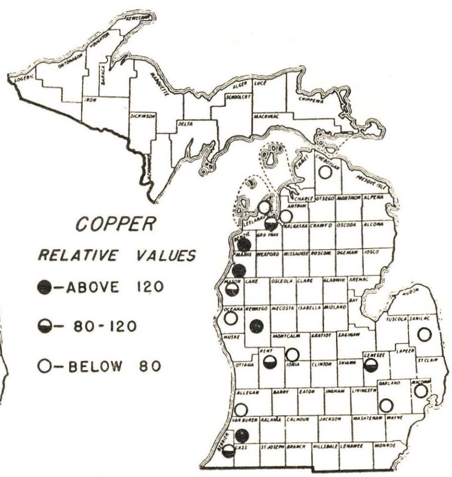


Fig. 17. Copper content of fruit tree leaves in geographic areas of Michigan.

Above average–Van Buren, Manistee and Benzie counties.

Average–Berrien, Genesee, Kent, Mason and Grand Traverse Counties.

Below average–Allegan, Oakland, Macomb, Sanilac, Montcalm, Oceana, Antrim and Cheboygan Counties.

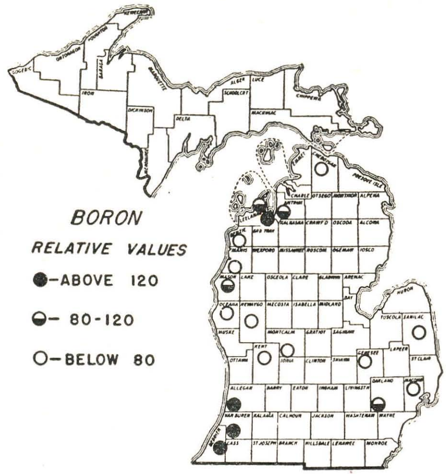


Fig. 18. Boron content of fruit tree leaves in geographic areas of Michigan.

Above average–Berrien, Van Buren, Allegan and Grand Traverse Counties.

Average – Oakland, Mason, Leelanau and Antrim Counties.

Below average – Sanilac, Macomb, Genesee, Montcalm, Kent, Newaygo, Oceana, Manistee, Benzie and Cheboygan Counties.

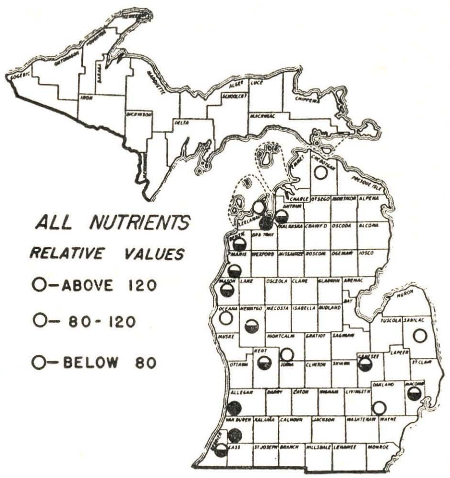


Fig. 19. Average nutrient-element content of fruit tree leaves in geographic areas of Michigan.

Above average–Van Buren, Allegan and Grand Traverse Counties.

Average–Berrien, Macomb, Genesee, Kent, Mason, Manistee, Benzie and Antrim Counties.

Below average–Oakland, Sanilac, Montcalm, Oceana, Leelanau and Cheboygan Counties.

NUTRIENT-ELEMENT BALANCE[7]

The relative balance for each geographic area is shown when the relative values are placed on the nutrient-element balance chart. An excess exists if the line representing a nutrient-element extends beyond the center of the white band. A shortage exists if the line does not extend to the center of the white band.

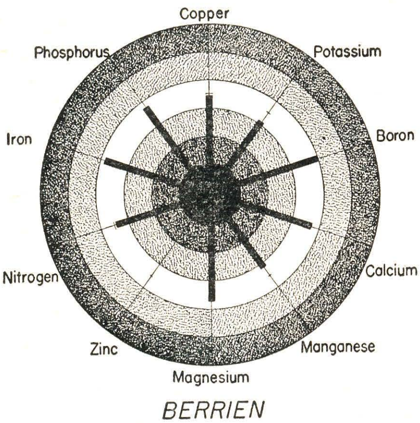


Fig. 20. Relative balance of nutrient-elements in Berrien County.
Excess of iron, phosphorus and boron.
Shortage of potassium and manganese.
Deficiency index–30.

