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Influence of Long-term Tillage and Crop Rotation Combinations on Crop Yields and Selected Soil Parameters for an Aeric Ochraqualf Soil

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INTRODUCTION

Tillage has long been used for row crop and small grain production for several reasons. Tillage provided the only economically reliable means of weed control, buried or otherwise manipulated previous crop residues so that available planting equipment could operate properly, loosened the soil, and helped mix fertilizer and lime throughout the upper 20 cm or so of the soil profile. All of these characteristics were necessary, or were believed to be necessary, for economical production of high crop yields.

The advent of herbicides for weed control gave an alternate method to tillage for that important function. Planters which could plant through a fairly large quantity of most types of crop residues were developed in the middle 1960's, thereby reducing the need for tillage to manipulate crop residues. Many crops, such as perennial forage legumes and grasses, grow well without much, if any, soil loosening. One question this study attempts to answer is, "How much tillage is required for high crop yield?"

During the last several decades farmers in the Corn Belt of the U. S. and western Ohio have been moving away from crop rotations and toward monoculture. Crop rotations at one time were essential for high yields of feed grains because the legumes in the rotation supplied nitrogen for the grain crops. Cheap, abundant nitrogen fertilizer materials generally replaced that aspect of rotations, at least for the time being.

Crop rotations have long been advocated as excellent means of soil conservation, which they certainly are. However, methods of row crop production which leave the soil surface very rough or with much of the previous crop residues on the soil surface are good alternatives for adequate soil conservation. Some of the crops in traditional rotations, such as the forage legumes and grasses, are no longer needed by many producers, especially with animal power nearly completely replaced by machines. Crop rotations remain a principal means of controlling insect and disease pests of many crops. However, many effective pesticides have been developed which offer alternatives to crop rotation for that important function. Therefore, two other questions this study attempts to answer are, "To what extent are crop rotations required for high corn *(Zea mays* L.) yields, and to what extent do rotation and tillage combinations influence corn yields?"

Over the years one generally accepted tillage practice has evolved for both row crop and small grain production in the U. S., regardless of soil type. Two other questions asked in this study are, "Do soil type differences influence the relationships between tillage, crop rotation, and corn yields?" and "Are these relationships dependent on the duration of the particular combination of practices on the same field?" The portion of the study reported here is the 11-year period, 1962 through 1972, on Crosby silt loam soil, an Aeric Ochraqualf soil, located at the Western Branch of OARDC in Clark County. Other reports describe the same experiment conducted on four other soils in Ohio (1, 11).

MATERIALS AND METHODS

Site Characteristics

Soil and Drainage: The Crosby series is a member of the fine, mixed mesic family of Aeric Ochraqualfs. Crosby soils typically have dark grayish brown silt loam AP horizons, yellowish brown mottled silty clay loam and clay loam B horizons, and yellowish brown mottled loam C horizons. Crosby soils are on nearly level (this site was $\leq 1\%$ slope) to gently sloping topography on moraines, drumlins, and till plains. They form in loam calcareous till of Wisconsin age. The soils are somewhat poorly drained, have slow or very slow runoff, and slow permeability (8).

Selected properties of the site at the OARDC Western Branch, are listed in Appendix Table I. Figure 1 shows the distribution of 1967 cropland on Crosby and the other four major Aeric Ochraqualf soils in Ohio (Bennington, Blount, Fincastle, and Nappanee). It is assumed that the results obtained in this study would be applicable to all Aeric Ochraqualf soils in Ohio having equally good supplemental drainage.

Tile laterals of 10 cm (4 inch) inside diameter were installed in 1960 at 12.2 meter (40 foot) lateral spacing about 1 meter deep. Tile line direction was perpendicular to crop rows.

Crop and Tillage History: The site used for this experiment had been cropped alternately to corn

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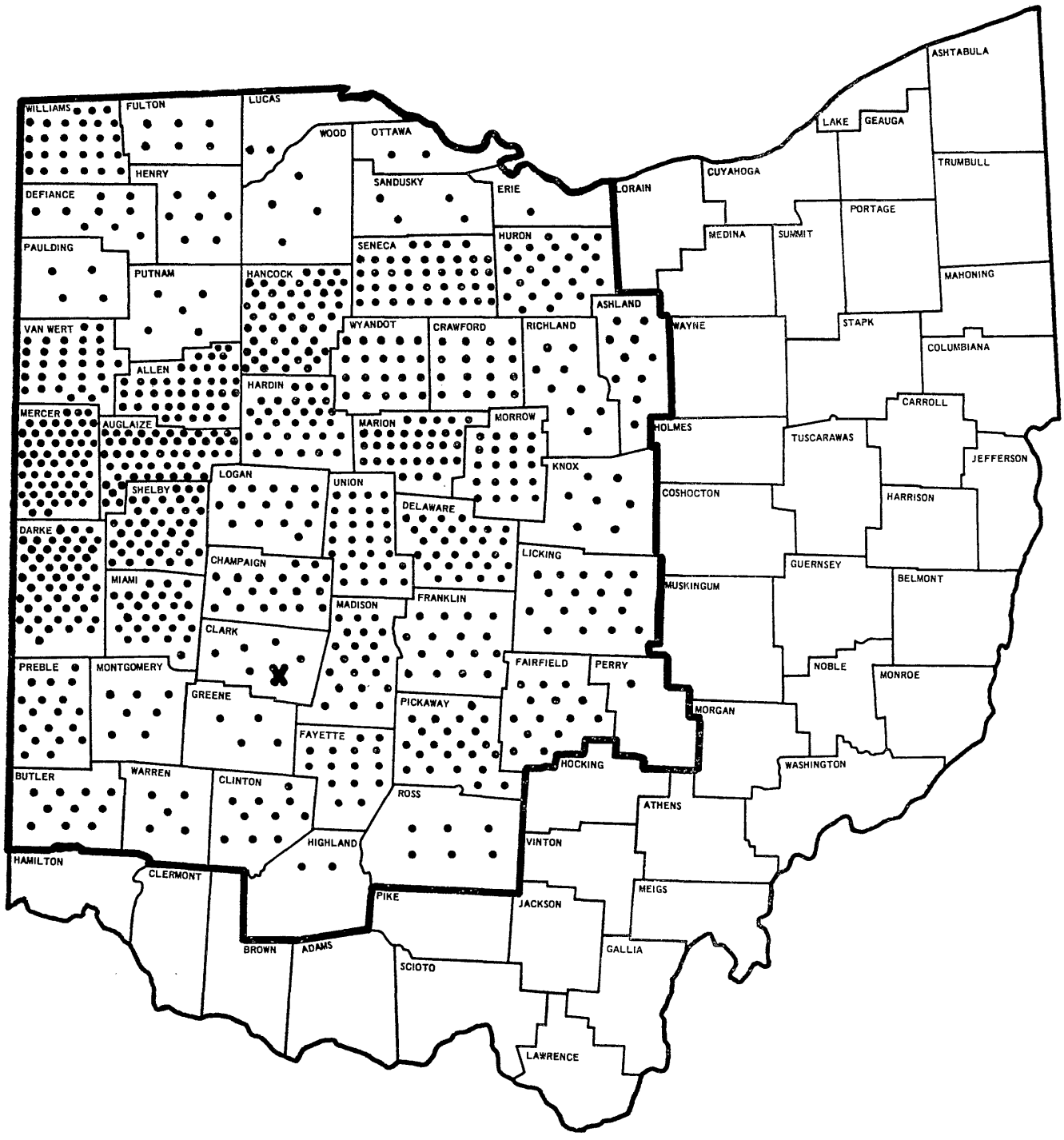

FIGURE 1.—Distribution of 1967 cropland on Aeric Ochraqualf soils in Ohio. Total land in crops was 888,000 hectares (2,132,000 acres), with each dot representing 1,000 ha (2,400 acres). The large cross in Clark County is the location of OARDC's Western Branch.

and soybeans (*Glycine max* L.) for at least the 6 years prior to 1962, the first year in this experiment. Tillage generally consisted of early spring plowing to a 20 cm (8 inch) depth with a moldboard plow, followed by one or more passes with a double disk to a 10 cm (4 inch) depth, sometimes with and sometimes without a trailing spike-tooth harrow.

Climate: Annual and long-term average climatic parameters are listed in Appendix Table II and are summarized for four time periods in Table 1.

Experimental Design (1962 through 1971)

Tillage Variables (applied to grain crops in all rotations):

1. *Conventional Tillage (CT)* consisted of plowing to approximately a 20 cm (8 inch) depth with a moldboard plow in the spring from 1 to 40 days prior to planting, plus disking to a 10 cm (4 inch) depth an average of two times the day before or the day of planting. After planting and crop emergence, the row crops were cultivated to about a 5 cm (2 inch) depth an average of two times with sweep cultivators.
2. *Minimum Tillage (MT)* consisted of plowing as for CT. Planting was performed in the plowed land or in wheel tracks or strips tilled ahead of the planter by ground-driven rotary hoes or fluted coulters. After planting and crop emergence, the row crops were cultivated as for CT.
3. *No-Tillage (NT)* consisted of planting in strips tilled by fluted coulters mounted ahead of the planter openers, except that for oats the soil was occasionally disked one time to a 5 cm (2 inch) depth and planted with a drill not having fluted coulters.

