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Development of a Drainage Variable Facility for Soil and Crop Management Studies on a Lakebed Clay Soil

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Development of a Drainage Variable Facility for Soil and Crop Management Studies on a Lakebed Clay Soil:

I. Establishment of Drainage Treatments and Their Preliminary Effect on Crop Yield.

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Over six million acres of productive soil in Ohio produce only limited crop yields and have management problems due to persistent wetness during the spring planting season. This excess moisture during cool spring weather is caused by fine texture, poor internal drainage and level topography of these soils. On approximately one-third of the acreage this condition is compounded by recurring plasticity. This condition is found on those soil types which have field moisture contents greater than their lower plastic limits for extended periods of time. Tillage tools do not operate effectively under such conditions (1). When worked while plastic, these soils dry into forms shaped by the tillage tool and may remain intact through the growing season. Waiting for the soil to dry may delay seedbed preparation and planting with subsequently reduced yields (9) and inefficient use of labor and machinery. Unless the land is properly drained, excess water may remain on or within these soils well into the growing season or reappear at any time following significant amounts of rainfall.

Reduced soil aeration attendant with excess soil moisture may reduce root growth and damage root tissue (3, 5), reduce transpiration, water uptake and photosynthesis (4), and upset nutrient uptake (6) by the growing crop. The effects of poor aeration on plant development are conditioned by crop species, stage of plant development, magnitude and duration of poor soil aeration conditions and atmospheric conditions (2). Plant root proliferation and subsequent moisture and nutrient uptake may also be greatly reduced by compact soil masses produced by improper tillage (1).

On the majority of these soils, the problem of persistent wetness may be resolved with a reasonable degree of effectiveness by using certain remedial practices. These include the use of meadow crops in rotation and tile drainage. Crop rotations including meadows, however, tend to limit the flexibility of the cropping programs, and tiling represents a

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large initial investment. Although one of the heaviest concentrations of tile drainage systems in the nation is located in these soils, tile drainage alone has been insufficient to overcome restrictions of chronic plasticity on crop production. In addition, farmers contend that the effectiveness of tiling systems as an aid to crop production decreases with continued cropping of the soils.

Several reasons may be advanced to explain this situation starting with genetic soil properties. The evapo-transpiration of growing crops may be required to lower field moisture below the lower plastic limit so the soil may be tilled by conventional means. Development of new land management systems may offer a solution to the plasticity problems. Soils, such as these, which have slowly permeable subsoils (8) do not transmit water readily through the profile so that rapid removal of excess surface water by tile may be difficult. Where the most extreme conditions of fine texture, poor internal drainage and plastic conditions occur, tiling is considered so ineffective that the practice is not followed.

The problems outlined above are peculiar to these soils and cannot be resolved satisfactorily by extrapolation of experimental results obtained on other types of soils to answer these specific problems. In 1952, the Ohio Agricultural Experiment Station established a substation at a site having a plastic, wet soil, typical of northwestern Ohio and adjoining areas in Indiana and Michigan. A major research objective of this substation was to develop improved tillage and crop management systems for these potentially productive soil types. The first steps toward this goal were establishment of a uniform soil area suitable for field research and installation of two types of drainage systems as an experimental variable common to all subsequent studies. These two steps are described in this circular.

SITE DESCRIPTION

The experimental site is located on Hoytville silty clay loam, one of the more productive humic gley soils in the lake plain area south of Toledo. This soil has poor internal and surface drainage. It is plastic and sticky when wet and on drying is very hard and develops cracks up to one inch wide at the surface. The lower plastic limit is four percent by weight below the moisture content at field capacity, presenting difficult tillage problems in the spring. The topography of this area is almost flat with numerous shallow depressions. Drainage is necessary for satisfactory crop production. This soil type is more completely described elsewhere (8).

Prior to 1952 this land was privately owned and operated as a grain and livestock farm. The previous owner utilized good management practices and the soil had good tilth and high fertility when purchased by the Experiment Station.

The experimental facility (Figure 1) was laid out on a 58-acre area. Eight ranges, each 1274' long, run east and west, and eight columns, each 2000' long, run north and south. A border 50' wide separates adjacent ranges and a border 25' wide separates adjacent columns. These borders define 64 main blocks each 126' x 200'. Each block is further divided by a 20' wide alleyway running east and west. Each main block thus has two areas each 126' x 90' for every column and range. These two areas will accommodate twelve plots, each 21' x 90' or eighteen plots, each 14' x 90', or numerous other plot sizes as desired.

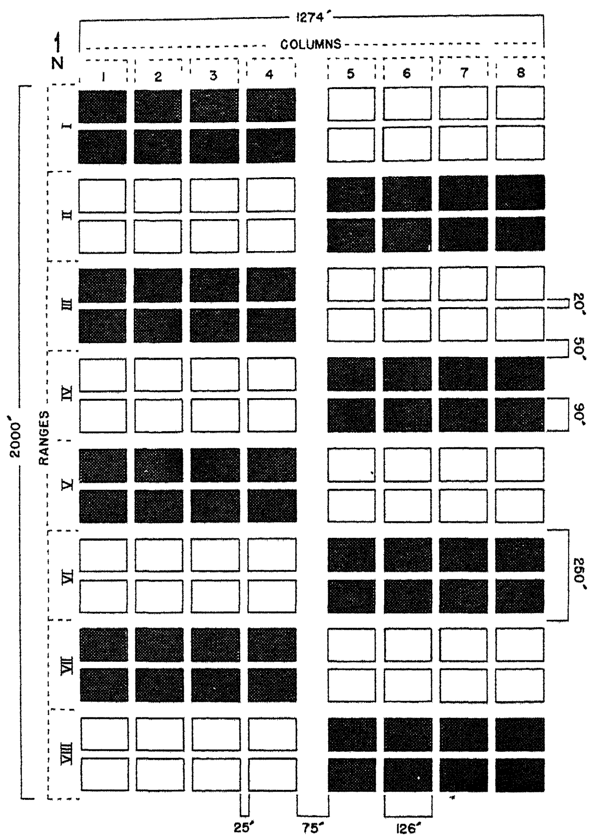


Fig. 1.–Map of the drainage variable facility showing dimensions of subdivisions in feet. Shaded areas are tile drained.

