The Ferden Farm Report Part III Soil Management for Soybeans 1946-1970
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THE FERDEN FARM REPORT

PART III

SOIL MANAGEMENT FOR SOYBEANS 1946-1970

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INTRODUCTION

The Ferden Farm research plots located in Saginaw Co. were terminated in 1970, at which time some projects were transferred to the new Saginaw Valley Bean and Sugarbeet Research Farm. The Cooperative Extension Service used the Ferden Farm results as a basis for soil management recommendations for more than 40 years.

This is one part of the final report. Part I was an introduction (5). It summarized projects active prior to 1940, described plot uses for other than research, listed individuals involved in research activities, and contained a summary of pertinent publications derived from the investigations. It also contained a brief outline of research activities between 1940 and 1970.

Sugarbeet studies were considered in Part II of the final report (6). Because of the importance of the crop in that area and because of many unanswered questions, sugarbeets were given significant consideration. Different parts of this final report will summarize other research projects by crops. The purpose of this section is to describe and summarize research activities as related to soybean production. The yield data have never been published, except as annual reports in mimeograph form or as summaries used for field days. Because some investigations served as a basis for research in progress elsewhere and because the data still are a basis for recommendations to farmers by the Cooperative Extension Service, this final report seems desirable.

The soil in the plot area is predominantly Sims sandy clay loam (Soil Management Group 1.5c). While it is somewhat finer-textured than many soils in the Saginaw Valley, it was considered to be representative of the more productive soils of the region.

The plot area was tile drained at a 4-rod spacing. This soil type is responsive to minimum tillage, livestock and green manures, as well as to artificial drainage. One of the more important, if not the most important, soil management problems is that of creating and maintaining a good soil tilth.

Soybeans represented a minor crop in Michigan before 1940 and most certainly were not important in the Saginaw Valley and Thumb regions. Maturity problems were common as far north as the Ferden Farm. Also, many farmers in the Saginaw Valley had more faith in their ability to produce navy beans which generally commanded a higher price.

To illustrate the situation as it existed, average soybean yields for Michigan are reported in Table 1. As will be shown, Ferden Farm yields were higher, which suggested that weather was not as limiting as many believed.

One reason for higher yields from the Ferden Farm is that soybeans were grown in 28-in. rows. This spacing was used on other plots for both sugarbeets and navy beans. Farmers in other parts of the state used wider rows. Narrower spacings became common after research showed benefits of spacings similar to those in the sugarbeet and bean areas of Michigan.

A beet and bean drill was used to plant the soybeans in all projects. Fertilizer was located in a band 1 in. to the side and approximately 2 in. below the seed. Research at a later date showed that this was a desirable placement for soybeans (2).

Table 1. Average soybean yields for Michigan 1941-1970

Year	Yield		Year	Yield	
	Per Year	Per 5 Years		Per Year	Per 5 Years
	Bu/Acre			Bu/Acre	
1941	16.0		1956	21.0	
1942	14.0		1957	22.0	
1943	16.5	16.2	1958	23.0	22.1
1944	17.0		1959	24.5	
1945	17.5		1960	20.0	
1946	15.0		1961	26.0	
1947	17.0		1962	21.3	
1948	17.5	18.5	1963	21.0	22.6
1949	23.0		1964	22.5	
1950	20.0		1965	22.0	
1951	20.5		1966	22.5	
1952	19.0		1967	20.0	
1953	19.0	20.3	1968	26.0	23.5
1954	21.0		1969	23.0	
1955	22.0		1970	26.0	

Residual Fertilizer

Soybeans were first grown on the Ferden Farm plots in 1946 in an experiment designed to evaluate high rates of fertilizer for corn. The project was referred to as the "corn belt rotation" because it involved soybeans, corn grown for two successive years, oats, and clover timothy hay. Such crops and management systems were common in the corn belt but not in Michigan's Saginaw Valley.

While field notes do not indicate the varieties used, it can be assumed that inoculated, certified seed of the best available varieties were used because Lee Ferden, owner of the farm, was a certified seed producer and distributor.

Fertilizer treatments for corn in this experiment varied. The other crops in the rotation, except for clover timothy, were uniformly fertilized. The clover timothy, as was the custom, received no direct application of fertilizer. All soybean plots were fertilized at planting time with 70-lbs/acre of 0-20-10 placed in a band beside the seed.