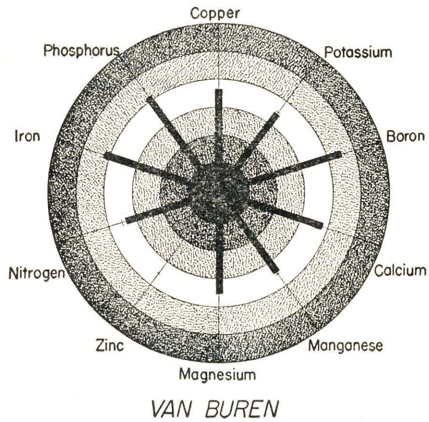


Fig. 21. Relative balance of nutrient-elements in Van Buren County.
Iron, phosphorus, copper, boron and calcium above optimum.
No nutrient-element below optimum.
Excess of iron, phosphorus, boron and copper. Deficiency index–9.

[7]The term "deficiency index" as used in this section refers to the relative shortage of all nutrient-elements.

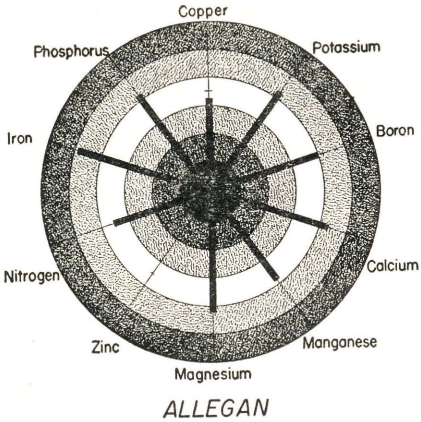


Fig. 22. Relative balance of nutrient-elements in Allegan county.

Excess of iron, phosphorus, potassium, boron, calcium, manganese and magnesium.

Deficiency index–9.

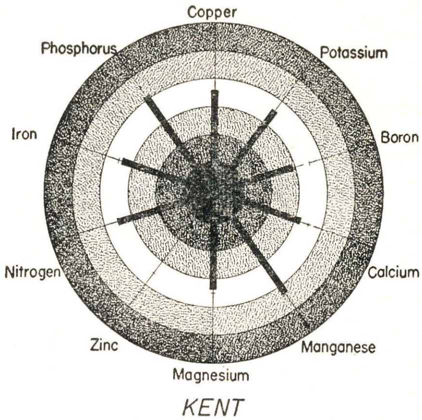


Fig. 23. Relative balance of nutrient-elements in Kent County.

Excess of phosphorus and manganese.

Shortage of iron, boron and calcium.

Deficiency index–36.

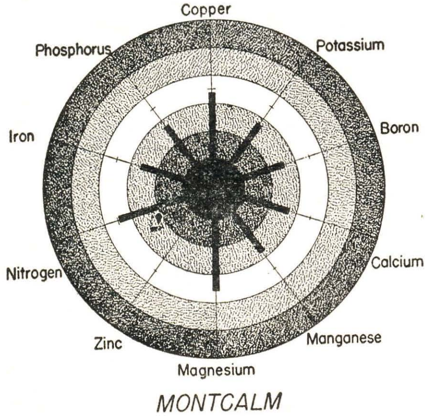


Fig. 24. Relative balance of nutrient-elements in Montcalm County.

No nutrient-element in excess.

Shortage of iron, phosphorus, potassium, boron, calcium and manganese.

Deficiency index–148.

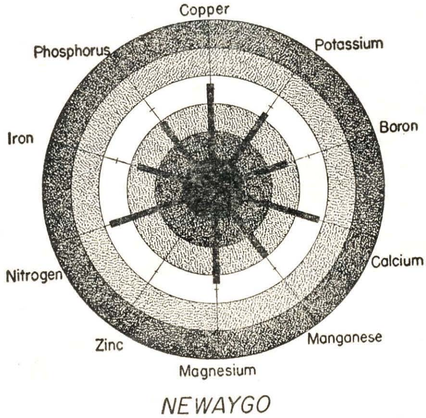
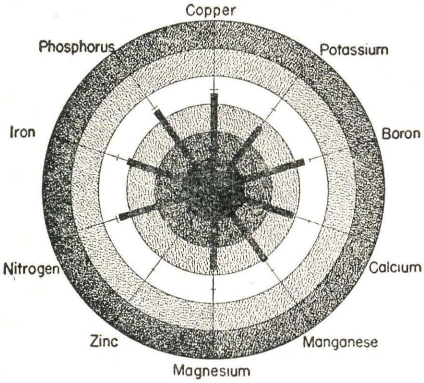


Fig. 25. Relative balance of nutrient-elements in Newaygo County.

Excess of calcium.

Shortage of iron, phosphorus, potassium, boron, manganese and magnesium.