DRAINAGE SYSTEMS BEFORE LAND FORMING

In 1956 two types of drainage systems were selected for these experimental plots. Because controlled surface drainage has proven valuable from crop yield (7) and land management (10) standpoints at other locations, this system was installed on all of the plots. On one-half of the plots surface drainage was combined with tile drainage, Figure 1.

Surface Drainage

Initially the surface drainage system consisted only of grassed waterways installed on each side of the experimental area and in the borders between the various ranges. Thirteen of the waterways drain into surface inlets connected to the tile mains while the remainder empty into surface ditches. The ditches have 0.5 percent slope, are five feet wide at the bottom, and have four to one side slope so machinery can operate over them. This system has sufficient capacity to remove surface water rapidly from the plots even after high intensity storms.

Tile

Tile was installed with a trenching machine after the existing tile system was destroyed. Tile specifications were:

Depth: 3-3.5 feet
Size of lateral: 4 in. diameter
Type of tile: Clay
Slope: 6 in. per 100 ft.
Blinding: None
Distance between laterals: 50 ft.
Direction of laterals: East and west
Number of laterals per range: 5

Sump

The tile mains empty into a 12' diameter x 13' deep sump equipped with a 1100 gallons-per-minute capacity pump which lifts the water into a surface ditch. This system can remove one inch of surface and/or tile flow in 26 hours from the experimental site.

Location of Drainage System

Figure 1 shows the location of the two drainage systems within the experimental site. These are so arranged that within any one column four main blocks of each drainage system alternate from north to south. This permits four replications for a given experiment with drainage systems as the main plot and all other treatments regarded as split plots within the main plot.

In 1957 soybeans were grown over the entire area and the backfill over the new tile system allowed to settle. No experimental data were obtained.

CROP YIELDS

A series of uniformity trials was initiated in 1958 to determine the influence of microtopography and other possible soil variables upon plant yield variance within and among the main blocks of the site.

Methods and Materials

In 1957 the entire site was fall plowed. The following spring corn was planted in 42" rows on May 24, 26, and 27. Each column was planted as a unit. Fertilizer broadcast before planting consisted of 300 lb./A NH_4NO_3 and 500 lb./A 0-20-20. The corn was cultivated twice during the growing season. Eighty-foot sections of the two center rows of each six-row plot were marked and stand counts made during August. At harvest time five feet was trimmed from the ends of these marked rows and they were harvested for grain yield.

In 1959 the entire site was spring plowed on March 19 and 25. This was early enough that the soil received some frost action prior to sowing oats. Oats were drilled on April 20-25 on the east half of the area at the rate of 2 bu./A and fertilized with 300 lb./A 0-20-20. Each oat plot was trimmed to 80' and a six-foot swath harvested for grain yield on July 30-31. Ponded water was mapped after a 1.56 inch rain on April 28. Silage corn grown on the west half of the area was not harvested for yield.

Results and Discussion

Tile drainage improved corn yields in 1958 and oats yields in 1959. Figures 2 and 3 indicate that the highest yielding plots in both tiled and untiled areas were within 10 bushels of each other. On the tiled areas, 54 percent of the corn yields in 1958 and 49 percent of the oat yields in 1959 were within ± 10 percent of the average yield. In the non-tiled areas, however, the spread in plot yields was much greater with a less clearly defined peak. Only 17 percent of the oat yields and 20 percent of the corn yields were within ± 10 percent of the average yield.

In an analysis of these data (Table 1), the block effect was removed, each block consisting of 12 plots. The residual or error term contains within-block variation and is quite high for the non-tiled areas for both crop years. A comparison of the variance for the tiled and non-tiled areas using an F test indicates that they do not belong to the same population. For both crop years, the coefficient of variability was 9-10 percent for the tiled areas and 25-27 percent for the non-tiled areas.

The relationship of lower yields and poorly drained depressions in the east one-half of the field is indicated by the correlation between plot

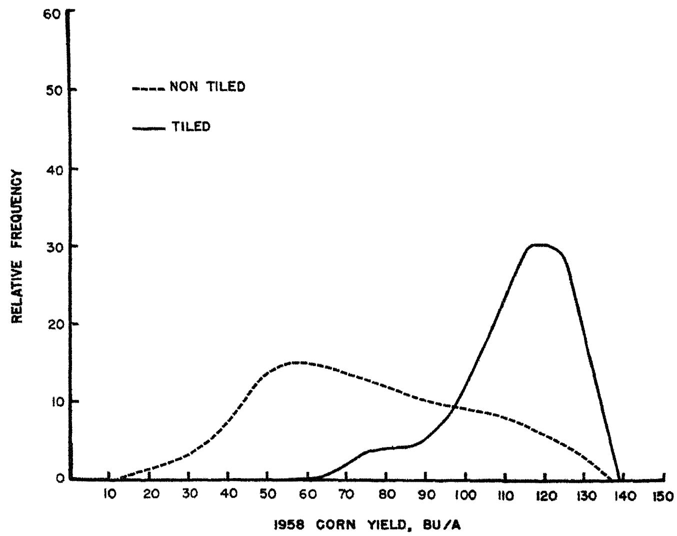


Fig. 2.–Relative frequency of corn yields in 1958 with 384 plots represented for each drainage system.