The fertilizer for corn was located on the plow sole in bands 14 in. apart. A special plow attachment was used. The rates were considered to be exceptionally high. The treatments were as follows:

1. No fertilizer for either corn crop.
2. 800 lb of 10-10-10 per acre plowed down for each corn crop (Total-1600 lb).
3. No fertilizer for first-year corn and 800 lb of 10-10-10 plowed down for second-year corn (Total-800 lb).
4. 800 lb of 10-10-10 plowed down for each corn crop plus 100 lb of 5-20-10 banded at planting time for each crop (Total - 1800 lb).
5. 100 lb of 5-20-10 banded at planting time for both corn crops plus 800 lb of 10-10-10 plowed down for second-year corn (Total - 1000 lb).

Soybeans yields were not increased by any fertilizer treatment (Table 2). The 10-plus bushel increase for the second 5-year period is believed to reflect primarily improved drainage from newly installed tile.

Soybeans did not respond to high rates of fertilizer applied to previous crops when low rates of planting time fertilizer were used. Also, the data show that satisfactory soybean yields can be produced in the latitude of the Ferden Farm. Yields were 10 bushels per acre higher than state averages.

Nitrogen Side Dressing

When anhydrous ammonia was first introduced into Michigan, evaluations were made on both established plots and fields used for commercial production. Reponse to supplemental nitrogen in one instance was outstanding in that average soybean yields were increased up to 8 bushels per acre (Table 3). The effect on yields was apparently related to both soil texture and drainage because at another location within the same field no response was obtained from either anhydrous ammonia or ammonium sulfate. The soils at this site contained more organic matter and sand.

The following year in another field and with other carriers of nitrogen, yield increases approximated 5 bushels per acre. In each experiment soybeans followed

Table 2. Soybean yields as affected by residual fertilizer

Treatments						
First Year Corn		Second Year Corn		Years and Soybean Yield		
Planting time [a]	Plow down [b]	Planting time [a]	Plow down [b]	1946 to 1950	1951 to 1956	Mean
lb/Acre				Bu/Acre		
0	0	0	0	25.0	35.7	30.4
0	800	0	800	26.1	35.6	30.9
0	0	0	800	25.7	36.5	31.1
100	800	100	800	25.5	36.7	31.1
100	0	100	800	25.6	35.7	31.6

a 25-20-10
b 10-10-10

Table 3. Soybean yields as affected by sidedressing with 40 lb nitrogen per acre

	Nitrogen Carrier			
Year	No Nitrogen	Anhydrous ammonia	Ammonium sulfate	Ammonium nitrate
	Bu/Acre			
1949	27.4	35.9	-	-
1949	39.0	40.5	41.7	-
1950	35.1	-	42.7	43.6
1950	30.1	-	34.8	34.8

Table 4. Soybean yields as affected by tillage methods

Year	Tillage method	Bu/Acre
1949	Conventional	41.5
	Minimum	41.5
1950	Conventional	42.1
	Minimum	41.0

corn where crop residues were plowed under. These data and others led to recommending nitrogen for soybeans where they were grown in cash crop rotations.

In recent years soybeans have not responded as greatly to supplemental nitrogen. An understanding of this situation is difficult but is at least partially related to the relatively high rates of nitrogen used today on other crops in the rotation. Nitrogen rates are now sufficiently high that residual nitrogen accumulates in the subsoil and is available to following crops (1).

Other evaluatioins of supplemental nitrogen are made in another section of this report. (Pages 5 and 6)

Minimum Tillage

While interest in the use of nitrogen was growing, there was at the same time increasing interest in the effect of different tillage implements upon production costs and crop yields.

The tillage investigations on soybeans perhaps should be classed as demonstration because no valid replication of treatments was involved. Yields are reported here primarily because of the very high levels produced (Table 4) and because yields were not affected by reduced numbers of secondary tillage operations.

In this project, "conventional tillage" involved plowing in the spring, disking twice, and then using a combination spring and spiketooth harrow, and finally planting. In 1949, the "minimum tillage" method included pulling a "clod buster" behind the plow and then planting. In 1950 the secondary tillage implement was a "cultimulcher."

At this time it was recognized that the ideal soil moisture level for plowing also represented a desirable level for rapid seed germination and that one of the secrets for successfully using the minimum tillage principle was to plant immediately after plowing.

These yield data were important because they demonstrated that even on a fine-textured soil it was not necessary to work the soil several times after plowing. The plots also showed a close relationship between tillage treatments after plowing and the number of weeds. The secondary tillage tools and the tractor pulling them firmed the soil so that weed seeds germinated as rapidly as soybeans. Weeds between the rows did not show on the minimum tillage strips until after heavy rains occurred. This project served, in part, as the basis for using minimum tillage methods for soybeans on all other plots after 1950.

