The Ferden Farm Report:1926-1970 Part 1. Soil Management; Soil Fertility
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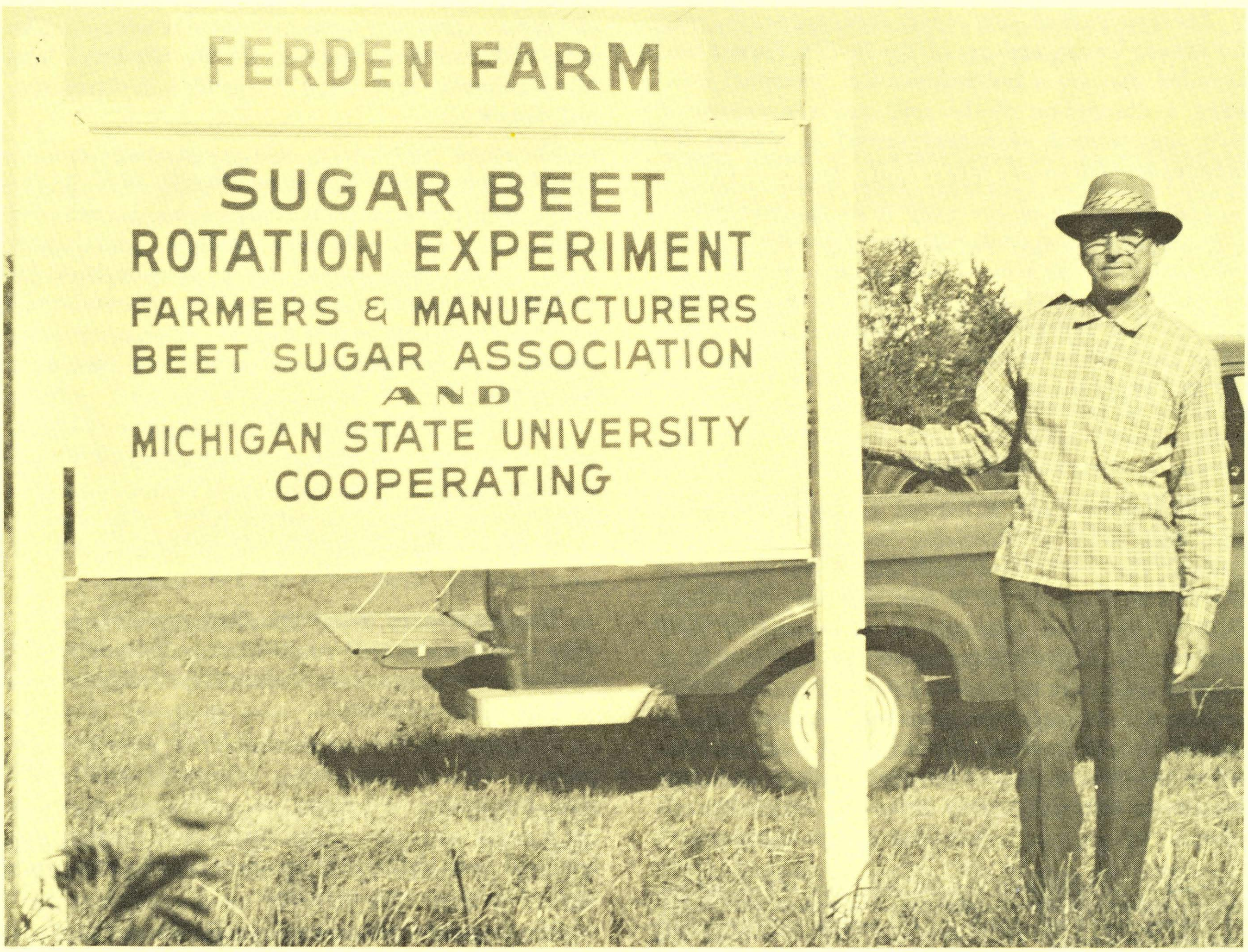
Part I.—Soil Management; Soil Fertility



The late Mr. L. D. Ferden, owner of Ferden Farm, and who cooperated closely with Michigan State University's experimental crops programs since 1926.

THE FERDEN FARM REPORT: 1926–1970
Part I.—Soil Management; Soil Fertility

by L. S. Robertson, R. L. Cook and J. F. Davis

INTRODUCTION

The Ferden Farm field experimental plots have been widely recognized, with results published in national and international journals. When work was terminated in 1970, a segment of history in cooperative research, both applied and fundamental, came to an end.

Although some findings have been formally published, many were summarized annually as mimeographed progress reports. Because much of the early work still serves as a basis for recommendations to Michigan farmers, the results have been brought together in this report.

The first part of this report deals primarily with the unique history and use of the Ferden Farm plots. Included also are a publications list, personnel summary, a description of the soil, and a summary of early unpublished work that served as a basis for later investigations.

The discussion of the early work is divided into three sections. One deals with investigations between 1926 and 1932, the second summarizes research completed between 1933 and 1948, and the third outlines research that will be reported subsequently on sugar beets, navy beans, soybeans, corn, small grains and hay and green manure crops.

HISTORY

The Ferden Farm is located in Saginaw County, four miles south of Chesaning and one mile east of Oakley. The soil is Sims sandy clay loam, containing 50-58% sand—much of it fine and very fine—and 25-28% clay. The relatively large amount of sand weakens the natural structure of the soil so that it puddles easily. It is a good soil to demonstrate the necessity of drainage, the merits of minimum tillage and the beneficial effects of commercial fertilizer. The pH of the plow layer is 6.8 and the cation exchange capacity is 13.5 meq/100 g of soil, of which 8.9 are calcium, 0.2 are magnesium and 2.5 are hydrogen.

