Organic Soil Test Levels, and Changes in Michigan, 1962-72
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INTRODUCTION

Less than 5% of the 4.5 million acres of organic soils in Michigan is used for crop production. However, this important segment of our agricultural soils is used to produce high value crops adapted to conditions of high moisture and organic matter - carrots, onions, celery, lettuce, mint, potatoes and sod.

Organic soils are defined as containing 30% or more organic matter at least one foot deep. Since these soils are naturally low in fertility, crop production depends on sound fertilization and liming practices. The nutrient status of organic soils tested during 1961 was discussed by J. C. Shickluna and R. E. Lucas (5). This report is of soil test data collected from 1962-72 and provides information about changes in organic soil fertility and trends in fertilizer use.

METHODS

Soil test data in this report are from the Central Soil Testing Laboratory of the Crop and Soil Sciences Department at Michigan State University. Soil pH was determined with a glass electrode using a 2:1 water to soil ratio; lime requirement by the Ohio SMP buffer procedure (6); "available" soil phosphorus by the Bray P 1 method (1); and exchangeable potassium, calcium, and magnesium by extraction with neutral 1 N ammonium acetate.

All soil test data were compiled by computer (Controlled Data Corporation Model 3600) and stored on magnetic tape. Since more than 20 county laboratories and fertilizer companies offer soil testing services, the samples processed by the Central Laboratory account for only part of the total soil samples tested in Michigan, but are assumed representative of those tested by other labs (Table 1).

Table 1. Number of organic soil samples analyzed in Michigan State University's central soil testing laboratory

YEAR	STATE	COUNTY					
		Lapeer	Ingham	Livingston	Newaygo	Jackson	Ottawa
1962	495	94	70	14	39	14	5
1963	949	178	123	10	43	56	41
1964	1059	171	151	53	69	127	26
1966	782	144	141	44	69	33	25
1967	586	112	97	55	14	23	4
1968	985	124	80	77	64	15	137
1969	748	149	29	159	16	50	32
1970	713	87	37	59	58	87	63
1971	475	104	94	9	57	5	20
1972	478	76	49	5	17	18	26

Michigan organic soils vary considerably. Hence, statewide averages may not give the most meaningful evaluation of organic soil test data. In a comparable summary of mineral soils data southern Michigan was divided into 5 geographical regions where soil types and cropping practices are similar (Fig. 1). These areas do not distinguish as well between types of organic soils, but do differentiate major production areas.

Changes in soil test levels and fertilization practices for regions II through V are presented for 1962, 1967, 1971, and 1972. Insufficient numbers of organic soils were analyzed (less than 10 per year) from northern lower Michigan and the upper peninsula to give a valid year-to-year comparison. Mean soil test values can be misleading unless distribution of samples falling within various soil test levels is considered. Evenso, mean distribution within levels may change considerably.

To distinguish accurately between types of organic soils, soil test data are presented for the six counties having the most organic soil samples analyzed by the Central Laboratory (Table 1).