Table 5. Five year average soybean yields (1957-1961) as affected by phosphate carriers, gypsum, and supplemental nitrogen

Phosphate source	Supplemental gypsum	Sidedressed Nitrogen 0 lb/Acre	Sidedressed Nitrogen 40 lb/Acre
	lb/Acre	Bu/A	
1. Normal superphosphate	0	35.5	37.3
2. Treble superphosphate	0	36.4	37.2
3. Treble superphosphate	100	35.8	37.0
4. Diammonium phosphate	0	36.2	37.7
5. Diammonium phosphate	100	34.9	36.4
		average 35.8	average 37.1

Phosphate Carriers and Gypsum

Research with phosphate carriers and gypsum was in effect at several locations in the late 1950's and early 1960's. Three phosphate carriers were used in an experiment involving 2 years of corn, soybeans, and 2 years of wheat. A mixed leguminous green manure crop was sown in the wheat the second year.

All crops, including soybeans, were fertilized with 200 lb per acre of a specially mixed 8-20-10. Half of each plot was treated with supplemental nitrogen as ammonium sulfate at the rate of 40-lb of nitrogen per acre.

The 8-20-10 was a blend of urea, muriate of potash, and the following sources of phosphate:

Treatment 1 - Normal superphosphate (0-20-0)

Treatment 2 - Treble superphosphate (0-45-0)

Treatment 3 - Treble superphosphate (0-45-0) plus gypsum

Treatment 4 - Diammonium phosphate (21-53-0)

Treatment 5 - Diammonium phosphate (21-53-0) plus gypsum.

Normal superphosphate was assumed to be 50 percent $CaSO_4$. Thus the gypsum in treatment 3 and 5 was calculated on that basis. It was also assumed that treble superphosphate and diammonium phosphate contained no $CaSO_4$ and therefore no sulfur.

The phosphate carriers all had similar effects upon soybean yields (Table 5). Gypsum did not increase yields.

The slight yield increase caused by ammonium sulfate was attributed to nitrogen and not to sulfur because yield reponses were similar to those obtained in other experiments involving urea and because there was no yield response to the gypsum.

Recent investigations showed that this interpretation was valid. Tests for sulfate-sulfur from many soils similar to those on the Ferden Farm plots were sufficiently high that yield responses would not be expected (7). Also, many cash crops have not responded to treatments with supplemental sulfur (4).

Rotations Systems of Cropping

The "old rotation" plots were in effect for 30 years, longer than any other plots on the farm. This experiment was originally designed to answer specific questions about the practicality of cash crop farming in the Saginaw Valley and the essentiality of leguminous sod crops in a rotation.

The experiment was initiated in 1940 and involved 7 different crop rotations. Each crop was grown each year, and all rotations required 5 years for the cycle.

Because soybeans were relatively unimportant in the Saginaw Valley when the project was initiated, they were not involved in the original design. After they became more important and after the original questions were answered, the experiment was modified. They were first grown in three different rotations in 1958.

Four years later soybeans were incorporated into one other rotation, but no reference will be made to this situation because of the relatively short duration of the treatments. Years are sometimes required to eliminate the effect on soil of a given cropping system.

For convenience, the rotations were numbered. Soybeans were grown in rotations 3,5 and 7 which represented cash crop systems. Rotation 3 included wheat with a mixed leguminous green manure crop seeded into the wheat, navy beans, sugarbeets, corn with another mixed leguminous green manure crop which seldom developed as planned—and soybeans.

Rotation 5 involved similar crops but in a different sequence. Wheat was followed by sweet clover which was grown to maturity before it was plowed down in late summer. Oats were planted immediately as a winter cover crop. Navy beans, sugarbeets and soybeans followed in this order.

Rotation 7 included sugarbeets, corn with a mixed leguminous green manure crop, wheat with another mixed leguminous green manure crop, and soybeans. Thus soybeans followed wheat in Rotation 7, sugarbeets in Rotation 5, and corn in Rotation 3.

Average soybean yields are reported in Table 6. Yields in each rotation increased with time, four or more bushels per acre. The highest average yields were obtained in Rotation 5 which also produced the higher sugarbeet yields (6). This rotation involved fewer plowings than the other two and included sweet clover as a "brown manure" crop. The structure of the soil in this rotation appeared to be more stable than in the other rotations. The soil was more resistant to crust formation. Because minimum tillage methods were used, the surface soil usually remained very porous during the entire growing season (See Fig. 1).

Each plot was split so that it represented 2 fertility levels which were conveniently labeled "high" and "low." During 5-year periods, between 1956 and 1970, the average extra fertilizer used in each rotation was 500, 1,000 and 1,500 lb per acre. Because half of the fertilizer was arbitrarily used for sugarbeets, the other crops in a rotation were fertilized at lower rates.