Deficiency index–91.

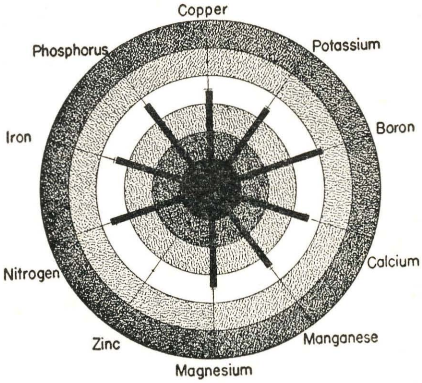


OCEANA

Fig. 26. Relative balance of nutrient-elements in Oceana County.

Shortage of all nutrient-elements except nitrogen, phosphorus, copper and boron. No acute shortage of any nutrient-element.

Deficiency index–101.



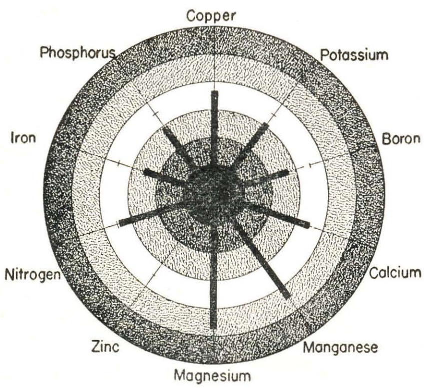
MASON

Fig. 27. Relative balance of nutrient-elements in Mason County.

Excess of boron.

No acute shortage of nutrient-elements. A desirable balance of all elements except boron.

Deficiency index–12.



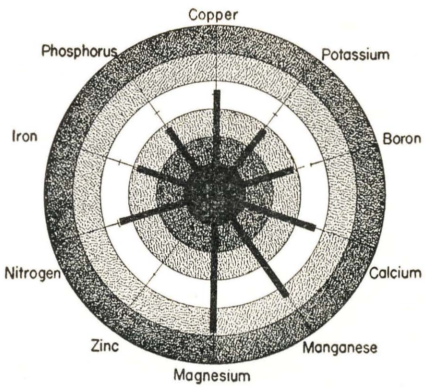
MANISTEE

Fig. 28. Relative balance of nutrient-elements in Manistee County.

Excess of manganese and magnesium.

Shortage of iron, phosphorus, potassium and boron.

Deficiency index–85.



BENZIE

Fig. 29. Relative balance of nutrient-elements in Benzie County.

Excess of manganese and magnesium.

Shortage of iron, phosphorus, potassium and boron.

Deficiency index–86.

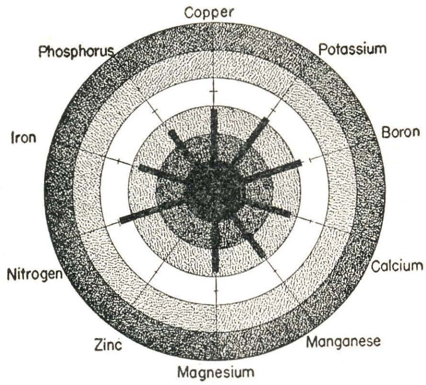


Fig. 30. Relative balance of nutrient-elements in Leelanau County.
Shortage of all nutrient-elements except nitrogen.
Deficiency index–149.

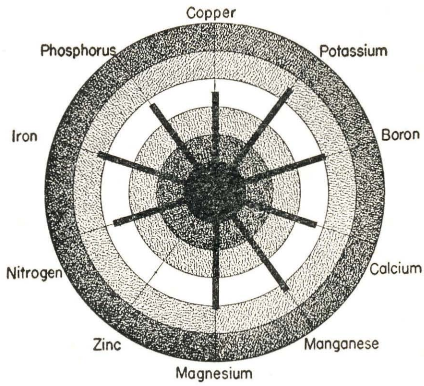


Fig. 31. Relative balance of nutrient-elements in Grand Traverse County.
Excess of iron, potassium, boron, manganese and magnesium.
No shortages of nutrient-elements.
Deficiency index–0.

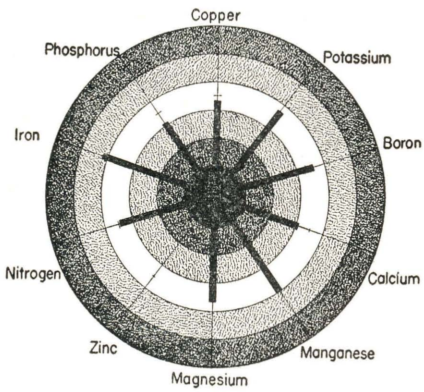


Fig. 32. Relative balance of nutrient-elements in Antrim County.
Excess of iron, potassium and manganese.
Shortage of phosphorus and calcium.
Deficiency index–36.