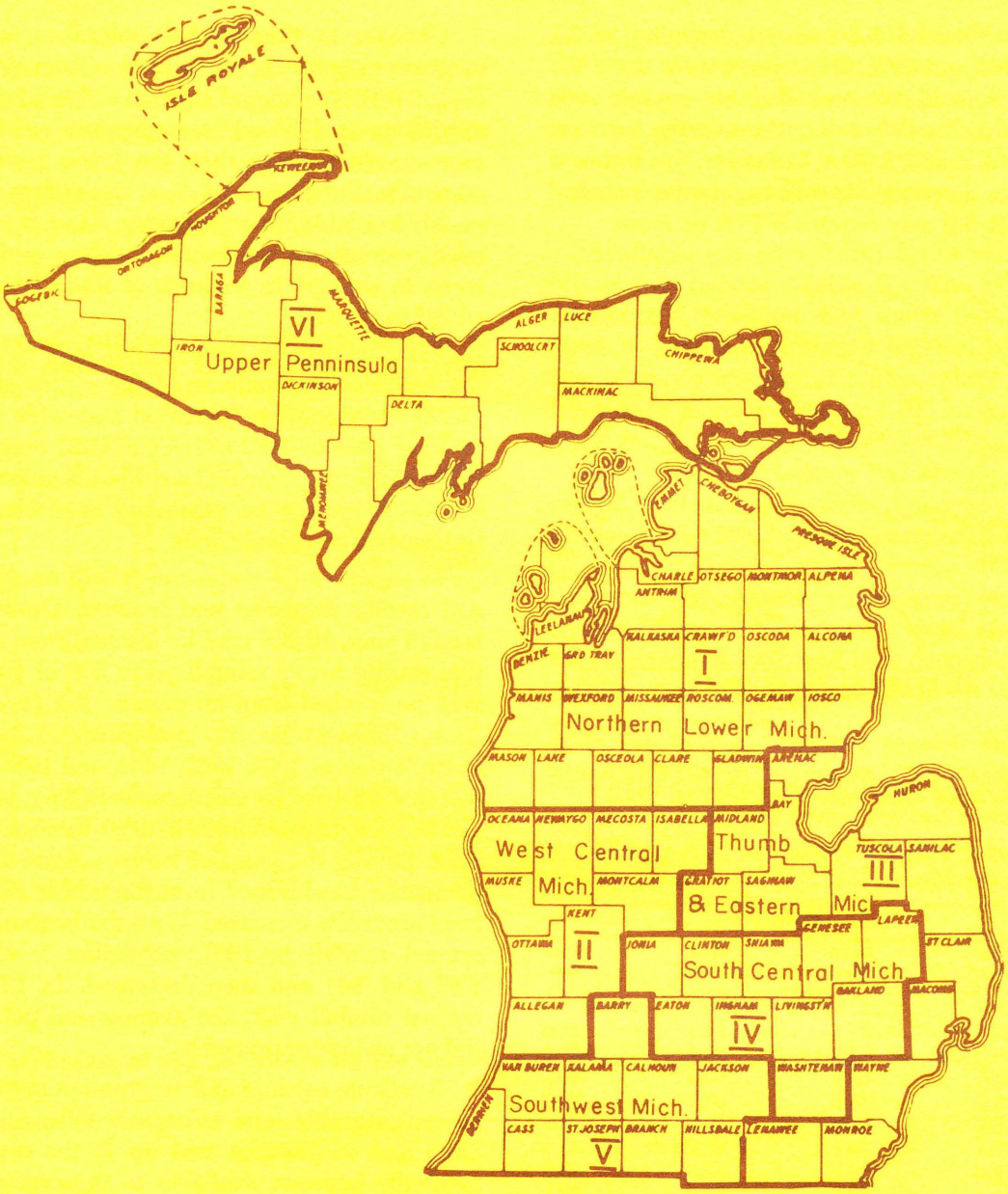

Fig. 1. Soil test summaries were prepared for these geographical regions in Michigan.

DATA AND DISCUSSION

Because nutrient requirements of specialty crops grown on organic soils are higher than common agronomic crops and because many organic soils are naturally low in fertility, more fertilizer, especially potassium, is needed on these soils. The amount of fertilizer appled per acre of organic soil is higher than the state average. Between 1962 and 1971 the state average for nitrogen (N) application increased from 20 to 59 lb/A, phosphate (P_2O_5) from 29 to 55 lb/A, and potash (K_2O) from 26 to 63 lb/A (4). The increase in nitrogen, phosphate, and potash fertilization on organic soils during this period was probably similar, but with actual rates being higher.

NUTRIENT LEVELS

State Averages

Variations in organic soil management are not as great between different areas of Michigan as mineral soils. Hence, changes in average fertility levels of organic soils give information about trends in fertility management practices (Fig. 2). The average soil pH

has fluctuated between 6.3 and 6.4 dropping to 6.1 only during 1963 and 1971. Both years were dry (Table 2). Since lime is recommended for organic soils only when the pH is below 5.2, the average lime requirement is less than 0.1 T/A. However, this figure is misleading since most organic soils require no lime and those below pH 5.0 may require 5 T/A or more.

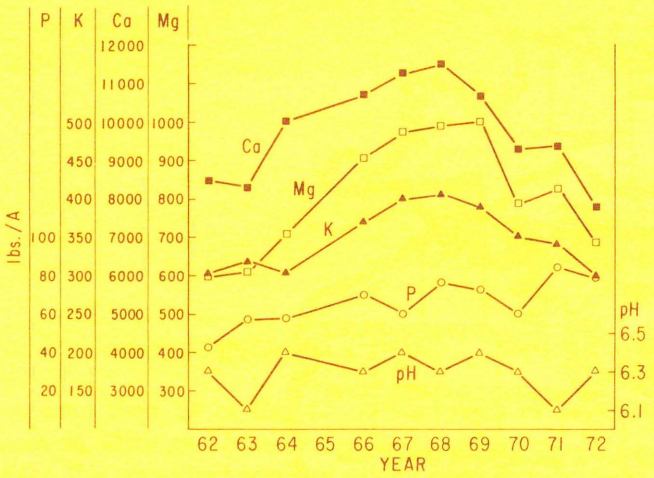

Fig. 2. State average soil test levels of pH, phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) for organic soils each year from 1962 to 1972.