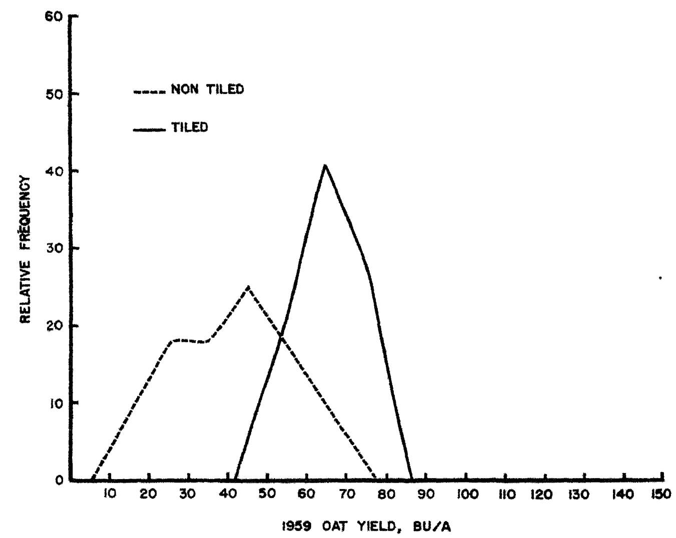


Fig. 3.–Relative frequency of oats yields in 1959 with 192 plots represented for each drainage system.

yields and ponded water on the non-tiled areas. Ponded water was mapped after a rain on April 28, 1959, and the plots were rated from 1-10 depending on the amount of the plot not covered by water. In these correlations r = .67** for oats in 1959 and .60** for corn in 1958. Thus, from 36 to 45 percent (r^2) of the total variabliity in crop yields was associated with low spots in the field. Areas with poor yields tend to remain in the same place as indicated by the correlation (r = .65**) between corn yields in 1958 and oats yields in 1959 for the non-tiled ranges.

Ponding or low spots in the tiled areas had less association (r = .29**) with crop yields than on the non-tiled areas. Thus, only 7-8 percent (r^2) of the total variability in the tiled areas was associated with the low spots in the field. The correlation (r = .39**) between corn in 1958 and oats in 1959 for the tiled areas was much lower than for the non-tiled areas and accounts for only 15 percent of the total variation (r^2). Ponding was probably less critical on the tiled areas because of the rapid drainage and short duration of flooding.

LAND FORMING - 1959-1960

Analyses of experimental data obtained in 1958 and 1959 indicated that poor crop development and low yields were associated with shallow depressions in the non-tiled ranges. To insure positive surface drainage, land forming operations were carried out on all ranges late in 1959 and early in 1960. Maps of ponded areas drawn after heavy rains were used as guides in locating the low areas. Soil was moved from high to low elevations in the field. Soil was then moved from the edges of each range toward the center, creating a slope toward the surface drain on the edge (Figure 4). After the soil was redistributed a land leveller was run

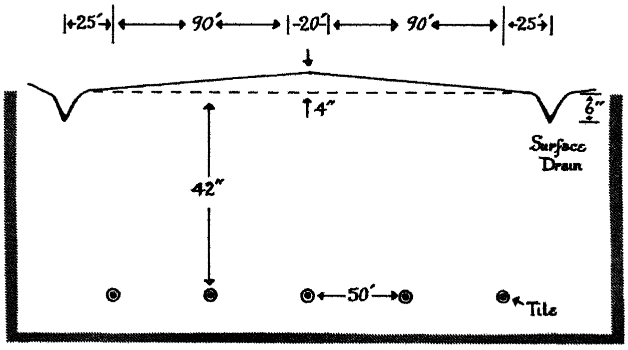


Fig. 4.—Cross section of tile drained range after installing positive surface drainage. Non-tiled ranges have similar surface conformation.

over the range to level the fill. As rain settled the soil and depressions appeared, the land leveling operation was repeated several times until there was no ponding of water on the area. Due to the extremely level macrotopography of the site, small depressions of only a few inches depth caused ponding of water on the soil surface.

Corn and oats were planted on the experimental site in 1960. However, a severe hailstorm damaged the crop in July and no data were obtained. Visual inspection of tiled and non-tiled areas revealed no apparent differences.

UNIFORMITY TRIAL – 1961

Materials and Methods

The site was fall plowed in 1960. On May 15-20, the east half of the area was planted to corn in 40" rows without further seedbed preparation. Before planting, 300 lb/A NH_4NO_3 were broadcast and 100 lb/A 6-24-12 were applied as a row fertilizer. After planting, a band of Atrazine, 20" wide (2 lb/A), was sprayed over the row for weed control. Stand counts were made of the harvest area in August and yields were obtained on November 1-6, 1961. Long term soil management studies were initiated on the west half of the site, and these studies are not reported herein.

Results and Discussion

After the 1959-1960 land forming operations were completed corn yields in 1961 on both the tiled and non-tiled areas were approximately the same, although the tiled ranges produced six bushels per acre (significant at the 5 percent level) more than the non-tiled ranges. In both areas, over 80 percent of the plot yields were within ±10 percent of the average yield for the entire area (Figure 5). Within block variation was not significantly different for the two areas, indicating that they belong to the same population (Table 1). The coefficient of variability was 4.6 and 5.6 percent for the tiled and non-tiled areas, respectively. This is satisfactory for field experiments of this type and land forming operations were considered completed.

Environmental conditions other than drainage probably restricted the maximum yields for all three crop years. Thus, some of the plot yields approached the limit set by factors other than drainage. The number of plots in this category increased as surface drainage improved. During 1961, drainage, particularly surface drainage, was not as limiting as in previous years and most of the plot yields approached the upper limit imposed by other environmental conditions.

Neither drainage system showed evidence that yields were limited seriously by drainage in 1961, although there was a 2.71-inch rain on

TABLE 1.–Summary of Analysis of Yield Data for Crops Grown on the Entire Field in 1958 and the East One-Half in 1959 and 1961.