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Initially, the farm was owned and operated by Peter Ferden and his son, Lee. Soon after Mr. Ferden moved to Chesaning, the responsibility for the plots fell entirely to Lee and his wife, Gladys. Their two children, Lyle and Carrol Ann (Mrs. Steven Terry), frequently assisted. These people cooperated beautifully with Michigan State University for more than 44 years. The arrangements were unique in that during all of that time there was no written contract. Relations were always satisfactory.

Over the years, the research involved widely different subject matter areas. All work between 1926 and 1940 was supported only by the Michigan Agricultural Experiment Station. Since 1940 some financial support came from commercial organizations. The long and continued support of the Farmers' and Manufacturers' Beet Sugar Association deserves special mention.

The time covered by this cooperative research includes the Great Depression, World War II, the period when horses were replaced by tractors and when cash cropping became profitable and largely replaced the small general farm. It goes back far enough to demonstrate that the use of commercial fertilizer was not economical on some crops and certainly not essential for the yield levels that were then produced.

The first investigations were designed to determine if commercial fertilizer was needed—if its use would be profitable. In 1926, some fertilizer came in 200 lb bags and was spread by hand or by manure or wagon end-gate spreaders. Many farmers did not have fertilizer attachments on their planters.

The significance of suitable field experimental designs soon became evident, and before long some plot work involved experimental design as well as testing of commercial fertilizer.

It is not possible to evaluate the Ferden Farm projects without recognizing other research in the state and nation. Fertilizer placement investigations are a prime example. Grain drills, corn planters and beet and bean drills with fertilizer attachments were used as they became available.

The original work on fertilizer placement for sugar

Horses were used for all early plot work at the Ferden Farm. Here sugar beets are being side-dressed with nitrogen in a project located in one of Mr. Ferden's fields.

beets, beans, peas and corn was done by the same individuals involved in the early Ferden Farm work. These investigations led manufacturers to design and produce new planters with improved fertilizer attachments. This research was also cooperative. The early work with the agricultural engineers of the United States Department of Agriculture was done partly on the Ferden Farm under direction of the writers of this bulletin. Furthermore, much of the work, until the very last years, involved the use of experimental fertilizer materials.

USE OF FERDEN FARMS EXPERIMENTAL PLOTS

The field experimental plots were designed to help researchers gain a better understanding of certain soil/plant relationships and improve production efficiency. The plots were used in other ways which, in retrospect, proved to be not only interesting but of lasting importance.

In agreement with the Land Grant philosophy, with close ties between research, teaching and extension, an estimated 7,000 farmers visited the Ferden Farm and studied the plots to learn how to better manage the soil. The plots were of interest to other groups, including farm managers, soil conservationists, chambers-of-commerce, vocational agricultural teachers and classes, and other university departments. Also, visitors from other states and countries studied the plots.

The plots were used both formally and informally as a training ground for graduate students in soil science. It was here that some learned firsthand the frustrations of trying to outguess weather at locations away from home base—the university—and the warm feeling of satisfaction from watching seeds germinate and eventually produce a bountiful crop due to special treatment provided by the student. These individuals are now scattered around the world and many hold responsible positions in universities, industry and government.

It was also on these plots that graduate students studied field plot design and experimental techniques and learned how to work successfully with others. Looking back, it is obvious that Lee Ferden was as interested in students as he was in crops or farmers. He understood the Land Grant philosophy well and demonstrated its practical use.

The individuals involved in Ferden Farm research but not in the way of publications are listed with their last known locations in Appendix A.

With time, it became evident that some equipment and tools were not suitable Therefore, improvements in planter design and equipment for more efficiently handling field experimental plots were developed.

The plots represented one of the first locations at which interdepartmental or interdisciplinary research with field crops was done in Michigan. Work with crop scientists, agricultural engineers, pathologists, economists and industry was common. This farm represented a unique situation and today many fondly recall their experiences with it.

PUBLICATIONS PERTAINING TO THE FERDEN FARM FIELD EXPERIMENTAL PLOTS

Someone once commented that research is of little value until the results are used. In many instances, the first step to getting field research into use is to publish.

To eliminate the need for repetition and to illustrate points that can not easily be made, a list of the more significant publications is included as Appendix B. It contains the names of more than 35 authors, men who worked on these plots, on soil from the plots in the greenhouse, or in the laboratory.

1926-1932: FERTILIZERS — NECESSARY OR NOT?

The time span over which the Ferden Farm research was conducted covers a period of marked changes in agricultural technology that influenced research goals. The depressed economy during the 1930s resulted in crop surpluses and correspondingly low prices. Farmers attempted to maintain income by expanding production. This further depressed prices, but showed how efficient farmers can be. The results eventually made it possible for American farmers to produce the large quantities of food needed to win World War II.

It is not surprising that over a period so marked with changes the original goals and plot arrangements underwent revision. Some alterations were the result of personnel changes that occurred more frequently in latter years.

The first study was to determine whether fertilizer was needed on the very good soils of the Saginaw Valley. The total fertilizer used in Michigan in those days (151,177 tons of relatively low grades in 1928) was so small that this study was logical. The first experiment lasted from 1926 to 1932. Corn, sugar beets, beans, barley, oats, wheat and alfalfa were grown, but not every crop was grown each year. The yield results are presented in Table 1.

A glance at corn yields shows that Ferden yellow dent corn could yield 50+ bu/acre on that soil without NPK fertilizers (Table 1). This was then a very satisfactory yield. State averages were approximately 37 bu. In fact, it was not until 1952 that state averages were as high as 50 bu/acre. Usually yields were much less, sometimes only 30 bu. In fact, as recently as 1946 and 1947 state corn yields averaged less than 30 bu/acre.

In this study weeds were well controlled by cultivator and hoe. Plant populations were low, about 8,000 plants/acre with row spacings of 42 in.