Table 2. Average yearly precipitation in four Michigan climatic regions

YEAR	REGION			
	West Central	South West	South Central	South East
	..... inches per year			
1962	27.7	27.5	24.1	26.6
1963	26.8	28.9	22.1	19.6
1964	28.5	30.7	27.9	26.1
1965	38.9	38.6	35.7	32.2
1966	32.9	36.4	30.3	28.6
1967	37.1	39.1	34.8	33.4
1968	32.6	36.7	36.3	36.6
1969	34.3	36.0	30.0	29.9
1970	34.4	38.2	35.2	28.6
1971	24.9	30.9	28.8	23.0
1972	32.2	39.4	37.9	32.9
Normal	31.3	34.4	32.5	30.7

From 1962-72 the average phosphorus soil test level increased from 43-79 lb available P per acre. On mineral soils about 10 lb of P_2O_5 per acre are required to increase the phosphate soil test one pound (7). Assuming this to be valid for organic soils also, 360 lb of P_2O_5 or 33 lb/A per year would have been needed to give the observed increase. Applying recommended rates of phosphate builds up residual phosphate because only about 20% of applied phosphate is taken up by vegetable crops during the first year (3, 7). The other 80% remains in the soil in a less available form contributing to a gradual increase in the phosphorus soil test level.

Changes in the average potassium, calcium and magnesium soil test levels were similar from 1962-72 (Fig. 2). Potassium and calcium soil test levels reached maximums in 1968 while magnesium reached a maximum in 1969. Since then the levels have decreased markedly. Fertilizer and lime use information is not readily available for organic soils. Thus, it is difficult to relate changes in potassium, calcium and magnesium levels to changes in amounts of these materials being added to the soil.

Fertilizer use on organic soils may closely parallel the fertilizer use pattern of the entire state. Potash (K_2O) tonnage has increased statewide from 89,337 tons per year in 1962 to over 173,023 tons per year in 1971. With this increase, a decrease in potassium soil test levels cannot be attributed to decreased potash fertilization of organic soils.

In organic soils, potassium is held on exchange sites and readily displaced and leached. During a normal rainfall year, 10-20% may be leached from the soil profile; during heavy rainfall years 50% of the potassium may be leached from an organic soil (2, 5). Rainfall data (Table 2) for this period reveal below normal precipitation in 1962, 1963, 1964, and 1971, above normal in 1965 (no soil test data available), below to normal in 1966, above normal in 1967 through 1970 and in 1972. During the years of below normal rainfall, little potassium was leached from the profile so the soil test level gradually increased. With the beginning of above normal rainfall in 1967, potassium levels stabilized ('67 and '68) and then decreased. In 1971, a below normal rainfall year, the average soil potassium level did not change appreciably.

Available calcium and magnesium occurs largely in an exchangeable form in organic soils. Additional calcium and magnesium tied up in the organic matter gradually becomes available as the organic matter is oxidized. With an average lime requirement of less than 0.1 T/A per year, liming accounts for only a small portion of the available calcium and magnesium in organic soils.

On the average, 1.2 in. of an organic soil is oxidized per year. Undeveloped organic soils contain, on the average, 1% calcium and 0.3% magnesium (2) or about 900 lb calcium and 270 lb magnesium per acre. However, this includes exchangeable and organically bound calcium and magnesium. Hence, the contribution due to oxidation is much less in cultivated organic soils. Like potassium, calcium and magnesium soil test levels increased during below normal rainfall years, stabilized during 1968-69 and then decreased as excessive precipitation continued. Calcium and magnesium soil test levels increased slightly in 1971, a below normal rainfall year.

Regional Averages

Table 3 shows the changes in the fertility status of organic soils in four Michigan regions. Trends within each region are similar to state averages (Fig. 2), but the nutrient soil test levels and degree of change vary among regions. Many organic soils in southwestern Michigan are becoming shallow, grading into the more acid underlying materials which reflects the lower soil pH.