Treatment	Number of Plots	Average Yield	Coefficient of Variability	Degrees of Freedom	Error Mean Square	F
Corn–1958 Nontiled	384	74	24.8%	350	338	3.09**
Corn–1958 Tiled	384	114	9.2%	350	109	
Oats–1959 Nontiled	192	41	27.8%	176	130	2.84%**
Oats–1959 Tiled	192	66	10.2%	176	45	
Corn–1961 Nontiled	180	102	5.6%	165	32.6	1.29
Corn–1961 Tiled	180	108	4.6%	165	25.4	

** Denotes significance at the 1% level of probability.

July 19, 1961. Individual plot yields and ponded water ratings appear in Appendix Table 1. Rainfall records for 1958, 1959, and 1961 appear in Appendix Figure 1 and Table 2. Data for several crop years will be necessary to critically evaulate the two drainage systems.

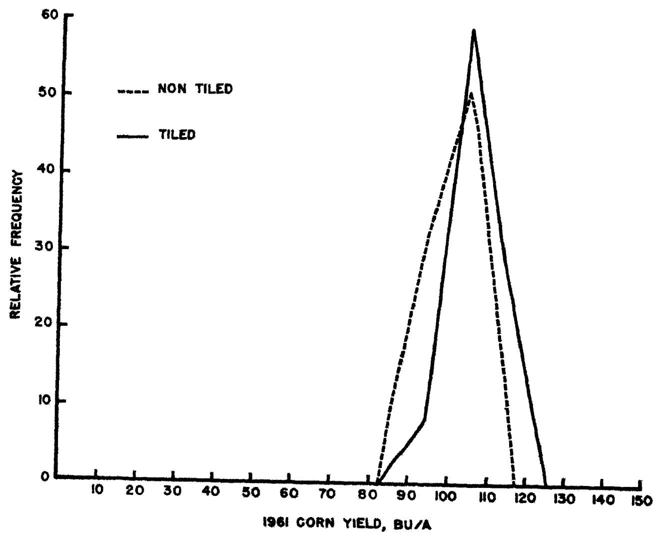


Fig. 5.–Relative frequency of corn yields in 1961 with 180 plots represented for each drainage system.

SUMMARY

In order to answer some of the crop production and management questions peculiar to the plastic, fine textured soils of northwestern Ohio, a 58-acre experimental site was established in the area during 1955-1956. This was designed with four replications and tile drainage or no tile drainage as the whole plots. Long term experiments are being initiated as the area is completed.

Uniformity trials with corn as the indicator crop in 1958 and oats in 1959 were grown on all or portions of the site in order to a ssess the amount of soil induced crop yield variability present. Results of these uniformity trials showed extreme variations in yields which made the site unsatisfactory for experimental work. A test of the variance between the tiled and non-tiled areas was significant indicating that these two areas belong to different populations.

A map of ponded water was made after a heavy rain on April 28, 1959. Lower corn yields in 1958 and lower oat yields in 1959 were associated with ponding on the non-tiled ranges, and to a lesser extent on the tiled ranges. Land forming operations designed to eliminate ponding and reduce variability were conducted after harvest in 1959 and 1960. Low spots were filled and soil was moved from the edges to the center of each range to insure positive surface drainage.

Corn yields in 1961 reflected a marked reduction in soil induced plant variability on both tiled and non-tiled areas. Over 80 percent of the plot yields were within ±10 percent of the mean in tiled and non-tiled areas andthe variances for the two areas were not significantly different. Thus, land forming operations eliminated ponding and reduced yield variability.

BIBLIOGRAPHY

1. Baver, L. D. Soil Physics. John Wiley & Sons, Inc., New York, N.Y. 1956.

2. Erickson, A. E., and D. M. Van Doren. The Relation of Plant Growth and Yield to Soil Oxygen Availability. 7th Int'l. Congress of Soil Sci. IV, 428-434. 1960.

3. Gill, W. R., and R. D. Miller. A Method for Study of the Influence of Mechanical Impedance and Aeration on the Growth of Seedling Roots. Soil Sci. Soc. Amer. Proc. 20: 154-157. 1956.

4. Kramer, P. J. Causes of Injury to Plants Resulting from Flooding of the Soil. Plant Physiol. 26: 722-736. 1951.

5. ____________, and W. T. Jackson. Causes of Injury to Flooded Tobacco Plants. Plant Physiol. 29: 241-245. 1954.

6. Russell, M. B. Soil Aeration in Soil Physical Conditions and Plant Growth. Academic Press, Inc., New York, N.Y. 1952.

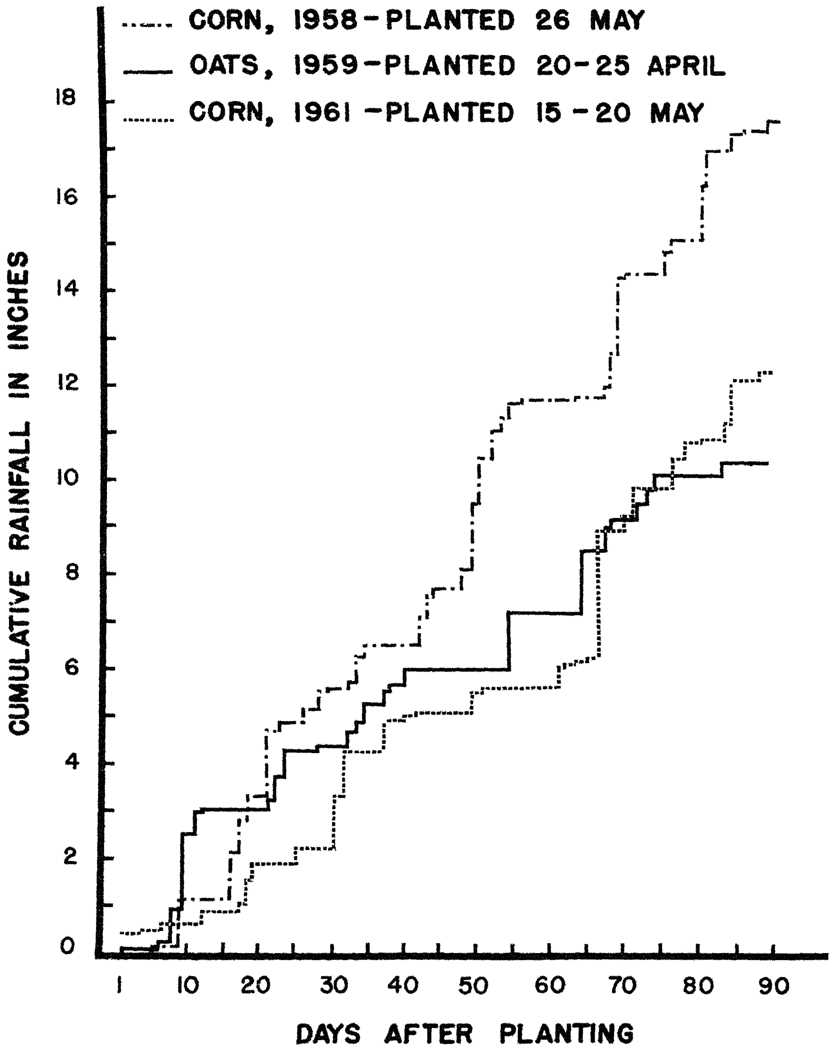
7. Saveson, I. L. Precision Surface Drainage for Sugar Cane. Agr. Eng. 41: 24-27. 1960.