In early growth, there was always a visual response to phosphate fertilizer. But as the season progressed, visible differences disappeared and grain yields generally were not affected by fertilizer treatments.

These experiments were also some of the first in Michigan in which gypsum ($CaSO_4$) was evaluated. Current results continue to indicate that this material does not increase corn yields. These results contradict some who still believe the use of gypsum will produce higher corn yields. Such individuals, of course, are basing their recommendations on research done elsewhere and are not aware of what has been done in Michigan.

A similar situation exists in regard to sulfur, a component of gypsum. There are some who promote the use of sulfur, which, according to these data and other of very recent origin, does not increase corn yields on soils similar to those on the Ferden Farm.

Sugar beet yields between 1926-1928 were so low that perhaps the results should be discarded (Table 1). Yet state averages were then seldom over 8 tons/acre. From the data it seems certain that phosphate was needed. Only 250 lb of 0-16-0 increased average yields for three years from 3.3 to 5.7 tons/acre. There was no evidence that potassium or limestone was needed and only slight evidence that $CaSO_4$ and nitrogen might be of value.

The results from beans grown in 1926 and 1927 are also reported in Table 1. There was a yield response from phosphorus and probably from potassium and nitrogen.

The yield levels of beans were very satisfactory, being double the state average for the period. This reflected the productivity of the Saginaw Valley soils and the Ferdens' superior management.

Barley responded well to superphosphate, but very little to potash (Table 1). The highest-yielding plots received nitrogen or limestone ($CaCO_3$) in addition to

Table 1. The effect of broadcast fertilizers on the mean yields of corn, sugar beets, navy beans, barley, oats, wheat and alfalfa (1926-1932)

Plot No.	Fertilizer grade	lb/acre	Corn[a] bu/A	Sugar Beets[b] T/A	Beans[c] bu/A	Average Yield Barley[d] bu/A	Oats[e] bu/A	Wheat[f] bu/A	Alfalfa[g] T/A
1	0-16-0	250	48.1	5.7	19.1	40.8	51.2	25.7	2.29
2	0-16-5	250	50.3	5.9	26.5	39.6	57.5	27.7	2.39
3	0-16-10	250	50.2	5.4	25.3	39.6	55.3	25.8	2.38
4	0-16-20	250	54.3	5.5	24.8	40.3	57.5	23.2	2.62
5	0-16-40	250	51.8	5.4	25.4	37.5	58.9	21.6	2.55
6	Check	0	51.7	3.3	24.0	31.2	56.6	17.8	1.77
7	0-16-0	500	52.6	5.7	24.4	38.9	54.4	21.2	2.82
8	0-16-2.5	500	52.2	5.0	24.3	40.3	54.1	22.1	3.04
9	0-16-5	500	54.1	5.7	26.3	40.5	54.3	27.2	3.19
10	0-16-10	500	51.7	6.1	29.9	41.1	54.4	25.3	3.18
11	Check	0	50.8	3.9	23.8	28.8	57.9	20.5	1.95
12	0-16-20	500	54.4	6.1	27.8	40.1	55.1	25.7	3.23
13E	0-16-0	500	56.6	6.8	24.6	39.6	56.8	28.3	3.01
	$CaSO_4$	200							
13W	0-16-0	500	53.1	5.5	27.2	47.1	62.5	22.9	—
	$CaCO_3$	4000							
14	7.2-16-20	500	55.4	6.8	27.9	48.0	61.5	36.3	3.00
15	0-16-20	500	51.3	5.7	23.6	41.2	48.6	32.0	3.13

(a) 1926, 1927, 1928, 1930, 1931, 1932.
(b) 1926, 1927, 1928.
(c) 1926, 1927.
(d) 1930, 1931, 1932.
(e) 1927, 1928, 1929.
(f) 1928, 1929, 1931, 1932.
(g) 1929, 1930, 1931, 1932.

phosphate and potash. An explanation of the apparent response to $CaCO_3$ is not evident. Later experiments indicated that yield increases from nitrogen were in fact due to fertilizer nitrogen.

State barley yields in the early 1930s approximated 30 bu/acre, so that the levels produced were considered satisfactory.

Oats failed to respond to any fertilizer treatment, but wheat yields were definitely increased by fertilizer. The one plot that received nitrogen produced in excess of 15 bu/acre more than the average of the untreated plots. There was only slight evidence that potash was needed for wheat on that soil.

Average wheat yields for Michigan in the early '30s ranged between 20 and 25 bu/acre, while oats ranged between 35 and 40 bu.

Alfalfa was very responsive to residual fertilizer, especially phosphate. Potash was less effective than phosphate. Later experiments on the farm verify the validity of these results.

In summary, these were the first field experiments on the fine-textured soils of the Saginaw Valley that suggested that commercial fertilizer could and should be used in economic field crop production. While corn and oats did not respond to fertilizer in the manner that they do today, sugar beet, navy bean, barley and alfalfa yields were increased. The extra yields were caused primarily by the use of phosphate on these low-phosphate soils. Potash increased yields only slightly, probably because the soils had relatively high potassium-supplying powers.

1933-1948: FERTILIZERS VERSUS CROPPING SYSTEMS

Because the first fertilizer experiments were not well designed, a new set of plots was started in an adjoining field in 1933.

Wheat was planted in the fall of 1933 and the other crops in the spring of 1934. The plot layout was such that conventional planting and fertilizer application machinery could be used. Treatments were replicated three times, but were not randomized in an acceptable manner. Considerable liberty has been taken in using analysis of variance procedures because of the uniformity of the soil in the plot area. For lack of better procedures for analyzing the data this action seems justified. Treatments included six fertilizer grades and an unfertilized check (Tables 2-8). Average yields for each 5-year period are shown. In this way yield trends become more evident.

Early work with fertilizers for corn showed good growth response early in the season (top photo), but by harvest time all differences disappeared and little or no differences in yield were recorded (bottom photo).