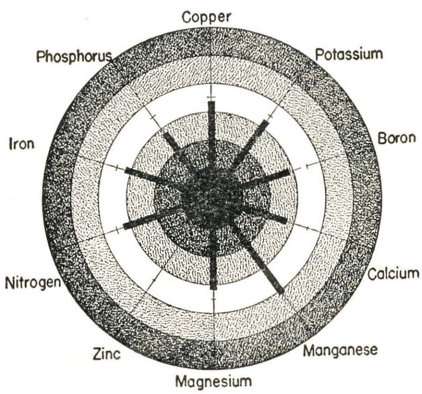


Fig. 33. Relative balance of nutrient-elements in Cheboygan County.
Excess of manganese.
Shortage of iron, phosphorus, boron, calcium and magnesium.
Deficiency index–107.

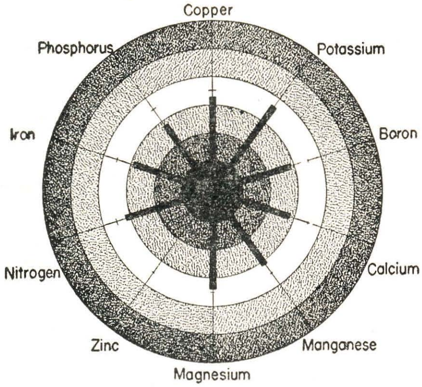


Fig. 34. Relative balance of nutrient-elements in Sanilac County.

No excesses of nutrient-elements.

Shortage of iron, phosphorus, copper, boron, calcium and manganese.

Deficiency index–113.

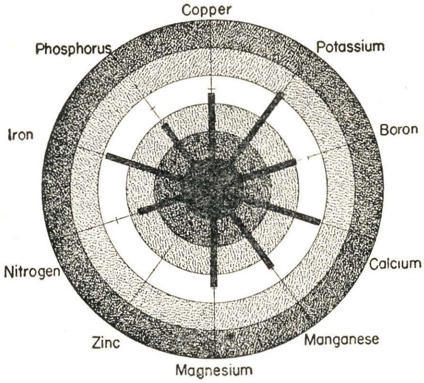


Fig. 35. Relative balance of nutrient-elements in Macomb County.

Excess of iron, potassium and calcium.

Shortage of nitrogen, phosphorus and boron.

Deficiency index–66.

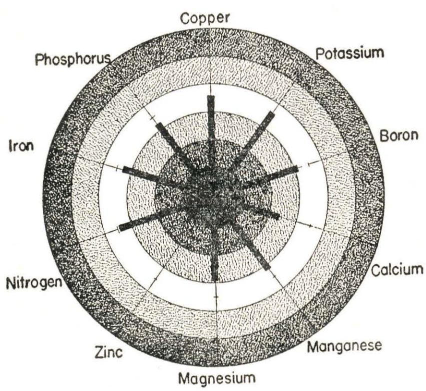


Fig. 36. Relative balance of nutrient-elements in Genesee County.

No excesses of nutrient-elements.

Shortage of iron, phosphorus, boron, calcium, manganese and magnesium.

Deficiency index–94.

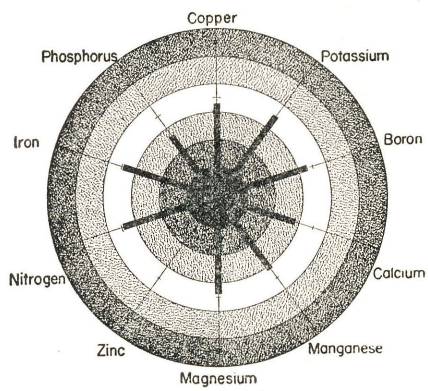


Fig. 37. Relative balance of nutrient-elements in Oakland County.

No excesses of nutrient-elements.

Shortage of phosphorus, calcium and manganese.

Deficiency index–85.

DISCUSSION

The orchard soils were relatively high in phosphorus, potassium and iron but relatively low in calcium, magnesium, manganese and pH.[8]. The amounts of soil calcium and magnesium were essentially only 50 percent of soil test standards. The calcium content of crop soils is usually 2 or 3 times that of potassium, while in these orchards there was essentially equal quantities of calcium and potassium. The apparently low level of calcium and the pH indicate that there may be need for lime in certain areas. The low levels of magnesium indicate that deficiencies of magnesium are eminent and should be watched for.