Table 3. Average soil test values of organic soils in four regions and all of Michigan for 1962, 1967, 1971 and 1972

REGION	YEAR	SOIL TEST LEVELS					
		pH	Lime Rqmt.	Phos-phorus	Potas-sium	Cal-cium	Magne-sium
			T/A	pounds per acre			
West Central Michigan	1962	6.3	0.1	73	477	9,002	564
	1967	5.9	0.1	96	490	11,663	927
	1971	6.1	0.4	91	420	8,927	695
	1972	6.2	0.2	106	393	8,564	681
Thumb and Eastern Michigan	1962	6.4	0.1	27	142	6,694	478
	1967	6.6	0.1	61	302	9,471	802
	1971	6.3	0.1	147	421	7,714	843
	1972	6.6	0.2	103	289	7,814	732
South Central Michigan	1962	6.3	0.3	38	304	9,193	661
	1967	6.5	0.2	57	424	12,059	1,065
	1971	6.1	0.5	78	312	11,559	1,019
	1972	6.5	0.0	57	262	8,885	839
South West Michigan	1962	6.0	0.1	39	201	8,002	546
	1967	5.8	0.3	50	331	8,744	718
	1971	5.9	0.4	53	217	7,115	664
	1972	5.4	0.0	94	272	4,386	395
Average for Michigan	1962	6.3	0.2	43	301	8,523	596
	1967	6.4	0.2	60	402	11,275	975
	1971	6.1	0.5	84	340	9,385	826
	1972	6.3	0.1	79	297	7,810	689

In the other regions soil pH has fluctuated around the state average, 6.3. The average lime requirement does not accurately reflect the lime need of all soils within a given region, but rather the lime need of a few acid soils (Table 4). Over 95% of the organic soils tested required no additional lime.

Available soil phosphorus levels varied considerably among regions (Table 3). The organic soils of west-central Michigan had much higher phosphorus levels in 1962 than the other regions. With the exception of the south-central region, phosphorus soil test levels have increased to about 100 lb/A.

The portion of organic soil samples having phosphorus levels less than 39 lb/A has decreased and the portion above 150 lb/A has increased (Table 5).

Potassium, calcium and magnesium levels for all regions followed the statewide trend of increasing between 1962 and 1967, and then decreasing to the present. However, the actual soil test levels varied considerably among regions.

The distribution of potassium soil test levels shifted upward in 1967, but during the last 2 years it has been concentrated in the middle ranges with fewer samples below 100 or above 500 lb/A (Table 6).

Table 4. Distribution of soil pH values for the organic soils of four regions of Michigan for 1962, 1967, 1971 and 1972

REGION	YEAR	RANGE IN pH VALUES							
		Below 4.5	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	7.0-7.4	Above 7.4
		% of samples							
West Central Michigan	1962	2.9	1.0	8.6	13.3	17.1	38.1	12.4	6.7
	1967	3.1	7.7	16.9	16.9	32.3	13.8	6.2	3.1
	1971	1.4	4.7	14.2	18.2	30.4	18.9	9.5	2.7
	1972	0.0	3.5	7.8	23.4	34.8	14.2	9.9	6.4
Thumb and Eastern Michigan	1962	10.6	0.0	0.0	7.1	17.6	24.7	24.7	15.3
	1967	0.0	0.0	2.8	12.7	23.6	26.8	16.9	16.9
	1971	0.0	0.0	17.2	17.2	24.2	13.8	13.8	13.8
	1972	0.0	2.9	2.9	5.7	31.4	28.6	11.4	17.1
South Central Michigan	1962	2.9	2.4	5.3	19.6	27.8	20.0	16.3	5.7
	1967	1.6	0.8	4.7	7.6	26.8	35.7	15.4	7.6
	1971	2.3	5.7	11.8	19.8	21.7	21.7	13.7	3.4
	1972	0.0	0.5	4.4	19.4	23.8	27.2	16.0	8.7
South West Michigan	1962	0.0	4.2	20.8	27.1	12.5	22.9	12.5	0.0
	1967	6.0	12.0	18.0	20.0	24.0	12.0	4.0	4.0
	1971	12.2	8.2	4.1	14.3	30.6	14.3	8.2	8.2
	1972	17.1	11.4	15.7	30.0	18.6	7.1	0.0	0.0
Average for Michigan	1962	3.8	1.8	6.4	16.7	22.1	25.2	17.1	6.8
	1967	1.9	2.4	7.2	10.9	27.0	29.5	13.3	7.8
	1971	2.8	6.2	12.1	18.8	24.6	19.8	11.5	4.2
	1972	2.5	3.1	6.9	20.7	27.4	20.3	11.5	7.5