This project involved two kinds of crop rotations. One consisted of navy beans, oats and wheat. A mixed legume green manure was seeded with the wheat in the spring. Crop residues returned to the soil were small because harvest procedures involved "staking" the beans and threshing at a later date away from the plot area. A binder was used in early July to harvest small grains. The bundles were shocked on the plots, dried and transported to a central location for threshing. This procedure undoubtedly reduced the need for nitrogen. Also, nutrient removal from soil was greater than if the straw had been returned to the soil. This influenced long-term yield trends of some crops as will be shown.

The other rotation represented a livestock system of cropping and included alfalfa-brome hay, corn, oats and wheat. This was a four-crop, four-field rotation, but the alfalfa was grown for two consecutive years. After the first wheat crop, corn, oats and wheat were again grown and the alfalfa was spring seeded into the second wheat crop. A leguminous green manure crop was spring planted in the first wheat crop. Thus, the rotation contained four crops but stretched over eight years by bringing the two years of alfalfa together.

Corn was picked by hand and the stover was left on the plots. Harvest procedures similar to those already described were used in this project.

FERTILIZER IN A CASH CROP ROTATION

Navy Beans, Oats, Wheat

Long-term navy bean yields are shown in Table 2. The complete fertilizers 4-12-4, 4-16-4 and 4-16-8 (150 lb/acre) very effectively increased bean yields. The annual increase ranged between 5.9 and 6.2 bu/acre for the 15-year period. The omission of nitrogen and/or potassium resulted in slightly lower average yields, but the differences caused by their absence were not statistically significant.

Table 2. The effect of fertilizer applied in a band at planting time on the yield of navy beans (1934-1948)

Fertilizer grade	lb/acre	Average Yield bu/acre 1934-1938	1939-1943	1944-1948	Average 1934-1948
0-16-0	150	31.5	24.1	20.4	25.4
4-16-0	150	32.7	24.7	19.4	25.6
0-16-8	150	32.9	25.6	21.0	26.6
4-16-8	150	33.0	26.4	21.6	27.0
4-16-4	150	33.1	26.1	22.1	27.2
4-12-4	150	32.4	27.1	22.4	27.3
Check	0	28.6	20.5	17.0	22.0

Experiments conducted at other locations during the same years showed that it generally paid to fertilize this crop. Yield responses were not great but they were consistent.

This 3-year rotation was similar in many ways to some rotations used today. The period between bean crops was short, the total amount of crop residues returned to the soil was small and the plots were plowed each year. Thus there was an opportunity for soil organic matter levels to decrease. The data strongly indicate that the physical condition of the soil deteriorated with time. Yields on the no-fertilizer plots were 11.6 bu/acre less during the third 5-year period than the first. Even on the fertilized plots decreases were almost as great (from 10.0 to 11.9 depending on the fertilizer treatment).

These plots were in part the basis for the warning issued to Michigan bean farmers about the disadvantages of short rotations. Despite this warning, many producers continued to use short rotations and by the late 1960s state navy bean averages had started to decline.

The effects of insects and/or disease are now being considered but, with one exception, were not observed during the study. The Robust variety, grown until about 1938, is reported to be resistant to the Bean Common Mosaic Virus. The Michelite variety, grown after 1938, is only partially resistant and on occasions the disease was probably present.

The oats in the rotation received 150 lb/acre of fertilizer. There was a definite yield response to phosphate but a very low response to potash or nitrogen (Table 3). In contrast to beans, the oat yields increased greatly during the second five years and were unchanged during the third 5-year period.

Wheat in this rotation received 250 lb/acre of fertilizer. As with both oats and beans, wheat responded primarily to phosphate (Table 4). The use of both nitrogen and potash, on occasions, slightly increased yields.

Table 3. The effect of fertilizer applied with a grain drill on the yield of oats in a bean, oat, wheat (green manure) rotation (1934-1948)

Fertilizer grade(a)	Average Yield bu/acre 1934-1938	1939-1943	1944-1948	Average 1934-1948
0-16-0	55.1	76.6	75.1	69.7
4-16-0	54.9	75.1	79.6	70.3
0-16-8	54.8	78.3	77.4	70.8
4-16-8	53.7	76.6	78.0	70.0
4-16-4	54.8	74.7	76.5	69.1
4-12-4	56.3	74.9	79.0	70.4
Check	49.5	65.7	70.0	62.1

(a) 150 lb/acre.

Table 4. The effect of fertilizer applied with a grain drill on the yield of winter wheat in a bean, oat, wheat (green manure) rotation (1934-1948)

Fertilizer grade(a)	Average Yield bu/acre 1934-1938	1939-1943	1944-1948	Average 1934-1948
0-16-0	29.2	27.3	28.4	28.3
4-16-0	31.3	28.3	30.7	30.1
0-16-8	32.1	27.0	28.8	29.3
4-16-8	32.7	28.9	28.7	30.1
4-16-4	33.6	28.9	29.8	30.8
4-12-4	34.2	28.2	31.3	31.2
Check	21.3	20.5	23.0	21.6

(a) 250 lb/acre.

When supplemental nitrogen was first used an interesting observation on responses was made. In 1948 a 7-ft-wide strip of supplemental nitrogen (40 lb of nitrogen as ammonium sulfate) was located along the edge of each series of plots. The growth and color response were striking on all plots except the check. The observations substantiated the fact that on this soil the first limiting factor was phosphorus and that responses to nitrogen were obtained only where phosphate fertilizers were used. The observations led to the use of supplemental nitrogen on other wheat plots after that date.

FERTILIZER RESPONSE IN A LIVESTOCK SYSTEM OF CROP ROTATION

The same fertilizer treatments as just discussed were made in a livestock system of cropping involving alfalfa-brome hay.