8. Taylor, G. S., T. Goins, and N. Holowaychuck. Drainage Characteristics of Toledo and Hoytville Soils. Ohio Agr. Expt. Station Res. Bull. 876: 1-23. 1961.

9. Wesseling, J., and W. R. Van Wijk. Land Drainage in Relation to Crops and Soils, in Drainage of Agricultural Lands. American Soc. Agron., Madison, Wisconsin, 1957.

10. Wojta, A. J., F. V. Burcalow, R. F. Johannes, and A. E. Peterson. Land Forming. Univ. of Wisconsin Ext. Circ. 587: 1-8. 1960.

APPENDIX



Appendix Fig. 1.--Cumulative Rainfall for 1958, 1959 and 1961 Growing Seasons.

TABLE 1.–Individual Plot Yields and Ponding, Columns 5-8.

Column	Range	Plot (A)	Block (B)	Drainage (C)	Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
					Grain Yield in Bu/A			
5	1	1	N	2	81	45	97	5
5	1	1	S	2	75	52	100	5
5	1	2	N	2	54	37	94	3
5	1	2	S	2	54	45	108	4
5	1	3	N	2	77	43	98	8
5	1	3	S	2	61	45	113	5
5	1	4	N	2	72	43	96	10
5	1	4	S	2	57	39	102	2
5	1	5	N	2	55	30	89	10
5	1	5	S	2	37	28	96	3
5	1	6	N	2	68	41	84	9
5	1	6	S	2	44	34	100	4
5	3	1	N	2	43	26	96	4
5	3	1	S	2	65	37	97	10
5	3	2	N	2	50	41	106	6
5	3	2	S	2	75	48	106	9
5	3	3	N	2	57	24	100	6
5	3	3	S	2	81	52	108	6
5	3	4	N	2	75	17	104	7
5	3	4	S	2	87	52	103	9
5	3	5	N	2	58	39	112	7
5	3	5	S	2		37	106	10
5	3	6	N	2	34	22	112	4
5	3	6	S	2	55	39	108	9
5	5	1	N	2	86	58	117	8
5	5	1	S	2	89	50	108	5
5	5	2	N	2	75	41	101	6
5	5	2	S	2	72	39	105	4
5	5	3	N	2	72	37	96	3
5	5	3	S	2	69	39	94	4
5	5	4	N	2	55	32	104	1
5	5	4	S	2	69	37	105	4
5	5	5	N	2	64	30	110	2
5	5	5	S	2	69	41	108	6
5	5	6	N	2	58	32	93	5
5	5	6	S	2	68	39	102	8
5	7	1	N	2	99	50	110	9
5	7	1	S	2	117	67	105	10
5	7	2	N	2	86	41	112	6
5	7	2	S	2	111	65	105	10
5	7	3	N	2	66	30	107	4
5	7	3	S	2	116	71	112	10
5	7	4	N	2	75	30	105	3
5	7	4	S	2	103	69	103	10
5	7	5	N	2	82	34	107	3
5	7	5	S	2	110	67	104	10
5	7	6	N	2	79	43	116	2
5	7	6	S	2	117	71	103	10

(A) 21 x 90 feet subdivisions in a block numbered 1-6 from west.

(B) North or South subdivisions, 126 x 90 feet.

(C) T = Tile; 2 = Non Tiled

(D) Rated 1-10. 1 = Completely covered. 10 = No ponded water.

TABLE 1. (Continued)–Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification: Column	Range	Plot (A)	Block (B)	Drainage (C)	Grain Yield in Bu/A: Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
5	2	1	N	1	111	60	110	9
5	2	1	S	1	97	67	110	9
5	2	2	N	1	89	58	110	8
5	2	2	S	1	98	65	112	8
5	2	3	N	1	117	69	114	7
5	2	3	S	1	114	71	121	9
5	2	4	N	1	130	67	110	6
5	2	4	S	1	127	69	111	8
5	2	5	N	1	135	76	114	6
5	2	5	S	1	127	78	118	8
5	2	6	N	1	119	78	111	6
5	2	6	S	1	120	78	116	7
5	4	1	N	1	116	60	104	7
5	4	1	S	1	112	60	103	10
5	4	2	N	1	107	65	103	5
5	4	2	S	1	109	67	109	10
5	4	3	N	1	114	60	105	5
5	4	3	S	1	115	65	105	10
5	4	4	N	1	117	63	99	5
5	4	4	S	1	108	67	102	10
5	4	5	N	1	114	63	108	5
5	4	5	S	1	112	69	106	10
5	4	6	N	1	105	69	102	5
5	4	6	S	1	111	67	118	10
5	6	1	N	1	98	63	114	9
5	6	1	S	1	116	76	105	9
5	6	2	N	1	108	65	108	8
5	6	2	S	1	117	669	113	8
5	6	3	N	1	107	65	109	5
5	6	3	S	1	113	67	114	8
5	6	4	N	1	109	65	102	5
5	6	4	S	1	119	69	108	8
5	6	5	N	1	107	56	116	5
5	6	5	S	1	110	73	117	8
5	6	6	N	1	99	69	114	6
5	6	6	S	1	109	69	111	8
5	8	1	N	1	124	63	114	10
5	8	1	S	1	117	71	110	10
5	8	2	N	1	125	71	112	10
5	8	2	S	1	126	69	108	10
5	8	3	N	1	124	65	101	10
5	8	3	S	1	130	69	111	10
5	8	4	N	1	123	69	109	10
5	8	4	S	1	125	69	104	10
5	8	5	N	1	133	73	108	10
5	8	5	S	1	133	69	110	10
5	8	6	N	1	129	71	114	10
5	8	6	S	1	127	69	113	10