The soybeans in Rotation 3 received no fertilizer because all of the fertilizer was allocated to other crops. The soybeans on the high fertility plots in Rotations 5 and 7 received 250 lb of 8-32-16 per acre and the low fertility plots 64 lb of the same grade. All fertilizer contained 1% manganese. Thus the soybeans in

Fig. 1-Soybeans in the cash crop rotation number 3. Notice how loose and porous the soil is around Lee Ferden's hand. The soils on other plots subject to different rotations were compact.

Rotation 3 received no manganese and, on occasion, showed slight symptoms of manganese deficiency, probably not sufficiently intense to greatly affect yields.

The rotation yields previously discussed are an average of both high and low fertility levels. The effects of the two levels are shown in Table 7. The extra fertilizer did not increase yields and did not mask the effect of rotations.

The plots were split once again so that supplemental nitrogen as a side dressing could be evaluated. Half of each soybean plot and those plots representing other row or small grain crops, were side-dressed or top-dressed with nitrogen. The rate for soybeans was 40 lb per acre. The carrier varied from year to year but most frequently was ammonium nitrate or urea.

Table 6. Soybean yields as affected by systems of cropping

Rotation Number	Crop Sequence[a]	Years and Yield 1958 to 1960	1961 to 1965	1966 to 1970	Mean
			Bu/Acre		
3	W(gm), Be, SB, C(gm), S	30.7	33.6	36.5	33.6
5	W, Sw(oats), Be, SB, S	32.9	36.3	36.9	35.3
7	SB, C(gm), Be, W(gm), S	29.6	28.3	34.0	30.5

a W-Wheat, gm-green manure, Be-navy beans, SB-sugarbeets, C-corn, Sw-sweetclover, S-soybeans

Table 7. Soybean yields as affected by systems of cropping and soil fertility levels

Rotation Number	Crop Sequence [a]	Fertility level	Fertilizer Rate lb/Acre	Years and Yield 1958 to 1960	1961 to 1965	1966 to 1970	Mean
					Bu/Acre		
3	W(gm), Be, SB, C(gm), S	High	0	31.1	33.1	36.7	33.6
		Low	0	30.3	34.0	36.3	33.5
5	W, Sw(oats), Be, SB, S	High	250	33.0	35.9	37.0	35.3
		Low	64	32.9	35.9	36.8	35.2
7	SB, C(gm), Be, W(gm), S	High	250	30.0	28.0	33.9	30.6
		Low	64	29.3	28.5	34.0	30.6

a W-wheat, gm-green manure, Be-navy beans, SB-sugarbeets, C-corn, Sw-sweetclover, S-soybeans

Table 8. Soybean yields as affected by systems of cropping and sidedressed nitrogen

Rotation	Crop Sequence [a]	Nitrogen lb/Acre	1958 to 1960	1961 to 1965	1966 to 1970	Mean
				Bu/Acre		
3	W(gm), Be, SB, C(gm), S	40	32.7	34.4	37.1	34.7
		0	28.8	32.8	35.9	32.5
		Difference	3.9	1.6	1.2	2.2
5	W, Sw(oats), Be, SB, S	40	34.7	36.7	37.8	36.4
		0	31.1	35.1	36.3	34.2
		Difference	3.6	1.6	1.5	2.2
7	SB, C(gm), Be, W(gm), S	40	30.8	29.1	34.0	31.3
		0	28.5	27.5	33.9	30.0
		Difference	2.3	1.6	0.1	1.3

a W-Wheat, gm-green manure, Be-navy beans, SB-sugarbeets, C-corn, Sw-sweetclover, S-soybeans

The effect of supplemental nitrogen is shown in Table 8. Yield increases were small but significant. With low nitrogen prices, side dressing was profitable.

The value of a leguminous green manure crop preceding soybeans was evident in Rotation 7 where increases in yield from supplemental nitrogen were small, amounting to only 2.3 bushels for the first period reported and averaging only 1.3 bushels for the 12 years.

Interestingly, the yield increase from supplemental nitrogen in the three rotations decreased with time. Apparently residual nitrogen from the liberal amounts applied for other crops in the rotation was sufficient for the soybeans. No significant disease or insect problems developed during the course of the experiment. Some root rot and leaf blight diseases were present, but the three rotations were similarly affected. The long period between soybean crops is believed to have reduced opportunities for such problems.

Continuous Soybeans

In another project, soybeans were grown continously for seven years. Immediately after each harvest a rye cover crop was planted to be plowed down the following spring. This was an effort to maintain soil organic matter levels. Also some farmers felt that rye at least partially controlled diseases, especially those associated with root rot complexes.