Fertilizer was applied to corn with a splitboot attachment to the planter. It was placed in two bands, one on each side of the seed. When the attachment was new, the bands were slightly below seed level and very little fertilizer made contact with the seed. However, with time the openers became worn and the fertilizer was located in approximately the same plane as the seed. Some fertilizer was in contact with the seed, which, if the soil was dry, delayed plant emergence.

During the course of this experiment, commercial fertilizer was not generally recommended for corn in Michigan. The data from this experiment served as part of the basis for this recommendation (Table 5).

Table 5. ***The effect of fertilizer applied with a splitboot applicator on the yield of corn in a livestock system of cropping (1934-1948)***

Fertilizer grade[a]	Average Yield bu/acre 1934-1938	1939-1943	1944-1948	Average 1934-1948
0-16-0	55.9	45.7	60.4	51.0
4-16-0	56.5	43.6	60.6	53.6
0-16-8	59.3	47.8	62.0	56.3
4-16-8	55.7	43.1	60.7	53.2
4-16-4	57.9	45.0	58.9	54.0
4-12-4	55.4	41.5	58.3	51.8
Check	57.2	47.2	55.8	53.4

(a) 125 lb/acre.

In only five years out of 15, 125 lb/acre of fertilizer significantly increased corn yields. During the first five years, treatments did not influence corn grain yields despite the fact that early in the season the plants on the fertilized plots always were darker green and taller—sometimes three times as tall as those on the check plots. However, by silking time the plants on the check plots caught up with those on the fertilized plots.

Yields dropped during the second five years. The reason for this was not apparent. In the third period the yields surpassed those produced in the first five years.

As in the cash crop rotation, phosphate increased early growth. No response was obtained from either nitrogen or potash.

In interpreting these data, keep in mind that the variety was open pollinated and the plant population averaged approximately 8,000/acre.

Oats followed corn in each of the 15 years except in 1935 when inclement weather ruined the crop. Fertilizer (150 lb/acre) was in contact with seed. Invariably, such placement retarded emergence. Plants on the check plots emerged from the soil before those on the fertilized plots. The leaves of the plants on the check plots frequently were yellow and on occasions had a purplish tinge that suggested plant nutrient deficiencies.

As with corn, statistically significant increases in oat yields occurred in only five of the 15 years. Both the 5-year and 14-year averages showed increases due to phosphate (Table 6). The use of both nitrogen and potash tended to increase yields slightly, although the increases were probably too small to be profitable at prevailing prices.

A comparison was made between the yields in this rotation and those in the cash crop rotation previously discussed. Differences in yield were small, especially in treatments that involved complete fertilizers. Yield differences on the check plots amounted to only 0.5 bu, suggesting that alfalfa was not essential for soil productivity maintenance for oats.

Table 6. ***The effect of fertilizer applied with a grain drill on the yield of oats in a livestock system of cropping (1934-1948)***

Fertilizer grade[a]	Average Yield bu/acre 1934-1938	1939-1943	1944-1948	Average 1934-1948
0-16-0	63.7	70.6	64.5	66.5
4-16-0	63.5	70.0	71.7	68.7
0-16-8	63.2	73.8	70.0	69.4
4-16-8	64.0	71.2	71.2	69.1
4-16-4	66.6	72.9	73.3	71.2
4-12-4	66.7	72.6	69.6	69.8
Check	61.2	67.5	58.7	62.6

(a) 150 lb/acre.

Wheat responded well to planting time phosphorus, slightly to potassium and with variable results to nitrogen. The yield increases in this 15-year experiment bear this out, ranging from 6.0 bu/acre for 0-16-0 to 7.2 bu for 0-16-8 and 8.4 bu for 4-16-8 (Table 7). All grades were used at the rate of 250 lb/acre. Yields were generally higher than in the rotation that did not include alfalfa. This is considered to be the result of wheat's response to nitrogen that was derived from plowed down alfalfa.

Table 7. ***The effect of fertilizer applied with a grain drill on the yield of wheat in a livestock system of cropping (1934-1948)***

Fertilizer grade[a]	Average Yield bu/acre 1934-1938	1939-1943	1944-1948	Average 1934-1948
0-16-0	31.8	29.2	33.0	31.3
4-16-0	34.6	28.4	36.4	33.1
0-16-8	32.7	29.2	35.7	32.5
4-16-8	33.9	30.1	37.1	33.7
4-16-4	34.1	29.4	34.8	32.8
4-12-4	32.6	28.2	35.2	32.0
Check	28.0	21.0	26.9	25.3

(a) 250 lb/acre.

As in the 3-year cash crop rotation a 7-ft-wide treatment of 40 lb of nitrogen as ammonium sulfate was made across all plots in 1948. The visual response to the supplemental nitrogen was much less on these plots. This suggested that the alfalfa was supplying some nitrogen to the wheat.

The alfalfa hay in this rotation did not directly receive any fertilizer, only that applied for wheat at planting time.

From these plots, 26 alfalfa yields were taken (Table 8). In 1936 and 1943 second cuttings were not made and in three other years yield increases were not significant. It is evident that throughout this study alfalfa yields were significantly increased by residual fertilizers, but probably only by phosphate. All first-cutting yields from the fertilizer plots averaged 2.19 tons, as compared with 1.72 tons from the check, while second-cutting yields were 1.17 tons from the fertilized plots and 1.00 ton from the check, making the average increase from both cuttings equal to 0.64 tons/acre.