Rotation Variables:

1. Continuous corn.
2. Corn-soybean 2-year rotation. Every crop appeared in the experiment each year.
3. Corn-oats (*Avena sativa* L.)-hay 3-year rotation. Every crop appeared in the experiment each year. Hay consisted of alfalfa (*Medicago sativa* L.) seeded with the oats or occasionally reseeded after oat harvest.

All combinations of the tillage and rotation variables gave nine treatments each year for corn, and three treatments each for soybeans, oats, and alfalfa, all replicated three times. The combinations of tillage and rotations were continued on the same plots from 1962 through 1971.

General Management (details of annual chemical applications and timing of cultural operations are shown in Appendix Table III):

1. *Plot size* was 10.7 meters (35 feet) long and 4.25 meters (14 feet) wide. Each plot of corn or soybeans had four planted rows until 1968, when six-row plots were begun.
2. *Fertilizer:* From 1962 through 1967 most of the P and K fertilizer was applied in a band 5 cm to the side of the row and 5 cm below seed level with the planter. Most N was broadcast prior to any tillage all years. Until 1968 fertilizer additions were probably insufficient and may have been a limiting factor to crop yield. From 1968 to 1972 P and K additions equaled or exceeded recommendations in the Ohio Agronomy Guide (1) based on soil test results, and soil fertility was probably not limiting to crop yield. All treatments for a given crop and year received the same quantity and formulation of fertilizer.
3. *Pesticides:* Insecticides were applied at planting time. Herbicides were applied shortly after planting. Only corn and soybean crops received pesticides.
4. *Row spacing* for corn and soybeans was 102 cm (40 inches) until 1968, when the distance between rows was reduced to 76 cm (30 inches) Oats were seeded at an 18 cm (7 inch) row spacing all years.
5. *Planting:* All treatments for a given crop and year were planted to the same variety with the same planter on the same day. Varieties of each crop were changed from time to time as new and better varieties were released.
6. *Harvest:* The center two rows of corn and soybeans, no longer than 9.1 meters (30 feet), were harvested for grain yield. A 2.1 meter (7 foot) wide

TABLE 1.—Summary of Mean Climatic Conditions for the Four Experimental Periods, 1962, 1963-67, 1968-71, and 1972. Data are summarized from Appendix Table II.

Year(s)	Mean Corn Planting Date*	Mean Rainfall					Mean Daily Temperature			
		Planting Date Thru May 31	June	July	Aug.	Total	Planting Date Thru May 31	June	July	Aug.
		mm					°C			
1962	124	14	92	159	43	308	20.2	21.1	21.2	21.4
1963-67	139	18	40	95	81	234	17.0	20.8	22.0	20.2
1968-71	122	147	125	94	82	448	15.0	20.0	21.4	20.6
1972	129	83	81	95	77	336	16.4	20.3	21.7	20.5

*Days from the first of each year (Jan. 1 = 1).

by 9.1 meter (30 foot) long harvest area was used for oats. Harvest length was sometimes shorter than 9.1 meters in order to achieve equal stand or weed control among all treatments on an area basis. Grain was harvested after drying in the field to moisture contents safe for storage. Corn was generally harvested by hand, while other crops were harvested by machine. All treatments of each crop each year were harvested the same date. One grain moisture sample was obtained for each plot at harvest. Grain weights were calculated on the basis of 15.5% moisture for corn and 13.5% moisture for oats and soybeans. Since hay growth was generally poor and generally lacking alfalfa, especially in the non-tilled plots, yields were often not taken. No hay yields will be reported.

Soil Samples and Measurements

A. **1967 Crop Year:**

On May 17, 1967, prior to spring tillage, five samples were collected per plot (20 cm deep x 2 cm diameter), composited, and analyzed by The Ohio State University Soil Test Laboratory. Amounts of available P, K, and pH were used to determine quantities of P_2O_5, K_2O, and lime to be applied for the 1968 and subsequent crop years.

B. **1971 Crop Year:**

1. *May 17, 1971 (after planting).* Soil cores 28 cm (11 inches) long and 7 cm (2.75 inches) in diameter were obtained with a hydraulic ram which forced the sampling tube into the ground. Ten cores were obtained from each corn plot and cut into appropriate lengths. All cores from the same plot and same depth increment were placed in one plastic bag.

a. *Available nutrients* (P, K) were determined by The Ohio State University Soil Test Laboratory from subsamples of each depth increment of each plot which had been air dried and ground to pass a 1 mm sieve.

b. *Soil organic matter* was measured by the Walkley, Black Technique (12) from an air-dried subsample of each depth increment of each plot.

c. *Atrazine* was determined by gas-liquid chromatography using a thermionic detector equipped with a Ru Cl bead and a column on the chromatograph containing SE-30 Dialoport S support. Atrazine was extracted from dried soil samples (which had been kept at field water content at 4° C until drying for analysis) by refluxing with acetonitrile. The atrazine extract was filtered, evaporated to dryness, and the dried residue dissolved in benzene. Substances which might have interfered with atrazine analysis were removed prior to placing the prepared solutions in the chromatograph by passing the benzene solution through a column packed with basic alumina.

d. *Bulk density* of each depth increment was calculated on a dry weight basis from total wet weight of sample corrected to zero moisture from gravimetric measurement of moisture content of a small subsample.

e. *Change in Mean Weight Diameter (CMWD) of soil aggregates* was obtained using the Yoder wet sieving technique (13) on samples from each depth increment in each plot. Air dry soil was forced through a 10 cm screen and then sieved for 15 seconds on a RoTap shaker.[2] A known weight of each of four aggregate sizes was placed on the top screen of the wet sieving apparatus. After 30 minutes of shaking in water, aggregates from each screen were dispersed and primary particles retained by the screen were removed. A change in aggregate size distribution from the original size range to the final size range (CMWD) was calculated according to DeBoodt (3).

2. *Oct. 29, 1971 (after grain harvest).* Resistance to penetration of a cone with side slope angle of 30° to the axis and a basal area of 7.9 cm^2 was determined in each plot. The penetrometer was forced into the soil at a constant rate of 100 cm/min. Force required for penetration was continuously recorded as a function of depth. Soil samples were collected at the same time for gravimetric moisture determination.

1972 Experiment

Half of all 54 plots from the 1962-1971 experiment were plowed and treated as MT treatment. The other half of all plots were treated as NT. Corn was planted on both halves at the same time with the same equipment, row spacing, and planting rate. Fertilizer and pesticide applications were the same for all plots (see Appendix Table III). Plots were all harvested by hand from staked areas of known dimension within each of the halves of each of the 54 plots.

Corn Thinning, 1962-1972

Whenever possible the harvest area and adjacent border rows were thinned to a common stand when corn was between 0.2 to 0.5 meter tall.

RESULTS AND DISCUSSION

Crop Yields, 1962-1971

1. **Corn:** With adequate weed control and equal stands, the yields of CT and MT treatments were the same (Table 2). The NT treatments occasionally had lower yields than one or both plowed treatments (Table 2). This occurred during the first year and the 1963-67 period in the corn-soybeans and corn-oats-hay rotations. Tillage did not affect corn yields during the last 4 years of the experiment. Apparently the greater bulk density of the upper 28 cm in NT plots (Table 3 and Appendix Table IV)

[2]Use of brand names is for the benefit of the reader and in no way implies endorsement of the product by the authors or the OARDC.

TABLE 2.—Summary of Corn Yield and Stand for Plots Having Equal Stand and Adequate Weed Control Within the Same Year. Values are means of all replicates and years within the indicated time period. Analyses were performed on data in Appendix Tables XI and XII.

Measurement	Years	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation				LSD.05*
		CT	MT	NT	CT	MT	NT	CT	MT	NT		
Corn Grain Yield (kg/ha)	1962	8580	8730	8480	9270	8730	8330†	8980	9350	8330†		920
			8580			8780			8890		Rotation means	530
								8940	**8940**	**8380†**	**Tillage means‡**	**530**
	1963-67	5940	6380	6020	6400	6390	5480†	6730	6820	6690		690
			6110			6090			6750		Rotation means	400
								6360	**6530**	**6060†**	**Tillage means‡**	**400**
	1968-71	8540	8790	8740	9260	9390	8880	9620	9330	10320		730
			8690			9180			9760		Rotation means	420
								9140	**9170**	**9310**	**Tillage means‡**	**420**
Corn Stand (thousands/ha)	1962	42.3	42.7	42.3	42.6	42.7	42.6	42.7	42.7	42.3		0.4
			42.4			42.6			42.6		Rotation means	0.2
								42.5	**42.7**	**42.4**	**Tillage means‡**	**0.2**
	1963-67	37.5	37.9	37.9	38.4	38.2	38.8	38.4	38.6	36.8		2.9
			37.8			38.5			37.9		Rotation means	1.7
								38.1	**38.2**	**37.8**	**Tillage means‡**	**1.7**
	1968-71	45.4	45.8	45.6	46.7	45.5	46.4	47.3	45.7	45.8		4.0
			45.6			46.2			46.3		Rotation means	2.3
								46.5	**45.7**	**45.9**	**Tillage means‡**	**2.3**

*With unequal numbers of plots within each mean, a true LSD cannot be calculated. The LSD values presented in this table were calculated using a number at the low end of the range of numbers of plots within each mean to divide into the error mean square.