TABLE 1. (Continued)–Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification					Grain Yield in Bu/A			
Column	Range	Plot (A)	Block (B)	Drainage (C)	Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
6	1	1	N	2	58	34	96	9
6	1	1	S	2	28	26	106	6
6	1	2	N	2	58	39	92	10
6	1	2	S	2	45	37	104	7
6	1	3	N	2	89	43	90	9
6	1	3	S	2	57	48	104	7
6	1	4	N	2	85	43	90	8
6	1	4	S	2	43	28	91	2
6	1	5	N	2	52	34	93	9
6	1	5	S	2	23	19	103	2
6	1	6	N	2	66	39	98	10
6	1	6	S	2	27	22	107	4
6	3	1	N	2	66	15	104	2
6	3	1	S	2	34	28	106	1
6	3	2	N	2	47	28	114	3
6	3	2	S	2	72	37	107	1
6	3	3	N	2	68	43	112	8
6	3	3	S	2	78	56	119	5
6	3	4	N	2	75	54	115	9
6	3	4	S	2	72	56	106	10
6	3	5	N	2	68	56	120	9
6	3	5	S	2	71	54	114	9
6	3	6	N	2	63	48	110	8
6	3	6	S	2	69	48	110	7
6	5	1	N	2	61	26	---	7
6	5	1	S	2	76	34	---	10
6	5	2	N	2	45	17	---	5
6	5	2	S	2	48	28	---	8
6	5	3	N	2	30	13	---	3
6	5	3	S	2	38	17		6
6	5	4	N	2	22	6	---	2
6	5	4	S	2	47	22	---	4
6	5	5	N	2	34	13	---	1
6	5	5	S	2	43	22	---	3
6	5	6	N	2	30	15	---	1
6	5	6	S	2	36	24	---	2
6	7	1	N	2	87	43	110	2
6	7	1	S	2	100	67	106	10
6	7	2	N	2	75	30	99	4
6	7	2	S	2	103	63	107	10
6	7	3	N	2	61	24	99	3
6	7	3	S	2	98	69	99	10
6	7	4	N	2	58	26	105	1
6	7	4	S	2	97	67	98	10
6	7	5	N	2	51	24	106	1
6	7	5	S	2	96	69	91	10
6	7	6	N	2	62	26	100	2
6	7	6	S	2	101	56	110	10

TABLE 1. (Continued)—Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification					Grain Yield in Bu/A			
Column	Range	Plot (A)	Block (B)	Drainage (C)	Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
6	2	1	N	1	116	80	115	8
6	2	1	S	1	114	82	118	7
6	2	2	N	1	126	82	118	6
6	2	2	S	1	114	78	108	7
6	2	3	N	1	128	78	120	5
6	2	3	S	1	126	76	120	6
6	2	4	N	1	124	82	110	3
6	2	4	S	1	125	80	111	6
6	2	5	N	1	125	76	115	1
6	2	5	S	1	117	78	125	6
6	2	6	N	1	126	69	117	10
6	2	6	S	1	117	73	125	10
6	4	1	N	1	111	67	112	7
6	4	1	S	1	117	73	108	9
6	4	2	N	1	110	67	102	8
6	4	2	S	1	110	69	102	7
6	4	3	N	1	124	67	109	10
6	4	3	S	1	---	69	106	7
6	4	4	N	1	106	69	118	10
6	4	4	S	1	95	67	100	7
6	4	5	N	1	101	63	105	9
6	4	5	S	1	93	69	106	6
6	4	6	N	1	85	56	95	7
6	4	6	S	1	72	58	99	6
6	6	1	N	1	95	69	---	2
6	6	1	S	1	103	69	---	9
6	6	2	N	1	88	67	---	2
6	6	2	S	1	98	69	---	9
6	6	3	N	1	79	69	---	3
6	6	3	S	1	100	67	---	9
6	6	4	N	1	82	67	---	4
6	6	4	S	1	100	65	---	9
6	6	5	N	1	94	71	---	4
6	6	5	S	1	99	71	---	3
6	6	6	N	1	93	71	---	3
6	6	6	S	1	99	86	---	9
6	8	1	N	1	115	78	108	10
6	8	1	S	1	112	65	110	10
6	8	2	N	1	116	76	114	10
6	8	2	S	1	116	73	114	10
6	8	3	N	1	107	80	109	10
6	8	3	S	1	110	73	106	10
6	8	4	N	1	110	78	110	10
6	8	4	S	1	114	78	111	10
6	8	5	N	1	109	78	112	10
6	8	5	S	1	117	78	110	10
6	8	6	N	1	117	84	110	10
6	8	6	S	1	117	58	106	10