Table 8. The effect of fertilizer applied for wheat on the yields of alfalfa which was seeded in wheat (1934-1948)

	Ave. Yield and No. of Cuttings							
Fertilizer grade[a]	*1935 - 1938*		*1939 - 1943*		*1944 - 1948*		*1935 - 1948*	
	1st	*2nd*	*1st*	*2nd*	*1st*	*2nd*	*1st*	*2nd*
	(Tons/acre/cutting)							
0-16-0	2.29	1.21	2.19	1.14	2.01	0.94	2.15	1.14
4-16-0	2.21	1.28	2.19	1.11	1.96	1.09	2.09	1.14
0-16-8	2.39	1.32	2.35	1.09	2.04	1.14	2.25	1.17
4-16-8	2.43	1.41	2.35	1.14	2.04	1.15	2.26	1.21
4-16-4	2.49	1.38	2.31	1.18	2.03	1.10	2.26	1.20
4-12-4	2.26	1.36	1.83	1.18	1.79	1.01	2.11	1.15
Check	2.03	1.25	1.83	1.04	1.38	0.81	1.72	1.00

(a) 250 lb/acre applied to wheat.

In this experiment, alfalfa yields decreased with time not only on the check plots but also on the fertilized plots. This is considered to be due to a gradual reduction in available nutrients, especially phosphorus. Soil test levels before the experiment was initiated were in a low range. Fertilizer rates were not sufficiently high to maintain even the original low level. The average annual application of phosphate was only 22 lb/acre.

In summary, oats and wheat in two crop rotations produced approximately equal yields. No observations were ever made to suggest that the two rotations had different insect or disease problems. Neither corn nor oats responded consistently and significantly to the use of commercial fertilizer, regardless of grade. The increases in wheat and alfalfa yields were due primarily to phosphate. The yields of both alfalfa and beans decreased with time despite the fact that they were fertilized. This fact was the basis for later research.

1940-1970: RESEARCH PROJECTS

The research between 1940 and 1970 will be considered in detail in separate publications for each crop. Briefly, the projects involved micro-nutrient studies, fertilizer investigations, organic matter amendments and crop rotation investigations. The major projects are briefly described as follows.

With the support of the Farmers' and Manufacturers' Beet Sugar Association, the Ferden Farm sugar beet rotation investigations were initiated in 1940. This experiment proved to be well designed, and involved seven systems of cropping, each practiced at two fertility levels. Much of the work on sugar beets has already been published.

A year later, a project involving manganese was started. The crops included sugar beets, navy beans, barley and alfalfa.

At the same time (1941), research on fertilizing corn was started with the support of the Midwest Soil Improvement Committee (MWSI). This project involved a rotation of alfalfa brome, corn, navy beans and barley. The basis for this investigation involved using relatively large amounts of fertilizer on alfalfa as an indirect means of fertilizing corn.

Another project involved commercial fertilizer as a banded, plow-down treatment which was made with a special attachment for the moldboard plow.

In 1947, the support of the MWSI was withdrawn and a new project was superimposed on the old plots. This involved plowing down large amounts of supplemental organic matter as sawdust, wheatstraw and alfalfa.

In 1950, a new sugar beet rotation experiment was started. It was also supported by the Farmers' and Manufacturers' Beet Sugar Association, and had a design similar to the original rotations in that each crop was grown each year and the treatments involved two fertilizer rates. This rotation experiment was an attempt to improve the original sugar beet rotations.

From 1940 to 1970, every field on the Ferden Farm had some research in progress at one time or another. Yearly experiments included such topics as row spacings and fertilizer placement and the use of supplemental nitrogen.

APPENDIX A

Ferden Farm Research Personnel, 1926-1970[1]

A. L. Andersen, Department of Botany and Plant Pathology, Michigan State University

W. B. Andrews, Mississippi Chemical Corp., Yazoo, Mississippi

Aaron Baker, Agronomy and Soils, Washington State University

B. J. Birdsall, US-AID, San Salvador (Retired)

Harold Bockstahler, ARS-USDA, Michigan State University (Retired)

Roy Bronson, International Programs, Purdue University

Patrick Bruffy, Cooperative Extension Service, University of Missouri

M. J. Buschlen, Michigan Farm Bureau Services

T. R. Cox, American Cyanamid Co., New York

D. R. Christenson, Department of Crop and Soil Sciences, Michigan State University

Glenn Cummings, ARS-USDA, Beltsville (Deceased)

Clarence Dorman, Mississippi State University (Deceased)

Dale Eldridge, ARS-USDA, Beltsville

B. G. Ellis, Department of Crop and Soil Sciences, Michigan State University

Clarence Gray, III, Rockefeller Foundation, New York

Hugh Hough, University of Wyoming, Laramie

George Hogaboam, ARS-USDA, Michigan State University

Gary Jarstafer, Farm Machinery Development, South America

B. D. Knezek, Department of Crop and Soil Sciences, Michigan State University

I. M. Knickerbocker, Beechnut Foods, Canajoharie, New York

Bert Krantz, ICRISAT, Hyderabad, India

Joseph Lill, Agronomist, ARS-USDA, Michigan State University (Deceased)

R. E. Lucas, Department of Crop and Soil Sciences, Michigan State University

A. W. McAlister, General Foods, New York City

Gilbert Muhr, India

D. L. Mumford, ARS-USDA, Utah State University

J. E. Oaks, Department of Crop and Soil Sciences, Michigan State University

Walter Redditt, ARS-USDA, Beltsville

P. A. Reeve, Beet Sugar Association, Saginaw

P. E. Rieke, Department of Crop Soil Sciences, Michigan State University

Garry Rinkinberger, Dole Pineapple Co., Hawaii

H. T. Rogers, Agronomy and Soils, Auburn University, Alabama

J. D. Romaine, American Potash Institute, Washington, D. C.

L. N. Shepherd, Agronomy Department, Ohio State University

H. M. Singh, Ranchi Agricultural College, Bihar, India

Floyd Smith, Kansas Agricultural Experiment Station, Manhattan, Kansas

M. B. Tesar, Department of Crop and Soil Sciences, Michigan State University

Leslie Tobin, SCS-USDA, Hanibal, Missouri

James Tyson, Soil Science, Michigan State University (Deceased)

Howard Volbrecht, Campbell Soup Company

Richard Zielke, F & M Beet Sugar Association, Saginaw

[1]Personnel authoring reports are given in Appendix B.