†NT treatment mean is significantly lower than one or both of the plowed treatment means within the same rotation or among tillage means. Where this notation is used, the difference between means exceeds the sum of the least squares standard errors for the two means.

‡Average of tillage treatment data from all three rotations.

TABLE 3.—Summary of Soil Chemical and Physical Parameters Obtained May 17, 1971. Values by depth increments are given in Appendix Table IV.

Measurement	Units	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation				
		CT	MT	NT	CT	MT	NT	CT	MT	NT		$LSD_{.05}$*
pH		5.9	5.4	5.1	5.8	5.7	5.9	6.6	5.95	5.85		0.61
0-28 cm			5.5			5.8			6.1		Rotation means	0.35
								6.1	**5.7**	**5.6**	**Tillage means***	**0.35**
Available P	kg/ha	121	147	155+	167	145	146+	100	92	93+		37.4
Total 0-28 cm			141			153			95		Rotation means	21.6
								129	**128**	**131**	**Tillage means***	**21.6**
Available K	kg/ha	491	548	610	589	599	671	454	387	434		57.2
Total 0-28 cm			553			620			425		Rotation means	33.0
								511	**511**	**572**	**Tillage means***	**33.0**
Organic Matter	T/ha	60.7	62.5	64.3	54.5	55.0	64.2	60.0	74.7	65.4		6.1
Total 0-28 cm			62.5			57.9			66.7		Rotation means	3.5
								58.4	**64.1**	**64.6**	**Tillage means***	**3.5**
Atrazine	g/ha	316	370	309	248	315	61	161	272	266		211
Total 0-28 cm			322			208			233		Rotation means	122
								242	**319**	**212**	**Tillage means***	**122**
Bulk Density	g/cm^3	1.37	1.34	1.45	1.39	1.38	1.47	1.35	1.30	1.44		.055
Mean 0-28 cm			1.39			1.41			1.36		Rotation means	.032
								1.37	**1.34**	**1.45**	**Tillage means***	**.032**
CMWD Aggregates		450	453	449	453	448	441	402	433	431		14.1
Mean 0-28 cm			451			447			422		Rotation means	8.1
								435	**445**	**440**	**Tillage means***	**8.1**

*Average of tillage treatment data from all three rotations.

TABLE 4.—Summary of Penetrability Measurements Oct. 29, 1971. Data for CT and MT are shown separately in Appendix Table V and soil moisture content at time of sampling is shown in Appendix Table X.

		Force					
		Continuous Corn		Corn-Soybean Rotation		Corn-Oats-Hay Rotation	
Crop	Depth	Plowed	NT	Plowed	NT	Plowed	NT
	cm			kg			
Corn	0-7.5	76	147	60	122	74	100
	7.5-15	85	172	70	150	82	120
	15-22.5	118	188	104	148	133	137
	Mean	93	169	78	140	96	119
Soybeans	0-7.5			63	80	77	*
or Oats	7.5-15			68	109	84	*
	15-22.5			86	113	122	*
	Mean			72	101	94	
Hay	0-7.5					108	127
	7.5-15					121	154
	15-22.5					140	174
	Mean					123	152
		$LSD_{.05}$ for Depth-Tillage-Rotation combinations = 40.6 kg					
		$LSD_{.05}$ for Rotation-Tillage means = 20.3 kg					

*Plowed by mistake in 1970.

and greater force required to penetrate the soil of these plots (Table 4 and Appendix Table V) were not sufficient to reduce grain yields even during these favorable, high-yielding years. Crop rotation had a significant effect on corn yield. By the last 4 years yields were reduced as corn appeared more often in the rotation, with a 10% difference between the extremes. Earlier, corn yields from continuous corn and the corn-soybean rotations were equal.

Crop yields were much greater during the final 4 years than during the 1963-67 period. This is not considered a time effect *per se,* but is associated with the greater application of N, P, and K fertilizer (Appendix Table III), higher plant populations (Table 2), narrower rows, and greater rainfall during May and June (Table 1) during the final 4 years.

The difference in location of applied fertilizer among tillage treatments evidently had no influence on corn growth. Nutrient concentration of ear leaves (Table 5) was either the same or greater for the NT or MT treatments compared with CT treatments. Other reports derived from moderately fertile soils (10) show that applying fertilizer either in bands in the row or broadcast on the surface with no incorporation into the soil profile by tillage had no effect on uptake of nutrients. Tillage had little influence on total available P and K in the Ap horizon (Tables 3 and 6), even though distribution with depth was much different for plowed than for NT treatments (Appendix Table IV).

Every effort was made to obtain good weed control and equal stands for all treatments without regard for cost or labor (see Appendix Table III for materials used). This was done so that the yield potential of all treatments could be judged apart from limitations caused by inferior chemical technology and planting equipment, especially for NT. These results indicate that if and when economically sound and reliable herbicides are developed and reliable planting equipment is available, all three tillage treatments studied here have equal corn producing capabilities, more or less independent of the crop rotation employed, for this location. This conclusion differs from that drawn by Griffith, *et al.* (4) for a similar soil (Blount silt loam) in which weed problems and reduced stand significantly reduced corn yields on non-plowed (particularly NT) treatments. Absence of tile drains in the Blount soil also may have contributed to the yield differences they reported.

One example of the practical problems encountered during the experiment due to less than perfect planting equipment is illustrated in Table 7. Corn stand before thinning was as much as 18,000 plant/ha (7,500 plants/A) lower for NT than for plowed treatments during the first 6 years of the experiment. Planting equipment was changed in 1968, and except for continuous corn, emerged stands were nearly the same for all treatments. If no effort had been made to achieve equal stand after emergence, yield differences would have been much greater than those reported in Table 2. Consequently, the conclusions drawn concerning the corn yield potential of the tillage systems would have been more like those of Griffith, *et al.* (4).

2. **Soybeans:** Even with good weed control and reasonably similar stands, the NT treatment had

TABLE 5.—Summary of N, P, and K Composition of Corn Ear Leaves at Silking Time for the Period 1968-1971. Analyses were performed on data in Appendix Table VI.

Measurement	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation				$LSD_{.05}$*
	CT	MT	NT	CT	MT	NT	CT	MT	NT		
Percent N†	2.95	2.98	3.01	2.80	2.93	3.09‡‡	2.77	3.00‡‡	2.95		0.21
		2.98			2.94			2.90		Rotation means	0.12
							2.84	**2.97‡‡**	**3.02‡‡**	**Tillage means††**	**0.12**
Percent P‡	0.31	0.32	0.35	0.34	0.30	0.32	0.31	0.32	0.34		0.04
		0.33			0.32			0.32		Rotation means	0.02
							0.32	**0.31**	**0.34‡‡**	**Tillage means‡‡**	**0.02**
Percent K**	1.54	1.62	1.75‡‡	1.60	1.67	1.71	1.63	1.76	1.75		0.16
		1.64			1.66			1.71		Rotation means	0.09
							1.59	**1.68‡‡**	**1.74‡‡**	**Tillage means††**	**0.09**

*With unequal numbers of plots within each mean, a true LSD cannot be calculated. The LSD values presented in this table were calculated using a number at the low end of the range of numbers of plots within each mean to divide into the error mean square.

†Low level = 2.46 to 2.75%; sufficient level = 2.76 to 3.50% (6).

‡Low level = 0.16 to 0.24%; sufficient level = 0.25 to 0.40% (6).

**Low level = 1.26 to 1.70%; sufficient level = 1.71 to 2.50% (6).

††Average of tillage treatment data from all three rotations.

‡‡NT treatment mean is significantly greater than one or both of the plowed treatment means within the same rotation or among tillage means, or MT mean is greater than CT mean Where this notation is used, the difference between means exceeds the sum of the least squares standard errors for the two means.

TABLE 6.—Summary of Soil pH, Available P, and Available K in the Upper 20 cm of the Soil, May 17, 1967. Analyses were performed on data in Appendix Table VII.