Table 5. Distribution of available phosphorus values for the organic soils of four regions of Michigan for 1962, 1967, 1971 and 1972

Region	Year	RANGE IN PHOSPHORUS LEVELS (LB/A) 0-9	10-19	20-39	40-69	70-99	100-149	150-199	Above 200
		% of samples							
West Central Michigan	1962	6.7	21.0	18.1	14.3	12.4	4.8	20.0	2.9
	1967	6.2	7.7	12.3	15.4	15.4	21.5	12.3	9.3
	1971	6.8	5.4	10.1	20.9	16.9	27.7	7.4	4.7
	1972	4.3	6.4	9.9	17.0	13.5	23.4	17.7	7.8
Thumb and Eastern Michigan	1962	12.9	34.1	37.6	10.6	1.2	2.4	1.2	0.0
	1967	11.3	19.7	21.1	31.0	5.6	5.6	1.4	4.2
	1971	6.9	13.8	10.3	13.8	10.3	10.3	13.8	20.7
	1972	11.4	8.6	22.9	8.6	11.4	14.3	5.7	17.1
South Central Michigan	1962	22.9	23.7	18.8	16.7	8.6	6.1	3.3	0.0
	1967	12.0	16.4	16.7	21.1	15.9	14.1	3.6	0.3
	1971	8.4	11.8	19.8	19.8	16.0	9.9	4.9	9.5
	1972	3.9	14.1	25.2	24.8	19.4	9.2	1.9	1.5
South West Michigan	1962	25.0	10.4	20.8	27.1	10.4	4.2	2.1	0.0
	1967	14.0	28.0	20.0	18.0	8.0	6.0	2.0	4.0
	1971	8.2	22.4	24.5	28.6	0.0	10.2	2.0	4.0
	1972	1.4	10.0	15.7	20.0	20.0	11.4	11.4	10.0
Average for Michigan	1962	17.7	23.9	22.3	15.9	8.2	5.0	6.2	0.6
	1967	13.1	16.7	16.7	21.0	13.5	12.8	4.1	2.0
	1971	7.7	11.5	16.9	20.4	13.9	15.1	5.8	8.8
	1972	5.2	11.7	18.8	19.9	16.1	14.0	8.2	6.1

Table 6. Distribution of available potassium values for the organic soils of four regions of Michigan for 1962, 1967, 1971 and 1972

REGION	YEAR	RANGE IN POTASSIUM LEVELS (LB/A) 0-59	60-109	110-159	160-209	210-249	250-299	300-399	400-499	Above 500
		% of samples								
West Central Michigan	1962	2.9	5.7	1.9	0.0	7.6	1.9	13.3	21.0	45.7
	1967	7.7	7.7	4.6	4.6	7.7	4.6	10.8	3.1	49.2
	1971	0.0	4.7	5.4	6.8	7.4	10.1	16.9	17.6	31.1
	1972	2.8	6.4	10.6	9.2	8.5	10.6	7.1	12.1	32.6
Thumb and Eastern Michigan	1962	10.6	37.6	22.4	18.8	1.2	1.2	3.5	3.5	1.2
	1967	2.8	12.7	16.9	14.1	8.5	7.0	14.1	8.5	15.5
	1971	6.9	6.9	6.9	10.3	3.4	3.4	6.9	17.2	37.9
	1972	0.0	2.9	14.3	14.3	20.0	8.6	14.3	20.0	5.7
South Central Michigan	1962	11.4	20.8	13.5	8.6	6.1	2.4	6.5	5.7	24.9
	1967	4.7	7.8	9.6	7.6	3.6	7.6	13.0	9.1	37.0
	1971	3.4	11.0	16.0	14.1	9.5	6.1	8.7	10.6	20.5
	1972	0.5	9.7	20.4	14.6	11.7	10.2	17.0	8.3	7.8
South West Michigan	1962	10.4	20.8	16.7	12.5	10.4	10.4	6.3	10.4	2.1
	1967	4.0	16.0	8.0	14.0	12.0	10.0	10.0	2.0	24.0
	1971	6.1	22.4	14.3	4.1	4.1	16.3	26.5	6.1	0.0
	1972	1.4	10.0	11.4	22.9	11.4	10.0	17.1	4.3	11.4
Average for Michigan	1962	9.9	20.5	12.9	8.7	6.0	2.8	7.8	8.9	22.5
	1967	6.1	9.4	9.7	8.4	5.3	7.2	12.5	7.7	33.8
	1971	2.8	10.7	12.1	10.5	7.7	8.3	12.5	12.9	22.4
	1972	2.1	10.7	15.1	13.6	11.3	9.8	13.2	9.2	15.1