TABLE 1. (Continued)–Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification: Column	Range	Plot (A)	Block (B)	Drainage (C)	Grain Yield in Bu/A: Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
7	1	1	N	2	62	17	94	10
7	1	1	S	2	16	54	98	6
7	1	2	N	2	122	63	103	10
7	1	2	S	2	58	56	88	9
7	1	3	N	2	96	58	108	10
7	1	3	S	2	65	45	99	10
7	1	4	N	2	100	58	101	10
7	1	4	S	2	53	41	98	10
7	1	5	N	2	96	52	107	10
7	1	5	S	2	59	45	103	10
7	1	6	N	2	84	52	103	10
7	1	6	S	2	86	58	107	10
7	3	1	N	2	47	50	104	8
7	3	1	S	2	53	48	105	5
7	3	2	N	2	58	52	97	7
7	3	2	S	2	44	45	100	6
7	3	3	N	2	65	50	111	5
7	3	3	S	2	45	41	112	7
7	3	4	N	2	43	32	104	1
7	3	4	S	2	34	39	95	3
7	3	5	N	2	34	32	106	1
7	3	5	S	2	29	43	99	3
7	3	6	N	2	53	48	106	3
7	3	6	S	2	47	52	103	6
7	5	1	N	2	52	26	100	10
7	5	1	S	2	30	19	96	6
7	5	2	N	2	78	50	97	10
7	5	2	S	2	65	54	98	10
7	5	3	N	2	94	65	105	10
7	5	3	S	2	85	67	102	10
7	5	4	N	2	84	48	101	10
7	5	4	S	2	89	58	103	10
7	5	5	N	2	61	39	101	10
7	5	5	S	2	68	56	105	10
7	5	6	N	2	67	48	96	10
7	5	6	S	2	79	50	97	10
7	7	1	N	2	57	17	100	1
7	7	1	S	2	83	39	84	7
7	7	2	N	2	58	26	101	4
7	7	2	S	2	72	45	92	5
7	7	3	N	2	105	28	94	8
7	7	3	S	2	115	60	100	10
7	7	4	N	2	74	24	108	6
7	7	4	S	2	124	54	101	8
7	7	5	N	2	56	22	104	3
7	7	5	S	2	119	43	105	6
7	7	6	N	2	41	48	101	1
7	7	6	S	2	105	45	95	5

TABLE 1. (Continued)—Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification: Column	Range	Plot (A)	Block (B)	Drainage (C)	Grain Yield in Bu/A: Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
7	2	1	N	1	117	76	118	10
7	2	1	S	1	117	76	118	10
7	2	2	N	1	114	78	106	10
7	2	2	S	1	114	80	114	10
7	2	3	N	1	120	78	117	10
7	2	3	S	1	106	80	122	10
7	2	4	N	1	116	76	112	9
7	2	4	S	1	116	71	116	9
7	2	5	N	1	105	71	110	5
7	2	5	S	1	111	71	112	7
7	2	6	N	1	117	73	113	6
7	2	6	S	1	101	69	110	8
7	4	1	N	1	75	56	95	2
7	4	1	S	1	75	65	106	5
7	4	2	N	1	63	56	107	2
7	4	2	S	1	73	65	103	5
7	4	3	N	1	93	65	111	3
7	4	3	S	1	105	58	104	5
7	4	4	N	1	88	65	108	5
7	4	4	S	1	94	60	106	5
7	4	5	N	1	82	63	99	10
7	4	5	S	1	80	56	102	5
7	4	6	N	1	98	58	98	10
7	4	6	S	1	108	60	103	6
7	6	1	N	1	94	71	79	3
7	6	1	S	1	89	71	110	9
7	6	2	N	1	93	69	96	1
7	6	2	S	1	100	73	103	9
7	6	3	N	1	112	69	93	2
7	6	3	S	1	119	60	104	10
7	6	4	N	1	93	65	87	4
7	6	4	S	1	109	65	105	10
7	6	5	N	1	38	50	107	3
7	6	5	S	1	76	54	109	10
7	6	6	N	1	101	56	107	2
7	6	6	S	1	110	54	105	9
7	8	1	N	1	129	69	104	10
7	8	1	S	1	129	60	92	10
7	8	2	N	1	126	67	99	10
7	8	2	S	1	132	69	104	10
7	8	3	N	1	133	65	102	10
7	8	3	S	1	127	65	103	10
7	8	4	N	1	124	71	104	10
7	8	4	S	1	130	58	96	10
7	8	5	N	1	127	67	90	10
7	8	5	S	1	128	65	104	10
7	8	6	N	1	134	86	104	10
7	8	6	S	1	127	45	108	10

TABLE 1. (Continued)—Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification					Grain Yield in Bu/A			
Column	Range	Plot (A)	Block (B)	Drainage (C)	Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
8	1	1	N	2	103	52	104	10
8	1	1	S	2	93	63	98	10
8	1	2	N	2	110	63	109	10
8	1	2	S	2	105	63	106	10
8	1	3	N	2	117	69	102	10
8	1	3	S	2	110	69	114	10
8	1	4	N	2	103	67	108	10
8	1	4	S	2	105	73	118	10
8	1	5	N	2	100	58	99	10
8	1	5	S	2	87	58	103	10
8	1	6	N	2	104	60	107	10
8	1	6	S	2	102	65	105	10
8	3	1	N	2	49	45	103	6
8	3	1	S	2	39	48	102	7
8	3	2	N	2	58	45	112	5
8	3	2	S	2	51	52	103	7
8	3	3	N	2	59	52	104	6
8	3	3	S	2	51	58	95	7
8	3	4	N	2	47	43	110	6
8	3	4	S	2	41	50	97	6
8	3	5	N	2	57	50	103	6
8	3	5	S	2	49	54	100	9
8	3	6	N	2	65	50	104	8
8	3	6	S	2	69	54	100	8
8	5	1	N	2	49	32	94	8
8	5	1	S	2	62	41	90	5
8	5	2	N	2	44	28	106	6
8	5	2	S	2	72	41	102	4
8	5	3	N	2	42	17	90	3
8	5	3	S	2	58	32	92	4
8	5	4	N	2	35	9	91	1
8	5	4	S	2	44	32	101	4
8	5	5	N	2	19	11	93	2
8	5	5	S	2	47	24	91	6
8	5	6	N	2	22	13	89	5
8	5	6	S	2	51	22	96	8
8	7	1	N	2	58	15	108	9
8	7	1	S	2	107	32	108	10
8	7	2	N	2	54	15	104	6
8	7	2	S	2	117	30	98	10
8	7	3	N	2	55	13	95	4
8	7	3	S	2	108	26	92	10
8	7	4	N	2	50	17	105	3
8	7	4	S	2	100	34	100	10
8	7	5	N	2	52	22	108	3
8	7	5	S	2	111	39	94	10
8	7	6	N	2	89	24	106	2
8	7	6	S	2	100	37	93	10

TABLE 1. (Continued)–Individual Plot Yields and Ponding, Columns 5-8.