Measurement	Rotation	1967 Crop	CT	MT	NT	Mean
pH*	1 Yr	Corn	6.1	5.9	5.8	5.9
	2 Yr	Corn	6.4	6.0	5.9	6.1
	3 Yr	Corn	6.4	5.9	5.7	6.0
	2 Yr	Soybeans	6.3	6.1	6.0	6.1
	3 Yr	Oats	6.4	6.1	6.0	6.2
	3 Yr	Hay	6.4	6.1	6.3	6.3
		Mean	6.3	6.0	5.95	6.1
		$LSD_{.05}$ Tillage = 0.33; Rotation = 0.47; TxR = 0.80				
P	1 Yr	Corn	72	96	52	73
(kg/ha)	2 Yr	Corn	77	64	72	71
	3 Yr	Corn	58	88	67	71
	2 Yr	Soybeans	92	70	91	84
	3 Yr	Oats	86	70	92	83
	3 Yr	Hay	76	59	45	60
		Mean	77	74	70	74
		$LSD_{.05}$ Tillage = 11; Rotation = 15.5; TxR = 27				
K	1 Yr	Corn	161	162	155	159
(kg/ha)	2 Yr	Corn	143	168	150	154
	3 Yr	Corn	137	148	141	142
	2 Yr	Soybeans	146	152	145	148
	3 Yr	Oats	168	175	151	165
	3 Yr	Hay	139	164	135	146
		Mean	149	161.5	146	152
		$LSD_{.05}$ Tillage = 12; Rotation = 17; TxR = 29				

*pH values reported in this table are arithmetic means of pH data reported in Appendix Table VII using the justification of Jackson (5).

TABLE 7.—Summary of Corn Stand Before Thinning. Values are means of harvest rows and border rows, all replicates and all years within the stated time period. Analyses were performed on data in Appendix Table VIII.

Years	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation				$LSD_{.05}$*
	CT	MT	NT	CT	MT	NT	CT	MT	NT		
1963-67	45.9	38.4†	30.9†	45.3	38.9†	27.4†	46.3	41.9	33.2†		5.2
		38.4			37.2			40.5		Rotation means	3.0
							45.8	**39.7†**	**30.5†**	**Tillage means‡**	**3.0**
1968-71	53.3	48.6	42.8†	52.0	51.2	49.3	49.9	48.5	45.9		5.7
		48.3			50.8			48.1		Rotation means	3.3
							51.7	**49.4**	**46.0†**	**Tillage means‡**	**3.3**

*With unequal numbers of plots within each mean, a true LSD cannot be calculated. The LSD values presented in this table were calculated using a number at the low end of the range of numbers of plots within each mean to divide into the error mean square.

†NT treatment mean is significantly lower than one or both of the plowed treatment means or MT mean is lower than CT mean within the same rotation or among tillage means. Where this notation is used, the difference between means exceeds the sum of the least squares standard errors for the two means.

‡Average of tillage treatment data from all three rotations.

TABLE 8.—Summary of Soybean and Oat Grain Yields. Values are means of all replicates and years within the stated time periods. Analyses were performed on data in Appendix Table VIII.

Crop	Years	Equal Stand and Good Weed Control				All Data			
		CT	MT	NT	$LSD_{.05}$*	CT	MT	NT	$LSD_{.05}$*
Soybean Yield	1962	2140	No Data			2140	1240†	1720	660
(kg/ha)	1963-67	1970	1810	1360†	380	1970	1780	1240†	280
	1968-71	2630	2390	1980	890	2570	2300	1240†	520
Oat Yield	1962	2870	2770	2740	250	2870	2770	2740	250
(kg/ha)	1963-67	2630	2760	2530	290	2630	2760	2530	290
	1968-71	3080	2770	One plot	600	3080	2800	1970†	600

*With unequal numbers of plots within each mean, a true LSD cannot be calculated. The LSD values presented in this table were calculated using a number at the low end of the range of numbers of plots within each mean to divide into the error mean square.

†NT treatment mean is significantly less than one or both of the plowed treatment means, or MT mean is less than CT mean. Where this notation is used, the difference between means exceeds the sum of the least squares standard errors for the two means.

400 to 600 kg/ha (6 to 9 bu/A) lower yields than either plowed treatment (Table 8). The effect was consistent throughout the experiment. Adding weed problems (all data) further reduced NT yields. No actual stand counts of soybeans were made, and perhaps visual ratings were not sufficiently accurate to estimate equality of stand among treatments. In any case, the conclusion at present is that continued use of NT for full-season soybean production on this soil will result in reduced yields, even with good weed control.

3. **Oats:** Yields were independent of tillage treatment for the first 6 years of the experiment (Table 8). Weed problems during the last 4 years reduced yield of the NT treatment by almost 1000 kg/ha (28 bu/A) below the average of the plowed treatments. Since only one NT plot in 4 years was judged to be as weed-free as the plowed treatments, there was no check on the potential for NT to produce oats without weed competition during this time period. However, at least for 6 years, if oats can be seeded properly to establish a desirable stand and weeds can be controlled, all three tillage treatments appear to have equal oat-producing potential on this soil.

Soil Measurements, 1967

Table 6 summarizes the results of pH and available P and K determinations made on Ap horizon material during the sixth year of the experiment. Soil pH was not significantly affected by crop rotation as the treatments were managed, and was marginally affected by tillage. Available P was sufficient in all plots to maintain much higher yields of corn, soybeans, and oats than were achieved prior to 1968. Available K was equally deficient for all tillage and rotation treatments and could have been limiting yields for all crops prior to 1968.

Soil Measurements, 1971

Tables 3 and 4 summarize the results of selected chemical and physical measurements made on Ap horizon material during the tenth year of the experiment. Soil pH was significantly affected by tillage and rotation, although probably not sufficiently to cause crop yield differences. Available P and K were probably not influenced to a biologically significant extent by tillage or rotations, although the 3-year rotation had an average of 50 kg/ha (45 lb/A) and 150 kg/ha (134 lb/A) less available P and K respectively than the other rotations. At the concentrations measured, P and K would not be limiting to any crop for any treatment.

Soil organic matter was about 6 metric tons/ha lower for CT than for the average of the other two tillage treatments. The 3-year rotation had about 5 tons/ha more organic matter than continuous corn, which in turn had 4.6 tons/ha more than the 2-year rotation. While these effects are statistically significant, they are not necessarily in the same direction as crop yield effects, and hence would not be expected to be a prime cause of yield differences shown in Table 2.

Judging by the magnitude of the LSD in Table 3, atrazine concentration varied widely throughout the Ap horizon (Table D) and among treatments. Quantities measured probably reflect primarily the quantity added in 1971, and secondarily the quantities added in previous years. That would explain why the 2-year rotation had about ⅔ as much atrazine as continuous corn (⅔ as much was applied to the 2-year rotation in 1971) and about ⅔ as much in the 3-year rotation as in continuous corn (⅓ as much added to the 3-year rotation in 10 years). There was no great buildup of atrazine in the 10 years of the experiment. Of the 1,075 g/ha (1 lb/A) applied in 1971 and about 16 kg/ha (14 lb/A) applied

the previous 9 years, the maximum amount detected was 370 g/ha (⅓ lb/A).

Average Ap horizon bulk density was increased 0.03 g/cm³ by the disking associated with the CT treatments and reduced .04 g/cm³ by the 3-year rotation. These effects were small compared with the 0.09 g/cm³ greater bulk density of the NT treatments compared with the average of plowed treatments. Differences were greater when considering the top half of the Ap horizon (Appendix Table IV). However, these differences evidently did not by themselves create significant corn yield differences.

Aggregate stability as indicated by the CMWD of aggregates indicates very little difference among treatments. Soil from the 3-year rotation had slightly greater aggregate stability than soil from the other two rotations (smaller numbers ≡ greater stability) and MT had slightly lower stability than CT. It is doubtful if such small differences would have had much influence on corn yields by promoting greater water infiltration and gaseous exchange between soil and atmosphere.

Soil penetrability after 1971 harvest was primarily influenced by lack of plowing (NT) and depth (Table 4). There were some differences in soil water content at the time of penetrability measurement (Appendix Table X), but the distribution of water content values would be expected to reduce observed differences in penetrability. The two plowed treatments had equal penetrability and were averaged for presentation in Table 4. For all crop rotation combinations, NT required greater force to penetrate the soil. This has not been translated into differences in corn yield, but might be a partial cause for reduced soybean production with NT.

1972 Experiment

Corn Yields: With equal stand as actually attained for the tilled half of the experiment (Table 9, plowed) and as calculated for the non-tilled half (Table 9, adjusted no-til), neither 1972 tillage, antecedent tillage, nor cropping history affected 1972 corn yields. Previous tillage did not alter soil physical or chemical conditions to the extent of influencing 1972

TABLE 9.—Summary of Corn Grain Yield and Stand in 1972 as Affected by Previous Cropping and Tillage History. Values are means of three replicates. Analyses and correlations were performed on data in Appendix Tables XIII and XIV.