County Averages

Fertility levels of counties providing the largest number of soil samples give some indication of the fertility management practices used. Many farmers sample their soils only every 2 or 3 years. To get a good representation of trends in fertility levels, soil tests from periods of years were averaged together on a weighted basis (Table 7). A diversity of crops are grown in these six counties.

Low phosphorus levels in Livingston County reflect management practices for sod and corn grown on organic soils. High phosphorus and potassium levels of Newaygo and Ottawa Counties are the result of many years of celery production. Celery takes up large

Table 7. Weighted average soil test values of organic soils in six counties over a period of years

COUNTY	YEARS	pH	SOIL TEST LEVELS				Principle Crops Grown
			Phosphorus	Potassium	Calcium	Magnesium	
Lapeer	62-64	6.4	57	387	10,900	842	Carrots
	66-69	6.4	83	431	13,600	1229	Onions
	70-72	6.3	67	286	11,490	1025	Potatoes
Ingham	62-64	6.2	53	338	9,660	681	Onions
	66-69	6.4	58	342	10,610	909	Potatoes
	70-72	6.2	68	302	9,320	913	Sod
Livingston	62-64	6.6	25	199	10,370	880	Sod
	66-69	6.7	39	397	12,050	1294	Corn
	70-72	6.6	38	346	10,840	1124	Potatoes
Newaygo	62-64	6.3	82	398	8,850	440	Celery
	66-69	6.4	95	365	9,980	714	Carrots
	70-72	6.4	89	426	10,520	535	Onions
Jackson	62-64	6.1	38	265	9,460	690	Onions
	66-69	6.0	46	303	10,100	821	Lettuce
	70-72	6.0	68	423	10,717	899	Sod
Ottawa	62-64	6.3	83	492	8,710	860	Celery
	66-69	6.2	141	680	12,490	1142	Radishes
	70-72	6.3	100	544	11,200	992	Onions

amounts of phosphorus (60 lb/A) and potassium (385 lb/A). Relatively low magnesium soil test levels in Newaygo County (Table 7) result from the underlying marly material which is naturally low in magnesium. However, these magnesium levels are more than sufficient for good plant growth. Generally, the nutrient levels in organic soils in each of these counties follow state trends.

SUMMARY

Soil pH in organic soils throughout Michigan has averaged about 6.3 since 1962 (actual values depend on location). Phosphorus soil test levels gradually increased from 43 lb/A in 1962 to 79 lb/A in 1972. Levels of available potassium, calcium and magnesium changed in response to the amount of precipitation received. During below normal precipitation years the levels of these nutrients increased; in years receiving above normal precipitation their respective soil test levels stabilized and decreased.