Plot Identification: Column	Range	Plot (A)	Block (B)	Drainage (C)	Grain Yield in Bu/A: Corn 1958	Oats 1959	Corn 1961	Ponding (D) May 1, 1959
8	2	1	N	1	117	71	113	8
8	2	1	S	1	103	71	104	9
8	2	2	N	1	118	67	106	7
8	2	2	S	1	112	71	107	9
8	2	3	N	1	124	71	104	3
8	2	3	S	1	115	73	112	7
8	2	4	N	1	119	76	113	4
8	2	4	S	1	112	69	113	2
8	2	5	N	1	125	63	104	5
8	2	5	S	1	117	63	109	4
8	2	6	N	1	127	69	108	10
8	2	6	S	1	122	65	107	10
8	4	1	N	1	86	58	110	6
8	4	1	S	1	79	43	108	10
8	4	2	N	1	93	56	108	4
8	4	2	S	1	85	56	105	5
8	4	3	N	1	90	56	104	3
8	4	3	S	1	79	52	108	3
8	4	4	N	1	79	56	103	2
8	4	4	S	1	99	48	110	4
8	4	5	N	1	73	58	110	2
8	4	5	S	1	57	43	102	4
8	4	6	N	1	77	50	109	5
8	4	6	S	1	75	65	103	8
8	6	1	N	1	81	65	97	5
8	6	1	S	1	101	48	108	10
8	6	2	N	1	79	56	105	1
8	6	2	S	1	91	52	108	9
8	6	3	N	1	58	43	116	1
8	6	3	S	1	99	52	108	5
8	6	4	N	1	78	45	105	1
8	6	4	S	1	107	52	108	5
8	6	5	N	1	59	24	106	1
8	6	5	S	1	104	52	107	6
8	6	6	N	1	47	22	96	5
8	6	6	S	1	88	45	100	9
8	8	1	N	1	124	50	110	10
8	8	1	S	1	118	58	106	10
8	8	2	N	1	126	52	108	10
8	8	2	S	1	131	71	110	10
8	8	3	N	1	128	50	112	10
8	8	3	S	1	123	65	112	10
8	8	4	N	1	120	56	104	10
8	8	4	S	1	116	56	109	10
8	8	5	N	1	112	67	108	10
8	8	5	S	1	121	50	117	10
8	8	6	N	1	119	60	104	10
8	8	6	S	1	117	65	112	10

TABLE 2.–Precipitation During 1958 Growing Season.

	May	June	July	August
1.		1.12		0.03
2.				
3.	0.24			
4.	0.55		0.58	Trace
5.				
6.			0.46	0.54
7.			0.16	0.28
8.		0.96		
9.	0.14	0.66		
10.		0.55	0.35	
11.			1.39	1.08
12.			0.98	0.75
13.		1.39		
14.	Trace		0.58	
15.	Trace	0.09	0.28	0.40
16.			0.32	Trace
17.				0.01
18.	0.21	0.32	0.09	
19.		Trace		
20.		0.37		0.01
21.		0.05		0.26
22.	0.24			
23.				
24.		0.21		0.36
25.	Trace	0.52	0.07	
26.		0.25		
27.				
28.	0.04			
29.			0.20	
30.			0.67	
31.			1.61	
Total	1.42"	6.49"	7.74"	3.72"

TABLE 2. (Continued)—Precipitation During 1959 Growing Season.

	March	April	May	June	July
1.	0.16		0.01		0.34
2.		0.76			0.27
3.	0.01	0.22			
4.					
5.	0.10	Trace			
6.	0.51				
7.					
8.	0.09	0.30			
9.	0.46	0.46			
10.	0.02	Trace	0.28		
11.	Trace	Trace	0.41		0.27
12.	0.02		0.61	1.20	
13.					
14.	0.05				
15.	0.46				
16.	0.02		Trace		
17.	Trace		0.01		0.24
18.	0.01				
19.		Trace			0.51
20.		0.18	Trace		0.19
21.		Trace	0.35		
22.			0.21	1.35	
23.			0.42		0.18
24.					0.63
25.	0.49	0.09	Trace	0.49	
26.			0.26	0.14	
27.	0.52	0.72	0.07		
28.		1.56	Trace		0.05
29.			0.38		
30.	0.12	0.45		0.32	
31.	0.07				
Total	3.11"	4.74"	3.01"	3.50"	2.68"

TABLE 2. (Continued)—Precipitation During 1961 Growing Season.

	May	June	July	August
1.		0.45		
2.		0.40	0.48	0.11
3.				
4.				
5.			0.03	0.22
6.	0.25			1.10
7.	Trace	Trace		
8.	0.20	0.34		
9.	0.39			
10.		Trace		0.07
11.				0.07
12.				
13.		1.09	0.05	
14.		0.99	0.45	
15.	0.42		0.02	
16.			0.07	
17.				
18.	0.05		0.14	
19.			2.71	
20.	Trace	0.65		0.04
21.	0.15			
22.				
23.		0.07	0.27	0.26
24.			0.62	0.04
25.	Trace	0.03		
26.	0.27			
27.				0.01
28.			Trace	
29.			0.45	
30.			0.12	
31.	0.13		0.24	
Total	1.86"	4.02"	5.65"	1.92"