Tillage	Rotation	1971 Crop	Corn Grain Yield at 15.5% Moisture				Final Stand After Thinning			
			CT	MT	NT	Mean	CT	MT	NT	Mean
			kg/ha				Thousands/ha			
Plow	1 Yr	Corn	10490	10490	10900	10630	51.1	50.7	51.2	51.0
	2 Yr	Corn	10720	10140	10030†	10300	50.7	47.8	46.6†	48.4
	3 Yr	Corn	10500	11680	10710	10940	47.8	51.6	51.7	50.4
	2 Yr	Soybeans	10610	9900	10460†	10320	49.2	48.8	53.8†	50.6
	3 Yr	Oats	10350	10760	‡	10560	47.8	49.2	‡	48.5
	3 Yr	Hay	10660	11130	10110	10630	50.7	50.2	45.9	48.9
		Mean	10550	10680	10440	10560	49.6	49.7	49.8	49.7
		$LSD_{.05}$	Tillage = 480;	Rotation = 680;	TxR = 1160		Tillage = 1.8;	Rotation = 2.51;	TxR = 4.3	
No Til	1 Yr	Corn	9580	10400	8530	9500	48.3	49.7	41.1	46.4
	2 Yr	Corn	9080	10430	5280†	8260	45.4	49.2	25.1†	39.9
	3 Yr	Corn	9490	8870	2750	7040	46.9	39.2	12.4	32.8
	2 Yr	Soybeans	7910	8900	9580†	8800	40.2	47.8	43.8†	43.9
	3 Yr	Oats	8580	8200	‡	8390	38.7	39.7	‡	39.9
	3 Yr	Hay	9990	10140	10450	10190	46.9	49.7	48.3	48.3
		Mean	9100	9490	7320	8700	44.4	45.9	34.1	41.8
		$LSD_{.05}$	Tillage = 1010;	Rotation = 1430;	TxR = 2480		Tillage = 5.2;	Rotation = 7.3;	TxR = 12.6	
No Til Adjusted*	1 Yr	Corn	9840	10380	10220	10150				
	2 Yr	Corn	9920	10500	10160†	10200				
	3 Yr	Corn	10030	10950	10160	10380				
	2 Yr	Soybeans	9790	9260	10750†	9930				
	3 Yr	Oats	10750	10180	‡	10460				
	3 Yr	Hay	10540	10110	10710	10450				
		Mean	10140	10230	10400	10260				
		$LSD_{.05}$	Tillage = 400;	Rotation = 570;	TxR = 980					

*Yields adjusted to stand of 49,700 plants/ha based on the following regression obtained from all 1972 data: Grain yield (kg/ha)=510 + 199.4 x plants/ha x 10^{-3} (correlation coefficient = 0.94).

†Mean of only two replicates. One was plowed by mistake in 1967.

‡Plowed by mistake in 1970.

corn yield. It is surprising that the rotation history did not influence 1972 yields since there had been as much as a 10% effect in previous years (Table 2). Excellent growing conditions in 1972 (10,000 + kg/ha or 160+ bu/A yield level) may have eliminated the effect of the cropping history. For that matter, the favorable growing conditions could also have masked any effects of soil characteristics inherited from the prior tillage history.

Since the correlation coefficient was 0.94 for the relation between stand and yield, the effect of previous history on yields from the non-tilled half of the 1972 experiment was mostly associated with 1972 stand (Table 9).

Nutrient concentration of corn ear leaf tissue, like grain yield, was not affected by tillage or cropping history (Table 10).

SUMMARY

All combinations of three tillage treatments (plow-disk-plant (CT); plow-plant (MT); and no-tillage (NT)) and of three crop rotations (continuous corn (1 yr); corn-soybeans (2 yr); and corn-oats-hay (3 yr)) were maintained on the same plots for 10 years, with all crops appearing every year. The soil was Crosby silt loam, a nearly level Aeric Ochraqualf soil having tile at 1 meter (3.5 foot) depth and 12.2 meter (40 foot) lateral spacing. The objective, although not always achieved, was to create equal stands of each crop within a year and weed control such that weeds would not be competitive with the crop. Results summarized only for plots with equal stands and good weed control give the potential crop-producing ability of each tillage-rotation combination without hindrance from inferior planter and herbicide technology.

With only one exception, yields of corn, oats, and soybeans were equal for CT and MT. Except for the first year in the 2-yr and 3-yr rotations and the average of the second through sixth years of the 2-yr rotation, NT produced corn yields equal to those of the plowed treatments. NT also produced equal oat yields through the first 6 years. Thereafter, NT oat plots were too weedy to be compared with plowed treatments on a no weed competition basis.

TABLE 10.—Summary of Corn Ear Leaf Tissue Analyses for N, P, and K at 50% Silking Time in 1972 from Plowed Halves of the Plots, Expressed as Percent of Dry Tissue. Analyses were performed on data in Appendix Table XV.

Measurement	Rotation	1971 Crop	CT	MT	NT	Mean
N	1 Yr	Corn	3.10	3.00	3.22	3.11
(%)	2 Yr	Corn	3.35	3.13	3.10†	3.19
	3 Yr	Corn	3.12	3.00	3.12	3.08
	2 Yr	Soybeans	3.00	3.28	3.10†	3.13
	3 Yr	Oats	3.10	3.07	‡	3.08
	3 Yr	Hay	3.02	3.05	3.03	3.03
		Mean	3.115	3.09	3.11	3.10
		$LSD_{.05}$* Tillage = 0.11; Rotation = 0.16; TxR = 0.27				
P	1 Yr	Corn	0.36	0.36	0.36	0.36
(%)	2 Yr	Corn	0.35	0.37	0.37†	0.36
	3 Yr	Corn	0.37	0.36	0.33†	0.35
	2 Yr	Soybeans	0.39	0.47	0.38†	0.41
	3 Yr	Oats	0.43	0.33	‡	0.38
	3 Yr	Hay	0.35	0.35	0.41	0.37
		Mean	0.375	0.37	0.37	0.37
		$LSD_{.05}$* Tillage = 0.04; Rotation = 0.06; TxR = 0.10				
K	1 Yr	Corn	2.06	1.83	2.06	1.98
(%)	2 Yr	Corn	2.11	2.18	2.04†	2.11
	3 Yr	Corn	2.10	1.93	2.05	2.03
	2 Yr	Soybeans	1.93	1.67	2.15†	1.92
	3 Yr	Oats	1.97	2.15	‡	2.06
	3 Yr	Hay	1.94	2.07	2.11	2.04
		Mean	2.02	1.97	2.08	2.02
		$LSD_{.05}$* Tillage = 0.135; Rotation = 0.19; TxR = 0.33				

*With unequal numbers of plots within each mean, a true LSD cannot be calculated. The LSD values presented in this table were calculated using a number at the low end of the range of numbers of plots within each mean to divide into the error mean square.

†Mean of only two replicates. One was plowed by mistake in 1967.

‡NT plots plowed by mistake in 1970.

The most consistent differential effect of tillage treatment on crop yield was with soybeans. Plowed treatments in this rotation averaged 400 to 600 kg/ha (6 to 9 bu/A) greater soybean yield than NT. The 3-yr rotation averaged 670 kg/ha (10.5 bu/A) greater corn yields than the other rotations for the 10-year period, while the 2-yr rotation averaged 490 kg/ha (8 bu/A) greater corn yield than continuous corn during the last 4 years.

Soil measurements during the tenth year showed small and biologically insignificant differences in available P and K among treatments, 4.6 metric ton/ha greater soil organic matter content of the Ap horizon of 1-yr compared with 2-yr rotation and 5 ton/ha greater organic matter content of 3-yr compared with 1-yr rotation, and no buildup of atrazine herbicide in 10 years. The largest differences in soil conditions occurred in measured bulk density and penetrability of the soil. NT had 0.09 g/cm^3 greater average bulk density and 20 to 50% greater average force for penetration of a steel cone.

The experiment was terminated in the 11th year by plowing half of all plots and planting the entire area to corn. With equal stand and satisfactory weed control, neither 1972 tillage, tillage history, nor cropping history affected corn yields.

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APPENDIX

TABLE I.—Physical Characteristics of Crosby Silt Loam at Western Branch, OARDC, in Clark County, Ohio.*

Horizon	Horizon Depths	Core Depths	Mechanical Analysis†			Moisture Retention‡				Bulk Density
			Sand	Silt	Clay	0 bar	0.06 bar	0.33 bar	15 bar	
	cm	cm	Percent			100 x cm^3/cm^3				g/cm^3
Ap	0-20	5-12	15	65	20	46.1	38.8	34.0	13.7	1.36
A_2	20-28	21-28	15	59	26	41.2	34.0	31.0	10.7	1.52
B_1	28-41	32-39	14	54	32	39.6	35.0	32.4	18.4	1.53
B_{21}	41-53	44-51	12	45	43	41.9	39.6	37.5	26.0	1.50
B_{22}	53-71	60-67	15	42	43	42.6	40.4	38.5	25.7	1.51
B_3	71-89	78-85	17	49	34	40.3	37.2	32.3	20.6	1.56
C_1	89-	92-99	24	48	28	39.0	35.6	32.2	23.6	1.61

*Data obtained by The Ohio State University Soil Survey Laboratory from a site within 1 km of the plots.
†Determined essentially as reported in reference (2) for pipette analysis.
‡Determined during desorption of 7.5 cm long x 7 cm diameter "undisturbed" cylinders of soil essentially as reported in reference (7) for 0 to 0.33 bar, and of disturbed samples as reported in reference (9) for 15 bar.

TABLE II.—Climatic Characteristics for the Duration of the Experiment.