The subsoil contained a lower supply of most nutrients than the surface soil. The surface soil beneath trees usually contained a greater supply of nutrients than the surface soil between trees. The greater supply of nutrients in the surface soil beneath trees probably reflects the practice of placing fertilizers beneath the limbspread. Fertilizer applications also probably account for the higher level of phosphorus, potassium and manganese in the surface soils since the subsoil did not contain as much of these elements as did the surface soil.

The soil in apple orchards generally had a lower supply of nutrients than did the soil in other orchards, while that in peach and pear orchards had the highest supply of nutrients. This variation in the soil nutrient supply may reflect differences in the general fertilizer practices, soil management methods, nutritional demands, and fruit habits of different kinds of fruit.

Certain fruit-producing areas appear to be considerably lower than others in the supply of nutrient-elements available in the soil. Also certain areas appear to be considerably lower than others in the amount of the various nutrient-elements contained in the leaves.

All of the nutrient-elements measured by use of either soil or leaf analysis were found to vary considerably. The balance of the nutrient-elements, however, was found to be satisfactory in many areas. The balance of nutrient-elements in other areas showed that from one to six nutrient-elements were below average. The fact that no deficiency symptoms were evident does not eliminate the possibility that improved growth and production may result from an addition of those nutrient-elements for which there was a shortage. Such an improvement in growth and production may be expected in many instances

[8]Spurway and Lawton, *op. cit.*

because in certain areas and individual orchards the shortage of nutrient-elements appeared to be critical.

The possibility of a deficiency of nutrients which appear to be adequate should not be overlooked. Orchards in the same area, growing on different soil types or receiving different fertilizer treatments and management practices, may have altogether different nutritional conditions. For example, magnesium deficiency has been found in Van Buren County. The survey results indicate an adequate supply of magnesium. The magnesium deficiencies have been observed to follow sudden changes in the fertilizer program and the continuous application of potassium.

Deficiencies of nitrogen, potassium, manganese, magnesium and boron have been found and identified in various Michigan orchards. Results of leaf analysis indicate that the supply of nitrogen, despite the extreme variation in amount applied, was less variable than that of other nutrients. Potassium deficiencies are probably more common than deficiencies of any other single element. The results indicate that certain areas are low in soil potassium. Interestingly enough, those areas where soil potassium was low were not necessarily low in leaf potassium. This lack of correlation between soil and leaf analysis is not uncommon and may be due to the relative proportions of other elements such as calcium and magnesium in the soil, the exchange capacity of the soil, or weather conditions.

Potassium deficiency is found more frequently in newly planted orchards. The newly planted orchards appear to develop potassium deficiency when the planting follows a crop that has a high requirement for potassium and calcium, such as alfalfa. Certain crops, such as alfalfa, require larger amounts of calcium and potassium than fruit trees, and heavy applications of lime are usually made to such crops. Often when the orchard is planted, supplemental potassium applications are not made on such fields and thus, potassium is not brought into proper balance with calcium. The general practice of not applying any fertilizer when the orchard is planted may, in part, be responsible for the occurrence of potassium deficiency in newly planted orchards. Recent research[9] indicates that potassium may be applied safely to newly planted orchards in the form of a starter solution and may greatly benefit tree growth.

Deficiency symptoms often develop when the fertilizer program is altered without due concern for certain other elements. Magnesium

[9]McManus, George A. (1953). The influence of certain starter solutions upon the growth of cherry trees. Thesis for degree of M.S., Mich. State Col., East Lansing. (Unpublished).

deficiency has been observed to develop when the fertilizer program was changed from nitrogen to a high-potassium complete fertilizer. The additional amounts of potassium may not only depress the absorption of magnesium but also increase the demand for magnesium. This influence of potassium upon magnesium has resulted in visible symptoms of magnesium deficiency developing on older trees growing in areas having a low amount of available magnesium. In addition, many orchard practices increase the availability of magnesium and its possible loss from leaching from more sandy soils.

Manganese deficiency may be induced because of alterations in fertilizer practices. Applications of lime may reduce the available supply of manganese to such a level that deficiency symptoms develop. Applications of nitrogen, potassium and certain other fertilizers may increase the absorption of manganese. An alteration in the fertilizer program which results in a reduction in the availability of manganese or increased absorption of manganese could result in a deficiency of manganese in areas where the manganese supply was already low.

Fertilizer applications may result in what may be considered as "induced" deficiencies, and such effects should be considered when altering the fertilizer program. If nutrient-elements other than those to be applied in the revised fertilizer program are known to be somewhat low in the supply, precautions should be made to safeguard against inducing a deficiency.

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