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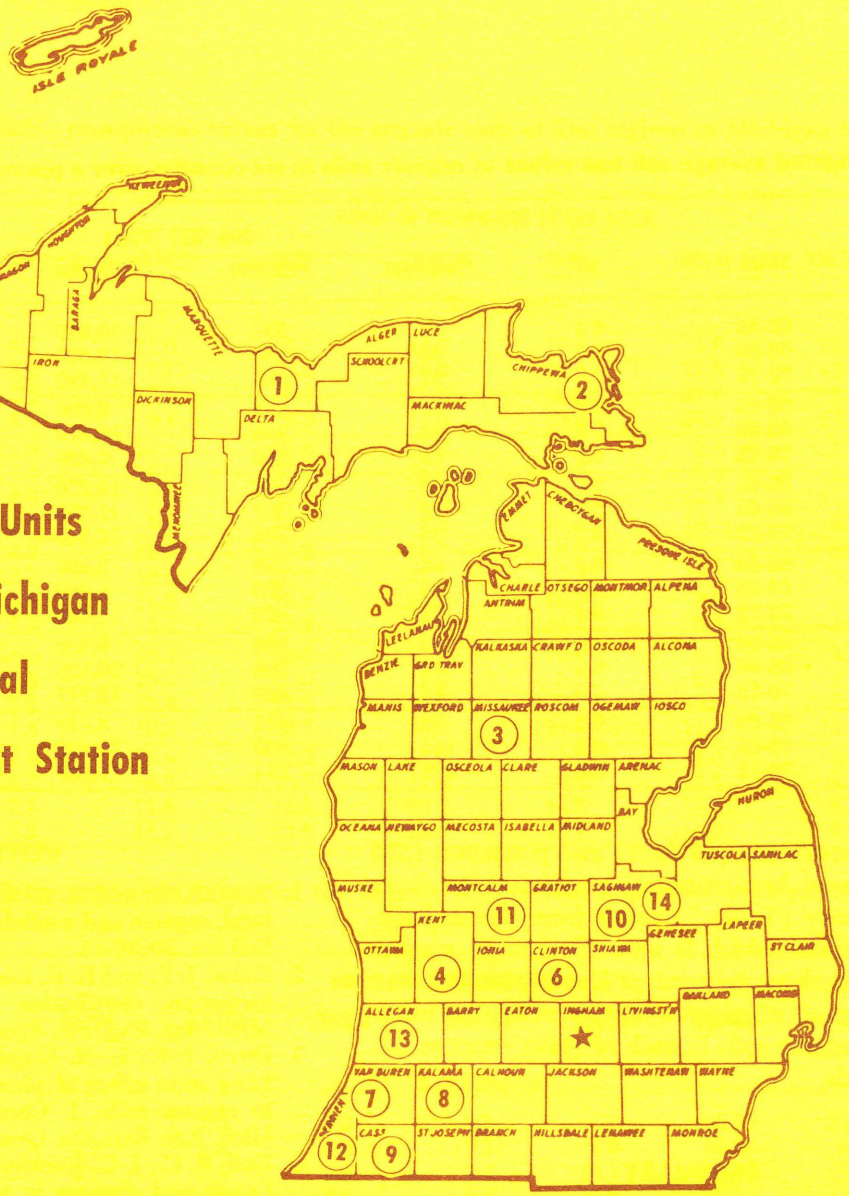

Research Units of the Michigan Agricultural Experiment Station

(1) Upper Peninsula Experiment Station, Chatham. Established 1907. Beef, dairy, soils and crops. In addition to the station proper, there is the Jim Wells Forest.

(2) Dunbar Forest Experiment Station, Sault Ste, Marie. Established 1925, forest management.

(3) Lake City Experiment Station, Lake City. Established 1928. Breeding, feeding and management of beef cattle; and fish pond production studies.

(4) Graham Horticultural Experiment Station, Grand Rapids. Established 1919. Varieties, orchard soil management, spray methods.

★ Michigan Agricultural Experiment Station, Headquarters, 101 Agriculture Hall, MSU, East Lansing. Established 1888. Research work in all phases of Michigan agriculture and related fields.

(6) Muck Experimental Farm, Laingsburg. Plots established 1941, crop production practices on organic soils.

(7) South Haven Experiment Station, South Haven. Established 1890. Breeding peaches, blueberries, apricots. Small fruit management.

(8) W. K. Kellogg Farm and Bird Sanctuary, Hickory Corners, and W. K. Kellogg Forest, Augusta. Established 1928. Forest management, wildlife studies, mink and dairy nutrition.

(9) Fred Russ Forest, Cassopolis. Established 1942. Hardwood forest management.

(10) Ferden Farm, Chesaning. Plots established 1928. Soil management, with special emphasis on sugar beets. (Land Leased)

(11) Montcalm Experimental Farm, Entrican. Established 1966. Research on crops for processing, with special emphasis on potatoes. (Land Leased)

(12) Sodus Horticultural Experiment Station, Sodus. Established 1954. Production of small fruit and vegetable crops. (Land Leased)

(13) Trevor Nichols Experimental Farm, Fennville. Established 1967. Studies related to fruit crop production with emphasis on pesticides research.

(14) Saginaw Valley Beet and Bean Research Farm, Saginaw. Established 1971. Studies related to production of sugar beets and dry edible beans in rotation programs.

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