Year	Mean Corn Planting Date*	Total Rainfall				Mean Daily Temperature			
		Planting Date Thru May 31	June	July	Aug.	Planting Date Thru May 31	June	July	Aug.
		mm				°C			
1962	124	14	92	159	43	20.2	21.1	21.2	21.4
1963	135	23	32	126	139	15.0	21.1	22.1	19.6
1964	134	35	62	59	39	17.4	20.9	23.4	21.2
1965	139	4	32	133	103	18.7	20.2	20.3	20.2
1966	137	28	27	87	109	17.1	21.1	23.1	20.5
1967	152		45	72	16		20.8	21.1	19.2
1968	121	287	82	70	119	13.0	19.7	21.2	21.1
1969	121	95	192	130	99	15.3	18.7	21.9	20.1
1970	124	108	81	74	41	18.1	21.1	21.9	21.7
1971	120	99	146	102	68	13.7	20.6	20.6	19.6
1972	118	139	101	48	72	15.8	17.5	21.4	20.5
11-Year Average	129	83	81	95	77	16.4	20.3	21.7	20.5
15-Year Average			84	101	84		20.3	21.7	20.8

*Days from the first of each year (Jan. 1 = 1).

TABLE III.—Cultural Practices Details.

Crop	Year	Plow Date*	CT Disking		Planting Date*	CT and MT Number of Cultivations	Fertilizer†					
							Broadcast			In Row		
			Number	Date*			N	P_2O_5	K_2O	N	P_2O_5	K_2O
							kg/ha					
Corn	1962	114	1 + 1	116 + 123	124	2	168	0	0	18	72	36
	1963	102	1	134	135	1	168	0	0	13	54	27
	1964	107	3	134	134	3	168	180	180	13	54	27
	1965	123	3	139	139	1	168	0	0	13	54	27
	1966	112	2	137	137	3	168	0	0	13	54	27
	1967	145	2	152	152	1	168	112	112	13	54	27
	1968‡	115	2	121	121	1	224	67	140	0	0	0
	1969	119	2	121	121	1	280	67	134	0	0	0
	1970**	122	2	122	122	1	280	78	78	0	0	0
	1971	95	2	120	120	1	280	56	113	0	0	0
	Mean	115	2.1	130	131	1.5	207	56	66	8	34	17
Soybeans	1962	114	1 + 1	116 + 143	144	3	0	0	0	0	45	45
	1963	102	1	134	135	1	0	0	0	0	45	45
	1964	107	3	134	134	4	0	180	180	0	45	45
	1965	123	3	139	139	2	0	0	0	0	45	45
	1966	112	2	137	141	3	0	0	0	0	45	45
	1967	145	2	152	153	0	0	112	112	13	54	27
	1968‡	115	2	157	157	1	0	67	67	0	0	0
	1969	119	2	142	142	1	0	67	67	0	0	0
	1970**	122	2	122	124	1	0	78	78	0	0	0
	1971	95	2	134	134	1	0	56	56	0	0	0
	Mean	115	2.1	138	140	1.7	0	56	56	1	28	25
Oats	1962††	109	1	109	110		0	0	0	27	27	27
	1963††	95	2	98	98		0	0	0	27	54	27
	1964‡‡	82	3	83	83		0	180 (180)	180 (180)	27	54	27
	1965	95	1	120	120		0	0	0	27	54	27
	1966	80	3	88	88		0	0	0	27	54	27
	1967‡‡	90	3	101	101		0	112 (112)	112 (112)	27	54	27
	1968‡	71	2	88	88		0	67 (67)	67 (202)	40	40	40
	1969	76	2	77	77		67	67 (67)	67 (202)	0	0	0
	1970**	71	2	99	99		67	78 (78)	78 (212)	22	58	58
	1971	—34	2	90	90		56	56 (56)	56 (190)	17	67	67
	Mean	74	2.1	95	95		19	56 (56)	56 (110)	22	46	33
Corn	1972	115			117	0	280	90	90	0	0	0

*Days from the first of the year (Jan. 1 = 1).

†Values in parentheses for oats are quantities of fertilizer applied to the subsequent alfalfa crop.

‡4500 kg/ha (2 tons/A) limestone broadcast Feb. 19, 1968; soil test results from Nov. 1967 sampling averaged pH = 5.6, available P = 112 kg/ha, and available K = 195 kg/ha Broadcast approximately 33,600 kg/ha (15 tons/A) strawy manure over entire experiment in March 1968.

**Broadcast 4500 kg/ha (2 tons/A) limestone over entire experiment April 15, 1970.

††NT oat plots were disked twice to a 5-cm (2-inch) depth.

‡‡NT hay plots were reseeded to alfalfa after disking once to a 5-cm (2-inch) depth.

TABLE III (Continued).—Cultural Practices Details.

Crop	Year	Herbicide***	Insecticide†††
Corn	1962	All plots = 3.4 At NT plots = 4.5 Am	
	1963	All plots =2.2 At NT plots = 2.2 Am + additional 2.2 Am for NT, 3-yr plots	
	1964	All plots = 3.4 At + 3.4 Am NT, 3-yr plots = 1.1 Am + 1.1 Si	
	1965	All plots = 3.3 Am + 1.1 Li All plots except NT, 3-yr = 2.2 At NT, 3-yr plots = 1.1 Am + 3.4 Li + 1.1 Si	
	1966	All plots = 2.2 At + 1.1 Am All plots except NT, 3-yr = 1.1 Li NT plots = 2.2 Li + additional 1.1 At + 3.4 Am + 1.1 Si for NT, 3-yr plots	+ 3.4 Chl
	1967	All plots = 2.2 At + 1.1 Am All plots except NT, 3-yr = 1.1 Li NT, 3-yr plots = 1.1 At + 3.4 Am + 1.1 Si	+ 3.4 Ald
	1968	All plots = 1.1 Si + 0.6 Di + 0.6 Pa + 1.7 Li	+ 3.4 Chl
	1969	1-yr and 3-yr plots = 1.1 At + 1.1 Si + 3.4 Li + 0.6 Di + 0.6 Pa 2-yr plots = 0.7 At + 0.7 Si + 2.2 Li + 0.4 Di + 0.4 Pa	+ 3.4 Chl + 3.4 Chl
	1970	1-yr and 3-yr plots = 2.8 Si + 1.1 Li + 0.6 Di + 0.6 Pa 2-yr plots = 1.8 Si + 0.7 Li + 0.4 Di + 0.4 Pa	+ 3.4 Chl + 3.4 Chl
	1971	1-yr and 3-yr plots = 1.1 At + 1.1 Si + 2.2 Al + 0.6 Di+ 0.6 Pa 2-yr plots = 0.7 At + 0.7 Si + 1.4 Al + 0.4 Di + 0.4 Pa	+ 3.4 Chl + 3.4 Chl
Soybeans	1962	All plots = 3.4 Ch + additional 4.5 Am for NT plots	
	1963	All plots = 3.4 Ch + additional 2.2 Am for NT plots	
	1964	All plots = 4.5 Ch + additional 3.4 Am for NT plots	
	1965	All plots = 4.5 Ch + additional 3.4 Am for NT plots	
	1966	All plots = 4.5 Ch + additional 3.4 Am for NT plots	
	1967	All plots = 4.5 Ch + additional 3.4 Am for NT plots	
	1968	All plots = 3.4 Ch + 3.4 Am + 1.1 Li	
	1969	All plots = 3.4 Ch + 1.1 Li	
	1970	All plots = 2.2 Al + 1.1 Li + 0.3 Pa	
	1971	All plots = 2.2 Al + 1.1 Li + 0.3 Pa	
Corn	1972	All plots = 3.4 At + 1.1 Si + 0.6 Di + 0.2 Pa	+ 1.1 Car

***Numbers refer to kg/ha active ingredient applied. Letters are codes for the following herbicides:
Al = alachlor (2-chloro-2'-6'-diethyl-N-(methyoxymethyl)acetanilide)
Am = amitrole (3-amino-s-triazole)
At = atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine)
Ch = chloramben (3-amino-2,5-dichlorobenzoic acid)
Di = dicamba (3,6-dichloro-o-anisic acid)
Li = linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea)
Pa = paraquat (1,1'-dimethyl-4,4'-bipyridinium ion)
Si = simizine (2-chloro-4,6-bis(ethylamino)-s-triazine)

1-yr plots = continuous corn
2-yr plots = corn-soybean rotation
3-yr plots = corn-oats-hay rotation

†††Numbers refer to kg/ha active ingredient applied. Letters are codes for the following insecticides:
Chl = Chlordane
Ald = Aldrin
Car = Carbofuran

TABLE IV.—Soil Chemical and Physical Parameters Obtained May 17, 1971. Mean Values per Depth per Treatment.