APPENDIX B

A Chronological Report of Popular and Scientific Articles Based Totally or in Part on Ferden Farm Research

1938

1. Millar, C. E.; R. L. Cook and J. F. Davis (1938). Fertilizers for white pea beans. Mich. Agr. Exp. Sta. Spec. Bull. 296.
2. Davis, J. F. and R. L. Cook (1938). A comparison between actual plot yields and those calculated from grain-straw ratios. Soil Sci. Soc. of Amer. Proc. 1:265-268.

1939

3. Davis, J. F. (1939). Comparison between yields calculated from grain-straw ratios and those calculated from small cut-out areas. Jour. Amer. Soc. Agron. 31 (10):832-840.

1942

4. Davis, J. F. (1942). The effect of sweet clover green manure on crop yields on the heavy soils of Michigan. Proc. Soil Sci. Soc. of Amer. 7:290-293.

1944

5. Davis, J. F. and L. M. Turk (1944). The effect of fertilizers and the age of plants on the quality of alfalfa and sweet clover for green manure. Proc. Soil Sci. Soc. of Amer. 8:298-303.

1945

6. Cook, R. L.; C. E. Millar and L. S. Robertson (1945). A crop rotation field layout with an illustration of the statistics involved in combining several years' data. Proc. Soil Sci. Soc. of Amer. 10:213-218.

7. Bell, R. W.; L. S. Robertson and R. L. Cook (1945). The effect of shearing sugar beet seed on labor requirements at time of blocking and thinning and on yield of roots. Mich. Agr. Exp. Sta. Quart. Bull. 28.

1946

8. Davis, J. F.; W. D. Baten and R. L. Cook (1946). The effect of time of application and levels of nitrogen, phosphorus, and potash on the growth of sugar beets with a detailed statistical procedure of confounding in a 3 x 3 x 3 design. Mich. Agr. Exp. Sta. Tech. Bull. 203.
9. Cook, R. L.; C. E. Millar and L. S. Robertson (1946). Sugar beets in seven Michigan systems of crop rotation. Proc. Amer. Soc. of Sugar Beet Tech., February.

1947

10. Cook, R. L.; L. S. Robertson, K. Lawton and P. J. Rood (1947). Green tissue testing with the Spurway soil testing equipment as an aid in soil fertility studies. Proc. Soil Sci. Soc. of Amer. 12:379-381.
11. Robertson, L. S. (1947). Results on the Ferden rotation experiment. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
12. Ferden, L. D. (1947). Good crop rotations improve the soil. Sugar Beet Jour. VII, No. 5, July-August.
13. Cook, R. L. (1947). Deficiency symptoms and tissue tests as aids in the production of sugar beets. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
14. Bell, R. W. (1947). Labor savings resulting from the use of segmented seed. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.

1949

15. Robertson, L. S. (1949). Results of sidedressing experiments on the Ferden Farm in 1948. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
16. Robertson, L. S. and R. L. Cook (1949). Efficiency in the use of fertilizers for corn. Mich. Agr. Exp. Sta. Quart. Bull. 30 (4):374-379.
17. Robertson, L. S.; R. W. Bell, R. L. Cook and H. W. Fairchild (1949). A comparison of segmented with natural sugar beet seed. Mich. Agr. Exp. Sta. Quart. Bull. 31 (4):465-471.
18. Cook, R. L. (1949). The relationship between balance of plant nutrients and crop production. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.

1950

19. Robertson, L. S.; A. E. Erickson and K. Lawton (1950). A study of the utilization of phosphorus by sugar beets as affected by placement. Field Fertilizer Experiments Using Radiophosphorus, North-central Region. 1949-1950:9-12.
20. Robertson, L. S. and C. M. Hansen (1950). A recording soil penetrometer. Mich. Agr. Exp. Sta. Quart. Bull. 33 (1):1-4.
21. Robertson, L. S. (1950). Plant tissue testing as a guide to side-dressing sugar beets. Proc. Amer. Soc. of Sugar Beet Tech. 348-352.

1951

22. Robertson, L. S. and C. M. Hansen (1951). A grain plot harvester. Mich. Agr. Exp. Sta. Quart. Bull. 34:147-148.
23. Robertson, L. S. (1951). Ferden Farm rotations. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., 113-117.
24. Robertson, L. S. (1951). Nitrogen application and its relationship to sugar beet yield. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., 81-86.

1952

25. Robertson, L. S.; R. L. Cook, P. J. Rood and L. M. Turk (1952). Ten years' results from the Ferden rotation and crop sequence experiment. Proc. Amer. Soc. of Sugar Beet Tech. 172-179.
26. Robertson, L. S. (1952). A study of the effects of seven systems of cropping upon yields and soil structure. Proc. Amer. Soc. of Sugar Beet Tech., 225-264.
27. Lawton, K.; L. S. Robertson, R. L. Cook and P. J. Rood (1952). Diagnostic techniques used in soil fertility studies. Mich. Agr. Exp. Sta. Quart. Bull. 34:466-471.
28. Robertson, L. S.; P. J. Rood and J. A. Porter (1952). Nitrogen top-dressing for wheat on heavy soils. Mich. Agr. Exp. Sta. Quart. Bull. 34:226-230.

1953

29. Cook, R. L. and P. J. Rood (1953). Minimum seedbed preparation. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
30. Rood, P. J. (1953). Progress report on results obtained from the Ferden Farm. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.