High yielding, early maturing varieties were not available when the project was initiated. The Chippewa variety did not mature soon enough to establish a satisfactory rye cover crop.

No fertilizer was used on the rye, but the soybeans received 300 lb of 5-20-10 which contained 1% manganese. The crop was side dressed with 40 lb of nitrogen in the middle of June.

Yields from this experiment are shown in Table 9 which also includes county and state averages. As expected, state averages did not vary as greatly as county or plot yields. The county averages were almost as high as the state, suggesting that Saginaw was better suited to soybean production than many believed. Yields in Saginaw dropped greatly in 1965 which, it is believed, was the result of adverse weather conditions during that year.

The yields from the continuous soybean project varied between 27.4 and 40.4 bushels per acre until the last year when the average was 15.1. Until this time no unusual pest problems were noticed. However, by the first of August, 1965, root rot, stem rot and leaf blight conditions were all visually identified on the continuous soybean plots.

As already suggested, the year 1965 was not good for soybeans at the farm or in the county as a whole; however, yields from the continuous soybean plots dropped more than did the county averages and more than those from other soybean projects on the farm. For example, the yields in Rotation 5 of the old rotation experiment averaged 30.2 bushels per acre. Because no serious pest problems were identified on those soybean plots, it was concluded that soybeans should be grown in rotations.

Row Spacing

Row spacing experiments in cooperation with agricultural engineers of the United States Department of Agriculture were located on several farms including the Ferden Farm in 1970. Results from the Ferden Farm were in general agreement with those obtained at other locations where herbicides were effective.

In the Ferden Farm experiment, populations average 190,000 plants per acre. This is mentioned because of variable seed sizes associated with different varieties. The soybeans received 8-32-16, containing 2% manganese, at the rate of 400 lb/acre.

The 14-in. rows produced significantly higher yields than did the 28-in. (Table 10). In this project herbicides were effective. At other locations, where herbicides were ineffective and where weed population was high, soybean yields were not increased with narrow row spacings.

Regim-8

Regim-8, sometimes referred to as TIBA (2-3-5 triiodobenzoic acid) is a growth regulator reported to increase soybean yields and reduce lodging through the control of plant growth. This material was used at the rate of 3 oz/ acre in the previously discussed row spacing experiment. Regim-8 did not improve soybean yields or reduce lodging in this project. This was in contrast with the results obtained on both navy and kidney beans at another location the previous year (3).

Table 9. Yields in a continuous soybean experiment compared to average county and state yields

Year	Continuous soybeans	County average	State average
	Bu/Acre		
1960	27.4	18.4	20.0
1961	31.7	24.9	26.0
1962	40.4	23.4	21.3
1963	35.6	23.7	21.0
1964	38.4	22.4	22.5
1965	15.1	17.3	22.0
Average	31.4	21.7	22.1

Table 10. The yield of three soybean varieties as affected by two row spacings (1970)

Variety	Row Spacings	
	14in.	28in.
	Bu/Acre	
Anoka	37.2	32.1
Hark	49.6	44.2
Harosoy	49.6	40.4

Table 11. The yield of three soybean varieties as affected by Regim-8

Variety	Check	Regim-8[a]
	Bu/Acre	
Anoka	32.7	30.8
Hark	49.6	47.9
Harosoy	49.6	48.3

a 3 oz/acre

SUMMARY

This is one part of a final report on the Ferden Farm plots. Investigations on soybeans involved fertilizers, cropping systems, tillage, row spacings and growth regulators. The following pertinent observations were made:

1. Longtime average yields ranging between 30 and 40 bushels per acre were produced as far north as the Ferden Farm in Saginaw Co.

2. Soybean yields were increased in intensive cash cropping systems with supplemental nitrogen where residual levels of nitrogen were low.

3. Normal superphosphate, treble superphosphate, and diammonium phosphate had similar effects upon soybean yields.

4. Gypsum had no influence upon soybean yields.

5. Soybean yields were not increased by high rates of fertilizer on previous crops.

6. A minimum tillage tool behind the plow provided the only secondary tillage needed.

7. Where weeds were well controlled, soybeans in 14-in. rows yielded significantly more than those in 28-in. rows.

8. Soybean yields were not increased with the growth regulator Regim-8.

9. The highest soybean yields were produced in cash crop rotations involving sweetclover as a "brown manure" crop.

10. The lowest soybean yields occurred in intensive cash crop systems where no attempt was made to maintain soil organic matter levels.

11. After 6 years of continuous soybeans, yields dropped rapidly due to disease.

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