Measurement	Depth (cm)	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
		CT	MT	NT	CT	MT	NT*	CT	MT	NT
pH	0-2.5	5.9	5.5	5.1	5.7	5.9	5.7	6.7	6.1	5.9
	2.5-5.1	6.0	5.5	4.9	5.8	5.9	5.6	6.6	6.1	5.9
	5.1-7.6	5.9	5.4	4.8	5.9	5.8	5.8	6.8	6.1	5.7
	7.6-12.7	5.9	5.4	5.1	5.8	5.7	6.0	6.7	6.0	5.7
	12.7-17.8	5.9	5.4	5.0	5.9	5.7	6.3	6.5	5.9	5.8
	17.8-22.9	5.9	5.4	5.0	5.8	5.6	5.8	6.5	5.9	6.0
	22.9-27.9	5.9	5.5	5.3	5.6	5.7	5.6	6.5	5.8	5.9
Available Phosphorus (kg/ha)‡	0-2.5	9	9	27+†	13	9	28+	6	6	24+
	2.5-5.1	11	12	32+	14	12	31+	12	8	22+
	5.1-7.6	12	15	25	15	19	23	10	8	11
	7.6-12.7	25	30	37	35	30	30	28	19	15
	12.7-17.8	27	36	17	47	35	17	24	20	10
	17.8-22.9	23	32	12	34	31	12	15	20	6
	22.9-27.9	14	13	5	9	9	5	5	11	6
	Sum	121	147	155+	167	145	146+	100	92	93+
Available Potassium (kg/ha)‡	0-2.5	30	33	74	38	31	100	23	19	70
	2.5-5.1	38	46	68	42	40	94	36	28	57
	5.1-7.6	46	52	62	46	60	69	34	32	58
	7.6-12.7	84	102	110	110	104	115	101	68	63
	12.7-17.8	88	104	90	117	117	102	89	79	61
	17.8-22.9	90	102	102	115	119	94	76	76	51
	22.9-27.9	115	109	104	121	128	97	89	85	74
	Sum	491	548	610	589	599	671	454	387	434
Organic Matter (T/ha)‡	0-2.5	4.5	4.0	8.6	4.1	3.3	9.0	4.5	4.3	10.4
	2.5-5.1	5.3	5.5	7.7	4.8	4.6	7.4	5.9	6.0	8.3
	5.1-7.6	5.4	5.3	7.0	4.9	5.5	6.7	6.1	5.5	6.5
	7.6-12.7	11.6	11.3	12.9	11.4	11.4	12.7	14.2	16.7	12.4
	12.7-17.8	13.7	13.8	12.4	11.8	12.1	11.9	13.1	16.4	13.0
	17.8-22.9	11.7	13.3	8.8	9.7	10.8	10.7	11.2	14.1	9.5
	22.9-27.9	8.6	9.3	6.9	7.8	7.3	5.8	7.0	11.7	5.3
	Sum	60.7	62.5	64.3	54.5	55.0	64.2	60.0	74.7	65.4
Cation Exchange Capacity (keq/ha)‡	0-2.5	34	33	41	37	29	38	27	30	34
	2.5-5.1	39	42	50	41	45	49	39	41	43
	5.1-7.6	44	46	59	48	60	47	38	44	47
	7.6-12.7	92	107	118	87	101	96	85	93	91
	12.7-17.8	103	111	112	78	110	103	75	97	90
	17.8-22.9	104	110	123	99	113	113	92	109	88
	22.9-27.9	161	163	147	150	168	150	128	113	125
	Sum	577	612	650	540	626	596	484	527	518
Atrazine (g/ha)‡	0-2.5	156	166	113	94	142	38	78	119	74
	2.5-5.1	64	58	19	54	84	0	52	55	9
	5.1-7.6	24	23	15	20	19	0	13	23	15
	7.6-12.7	36	20	10	0	28	8	0	57	45
	12.7-17.8	31	19	115	57	0	0	0	9	27
	17.8-22.9	5	10	37	18	42	0	0	9	15
	22.9-27.9	0	74	0	5	0	15	18	0	81
	Sum	316	370	309	248	315	61	161	272	266
Bulk Density (g/cm^3)	0-2.5	0.99	0.92	1.06	1.04	0.88	1.10	0.93	0.86	0.98
	2.5-5.1	1.20	1.18	1.24	1.22	1.16	1.40	1.24	1.17	1.29
	5.1-7.6	1.32	1.28	1.51	1.34	1.43	1.48	1.31	1.27	1.36
	7.6-12.7	1.32	1.28	1.49	1.44	1.39	1.54	1.38	1.30	1.46
	12.7-17.8	1.39	1.43	1.50	1.40	1.45	1.52	1.35	1.34	1.47
	17.8-22.9	1.42	1.44	1.56	1.48	1.45	1.54	1.47	1.39	1.49
	22.9-27.9	1.51	1.55	1.53	1.54	1.56	1.49	1.49	1.49	1.58
CMWD Aggregates (Max = 483 Min = 0)	0-2.5	455	464	442	472	444	452	346	427	382
	2.5-5.1	463	464	455	454	461	454	418	424	421
	5.1-7.6	455	466	461	462	460	447	421	427	438
	7.6-12.7	458	465	457	467	464	444	383	426	436
	12.7-17.8	462	466	453	463	468	442	406	434	430
	17.8-22.9	455	461	449	457	457	447	426	442	446
	22.9-27.9	412	403	430	408	391	417	405	437	436

*Mean of only two replicates, since one replicate was plowed by mistake in 1967.

†Actual value is greater than that given, since the concentration of P exceeded the capacity of the measuring technique.

‡Values for each depth increment were computed from measured concentration (units of material/g of soil) multiplied by the weight of soil per hectare within that depth increment (g/ha). Weight of soil per depth increment per ha was calculated using bulk density values reported in this table.

TABLE V.—Force Required for Penetration in Plots on Oct. 29, 1971. Mean Values per Depth per Treatment.

Crop	Depth	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
		CT	MT	NT	CT	MT	NT	CT	MT	NT
	(cm)				kg					
Corn	0-7.5	73	78	147	54	67	122	64	83	100
	7.5-15	86	84	172	64	75	150	72	92	120
	15-22.5	121	115	188	97	112	148	107	159	137
Soybeans	0-7.5				60	66	80	84	70	132†
or Oats	7.5-15				67	68	109	92	76	152†
	15-22.5				82	93	113	132	112	195†
Hay	0-7.5							113	102	127
	7.5-15							135	107	154
	15-22.5							133	148	174

$LSD_{.05}$ Depth - Rotation - Tillage Interaction = 20.6

*Average of two replicates because one replicate was plowed by mistake in 1967.
†Plowed by mistake in 1970.

TABLE VI.—Nutrient Composition of Corn Ear Leaves Sampled at 50% Silking and Expressed as Percent of Dry Tissue.

Nutrient	Year	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
			CT	MT	NT	CT	MT	NT	CT	MT	NT
						Percent					
N**	1968	1	3.15	2.95	3.35	2.90	3.20	3.10	3.00	3.35	3.15
		2	3.05	3.05	2.60	2.95	2.80	3.25	2.75	2.90	3.00
		3	3.10	3.05	2.50	3.00	3.05	2.90*	2.30	3.15	2.85
	1970	1	2.90	3.25	3.20	2.75	3.20	3.30	2.70	2.95	2.95†
		2	2.95	2.95	3.15	2.20	2.75	3.25	3.10	3.10	2.95†
		3	2.95	3.10	3.35	2.95	2.75	3.10*	2.80	2.90	3.35†
	1971	1	2.80	2.95	3.10	‡	2.85	3.01	2.90	3.00	3.15
		2	2.83	2.62	3.00	3.10	‡	2.82	2.68	2.85	2.95
		3	2.80	2.93	2.85	2.51	2.95	2.76*	2.73	2.70	2.47
P††	1968	1	0.43	0.36	0.43	0.38	0.31	0.33	0.34	0.38	0.42
		2	0.29	0.35	0.30	0.29	0.36	0.35	0.31	0.31	0.37
		3	0.29	0.34	0.39	0.33	0.28	0.34*	0.27	0.31	0.30
	1970	1	0.28	0.30	0.25	0.27	0.24	0.34	0.27	0.31	0.39†
		2	0.25	0.26	0.33	0.47	0.28	0.28	0.30	0.28	0.25†
		3	0.31	0.30	0.31	0.33	0.27	0.32*	0.27	0.28	0.26†
	1971	1	0.29	0.36	0.38	‡	0.33	0.34	0.35	0.33	0.33
		2	0.32	0.32	0.34	0.36	‡	0.33	0.34	0.35	0.34
		3	0.31	0.32	0.38	0.30	0.34	0.34*	0.34	0.32	0.36
K‡‡	1968	1	1.46	1.85	1.63	1.47	1.72	1.95	1.65	1.55	1.57
		2	1.63	1.38	1.68	1.58	1.59	1.42	1.81	1.52	1.66
		3	1.63	1.31	1.55	1.62	2.03	1.33*	1.74	2.07	1.82
	1970	1	1.15	1.75	1.43	1.44	1.40	1.35	1.45	1.67	1.72†
		2	1.45	1.38	1.59	1.64	1.48	1.58	1.58	1.65	1.77†
		3	1.37	1.41	1.72	1.44	1.28	1.66*	1.55	1.55	1.72†
	1971	1	1.56	1.75	2.03	‡	1.84	1.94	1.72	1.88	1.85
		2	1.97	1.93	1.97	1.69	‡	1.94	1.59	1.87	1.89
		3	1.66	1.86	2.13	1.73	1.85	1.72*	1.57	2.06	2.19

*No til plots plowed by mistake in 1967.
†No til plots plowed by mistake in 1970.
‡Missing data.
**<2.45 is considered deficient; 2.46-2.75 is low; 2.76-3.50 is sufficient N for optimum yield (6).
††<0.15 is considered deficient; 0.16-0.24 is low; 0.25-0.40 is sufficient; 0.41-0.50 is high for optimum yield (6).
‡‡<1.25 is considered deficient; 1.26-1.70 is low; 1.71-2.50 is sufficient K for optimum yield (6).