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31. Lawton, K.; A. E. Erickson and L. S. Robertson (1954). Utilization of phosphorus by sugar beets as affected by fertilizer placement. Agron. Jour. 46 (6): 262-264.
32. Robertson, L. S. and J. F. Davis (1954). Hydraulically controlled weighing equipment for use on field crops. Agron. Jour. 46:289.

1955

33. Owens, L.; K. Lawton, L. S. Robertson and C. Apostolakis (1955). Laboratory, greenhouse and field studies with mixed fertilizers varying in water soluble phosphorus contents and particle size. Proc. Soil Sci. Soc. of Amer. 19:315-319.
34. Hansen, C. M. and L. S. Robertson (1955). A method of mechanically harvesting corn research plots. Mich. Agr. Exp. Sta. Quart. Bull. 37:471-476.
35. Cook, R. L. and L. S. Robertson (1955). Sugar beet seedbed preparation. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
36. Lawton, K. (1955). How soluble should fertilizers be for sugar beets. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
37. Van Doren, D. M. (1955). Field adaption of oxygen diffusion measurements with the platinum microelectrode. Thesis for M.S. degree, Michigan State University.

1957

38. Mora R., J. A. (1957). Effects of organic amendments, fertilizer nitrogen, time and cropping systems on the mineralization of soil organic nitrogen. Thesis for M.S. degree, Michigan State University.

39. Cook, R. L.; J. F. Davis, M. G. Frakes, G. Nichol and P. A. Reeve (1957). Fertilizers for sugar beets. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
40. Guttay, J. R. (1957). Sugar beet yields as affected by crop rotation and weather. Proc. Amer. Soc. of Sugar Beet Tech., East Div., January.

1958

41. Au, Fredrick (1958). Mineralization of soil organic nitrogen as influenced by organic matter amendments, nitrogen fertilizer, crop sequence and time. Thesis for M.S. degree, Michigan State University.
42. Cook, R. L.; H. F. McColly, L. S. Robertson and C. M. Hansen (1958). Minimum tillage; save money, water, soil with. Mich. State Univ. Coop. Ext. Serv. Bull. 352, 23 pp.
43. Guttay, J. R.; R. L. Cook and L. S. Robertson (1958). Sugar beet production in Michigan as affected by cropping sequence and fertility level. Jour. Amer. Soc. of Sugar Beet Tech. 10 (1):66-75.
44. Van Doren, D. M. (1958). Relationship between oxygen diffusion rates as measured with the platinum microelectrode and plant growth. Thesis for Ph.D. degree, Michigan State University.

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45. Robertson, L. S.; C. M. Hansen, R. J. Dudley, H. M. Brown and H. D. Foth (1959). Growth and yield characteristics of spring oats and winter wheat as affected by various placements of fertilizer. Proc. Nat. Joint Comm. on Fert. App.
46. Robertson, L. S.; C. M. Harrison and C. R. Hoglund (1959). The effect of soil type, soil fertility level and climate upon the yield of forage crops. Proc., MSU Silage Conf.
47. Buchele, W. F.; C. T. Morten, J. R. Guttay and C. M. Hansen (1959). Plow planted and ridge planted sugar beets. Proc. Amer. Soc. of Sugar Beet Tech., January.

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48. Danfors, L. E. (1960). A study of soil aeration during drainage using the platinum microelectrode technique. Thesis for Ph.D. degree, Michigan State University.
49. Erickson, A. E. and D. M. Van Doren (1960). The relation of plant growth and yield to soil oxygen availability. Trans. 7th Intern. Cong. Soil Sci., Vol. III:428-434.
50. Singh, B. N. (1960). Mineral and organic forms of nitrogen in some Michigan soils and an agro-economic evaluation of their potential usefulness for advisory purposes. Thesis for Ph.D. degree, Michigan State University.

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51. Cook, R. L. (1961). The effect of soil treatment, cultural practices, and crop sequence on percentage sucrose and purity of sugar beets. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January.
52. Piper, C. D. and L. S. Robertson (1961). Sucrose content of sugar beets as affected by crop sequence and fertility levels and nitrogen sidedressing. Proc. Amer. Soc. of Sugar Beet Tech., East Div., January.

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53. Hulbert, W. C.; H. J. Retzer, C. M. Hansen and L. S. Robertson (1962). Performance test of commercial seed fertilizer openers for drills and development of a new side placement opener. Paper No. 62-607, Amer. Soc. of Agr. Engr., December.

1963

54. Harrison, R. M. (1963). Quantitative and qualitative changes in soil organic matter as related to residue addition, cropping sequence and management. Thesis for Ph.D. degree, Michigan State University.

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55. Robertson, L. S.; R. L. Cook, C. D. Piper, R. H. Dowdy and J. F. Davis (1964). Sugar beet production in Michigan as affected by crop sequence and fertility levels. Jour. Amer. Soc. of Sugar Beet Tech., Vol. XIII, No. 4, 304-313.

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57. Robertson, L. S. (1967). Soil crusts. Proc. Amer. Soc. of Sugar Beet Tech., East. Div., January, 19-20.

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58. Erickson, A. E. and L. S. Robertson (1968). Germination and emergence of sugar beet seeds. Sugar Beet Jour. 32, March.

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59. Robertson, L. S. (1969). Nitrogen for sugar beets in Michigan. Proc. Amer. Soc. of Sugar Beet Tech., East Div., January.

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60. Robertson, L. S. (1970). Fall preparation for next year's beet field. Sugar Beet Jour. 34, No. 1, 6-7.

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61. Robertson, L. S. (1971). Economic aspects of fertilizing sugar beets. Proc. Amer. Soc. of Sugar Beet Tech., East Div., January.

1975

62. Schneider, C. L. and L. S. Robertson (1975). Occurrence of diseases in sugar beet plots in a crop rotation experiment in Saginaw County, Michigan, in 1969-70-71. Plant Disease Reporter 59, No. 3, 194-197.

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