TABLE VII.—Soil Chemical Composition, Obtained May 17, 1967, from 0-20 cm Depth.

Measurement	1967 Crop	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
			CT	MT	NT	CT	MT	NT	CT	MT	NT
pH	Corn	1	6.0	5.4	5.8	6.4	5.0	6.2	6.4	5.8	5.8
		2	5.8	5.8	6.5	6.0	6.1	6.0	6.4	6.1	5.8
		3	6.4	6.6	5.2	6.8	6.9	5.5	6.4	5.9	5.4
	Soybeans or Oats	1				6.6	5.2	5.7	5.7	6.1	6.1
		2				5.9	6.0	6.3	6.6	6.4	6.0
		3				6.5	7.0	6.1	7.0	5.8	5.9
	Hay	1							6.7	5.6	5.9
		2							6.7	6.2	5.9
		3							5.7	6.4	7.0
Phosphorus (kg/ha available)	Corn	1	56	84	41	80	56	71	41	56	80
		2	70	89	59	82	49	56	57	92	52
		3	90	115	57	70	87	89	76	117	68
	Soybeans or Oats	1				112	77	95	71	66	56
						87	61	80	85	68	80
						78	72	99	102	76	141
	Hay	1							81	50	31
		2							66	64	67
		3							81	63	37
Potassium (kg/ha available)	Corn	1	161	135	135	128	168	135	128	135	128
		2	135	135	182	135	135	128	128	128	128
		3	188	215	148	165	200	188	155	182	168
	Soybeans or Oats	1				128	121	135	161	165	128
		2				148	135	135	175	165	161
		3				161	200	165	168	195	165
	Hay	1							121	128	128
		2							135	175	148
		3							161	188	128

TABLE VIII.—Corn Stand Before Thinning, 1962-1971.*

Year	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
		CT	MT	NT	CT	MT	NT	CT	MT	NT
		Thousands/ha								
1962	No Data									
1963	1	57.7	53.3	32.3	54.3	52.7	36.6	56.0	53.3	33.9
	2	57.6	56.5	41.4	54.9	55.4	32.8	54.9	54.3	43.0
	3	57.0	55.4	32.8	55.4	58.1	40.9	58.1	51.1	39.3
1964	No Data									
1965	1	36.6	45.7	36.1	44.1	40.9	35.5	44.1	39.3	35.0
	2	47.3	39.3	38.7	49.5	43.6	30.1	44.1	43.6	36.6
	3	46.8	39.3	39.3	45.2	46.8	31.2	45.7	39.3	37.7
1966	1	47.9	24.2	19.3	50.7	19.3	23.7	49.9	37.1	27.9
	2	43.5	24.7	24.7	33.4	17.8	18.8	30.1	31.6	33.4
	3	23.2	29.2	40.3	34.8	36.1	17.8	33.4	37.1	30.1
1967	1	47.4	30.1	12.8	36.1	31.1	20.0	51.6	29.2	34.6
	2	37.1	23.7	19.3	42.0	23.7	17.3	50.7	38.8	20.0
	3	48.4	39.3	34.3	43.5	40.8	†	36.6	48.4	26.9
1968	1	46.0	57.9	62.7	64.8	66.2	59.3	52.4	47.9	60.0
	2	62.7	57.3	57.3	57.2	60.0	54.6	57.3	61.4	62.1
	3	60.3	57.9	49.4	56.5	66.9	†	58.6	58.8	56.5
1969	1	61.0	40.9	30.8	53.1	45.9	34.4	45.2	45.9	45.2
	2	48.1	50.2	35.9	52.4	44.5	50.2	42.3	45.2	34.4
	3	56.7	52.4	33.0	54.5	47.3	†	48.8	43.8	35.1
1970	1	74.6	52.4	28.7	57.4	58.8	53.1	64.6	54.5	‡
	2	65.3	61.0	55.2	68.1	54.0	55.9	53.1	58.1	‡
	3	58.8	55.2	44.5	63.1	66.0	†	66.0	66.7	‡
1971	1	34.7	34.1	44.1	26.9	32.2	41.7	34.4	32.2	36.1
	2	34.7	29.3	37.1	31.7	35.2	41.9	36.6	32.8	30.7
	3	36.8	35.0	35.5	38.0	37.4	†	39.3	34.7	26.9

*Initial stand count before thinning. Includes non-harvest border rows which may give stand lower than the final "thinned" stand, which includes only harvest rows.

†NT plots plowed by mistake in 1967.

‡NT plots plowed by mistake in 1970.

TABLE IX.—Soybean and Oat Grain Yields Corrected to 13.5% Moisture, 1962-1971.

Year	Replicate	Soybeans			Oats		
		CT	MT	NT	CT	MT	NT
				kg/ha			
1962	1	2280	1350*	2090	3060	2900	2900
	2	2480	1210*	1440*	2850	2600	2740
	3	1660	1160*	1630*	2710	2820	2580
1963	1	2250	2040	2370	4320	3720	2890
	2	2840	3650	2680	3220	3500	3260
	3	2630	2840	2440	3440	3700	3300
1964	1	1330*	1370	440*†	2720	3300	3570
	2	1580	980	1120†	2910	3570	3360
	3	1560	860*	790†	3360	3830	3830
1965	1	1860	2240	1330†	900	1360	700
	2	2040	2000	780†	840	920	590
	3	2180	2110	1260	130	590	640
1966	1	2060	1310	1820	2750	††	1830
	2	1800	1510	930	2440	2640	2950
	3	1590	1660	560*	3260	2540	1520
1967	1	1940	1080	580	3260	3260	2950
	2	1710	1450	630	2850	2950	3360
	3	2170	1290	610‡	3060	2850	3150
1968	1	2540	2580	1610†	2130	3370	2800†
	2	2700	2110	1960†	4420	4450	2380†
	3	3000	2920	1430‡	4220	2590	1770†
1969	1	3260	1410*	*†	3160	‡‡	‡‡
	2	1800*	2230	*†	3260	‡‡	‡‡
	3	2050	2850	‡	2790	2130	2600
1970	1	**	2030	**	3660	2440	1630†
	2	2270	**	**	3150	3150	1420†
	3	2830	1430	1470	2950	1630	1630†
1971	1	2470	3170	2320	3120	2590	1640***
	2	2870	2390	2110	2800	2190	1660***
	3	2630	2530	2010‡	1310	3020	1760***

*Low stand judged before harvest to significantly reduce yield.
†Weed competition judged before harvest to significantly reduce yield.
‡NT plots plowed by mistake in 1967.
**No soybean stand due to wrong herbicide.
††Data lost.
‡‡No oat seed planted in more than half of each plot.
***NT plots plowed by mistake in 1970.

TABLE X.—Soil Moisture Content in Percent Dry Weight Basis Sampled on Oct. 29, 1971. Mean Values per Depth per Treatment.

Crop	Depth	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
		CT	MT	NT	CT	MT	NT	CT	MT	NT
	(cm)					Percent				
Corn	0-15	21.8	20.7	20.8	22.6	21.3	21.5	21.3	21.0	21.9
	15-30	20.5	20.2	20.4	21.5	20.7	20.7	22.6	17.5	20.3
Soybeans or Oats	0-15				19.4	21.2	25.1	21.9	22.2	19.5†
	15-30				22.6	22.6	20.3	22.3	20.9	17.4†
Hay	0-15							20.6	21.0	24.2
	15-30							21.2	20.0	18.4

*Average of only two replicates because one replicate was plowed by mistake in 1967.
†Plowed by mistake in 1970.

TABLE XI.—Corn Grain Yield Corrected to 15.5% Moisture, 1962-1971.

Year	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
		CT	MT	NT	CT	MT	NT	CT	MT	NT
						kg/ha				
1962	1	8790	8480	8480	9920	8600	8040	9790	9100	8350
	2	8660	9290	8350	8540	9100	8730	8040	10170	8660
	3	8290	8410	8600	9350	8480	8220	9100	8790	7970
1963	1	6650*	6530*	5520†	6970*	8040*	6030†	9170*	8480*	7350†
	2	6650	6530	7090	7280	6530	5020	7280	7160	8270
	3	6720	7160	5780†	7350	7160	6780	7660	7970	7280
1964	1	5210	5900	5020	5150	6470	6650	5400*	7280	4830‡
	2	4710	5960	5900*	5520	4210†	5650	5520	5710	5590
	3	4580	5210	6220	5900	4390	4520	5840	4520	7970
1965	1	6720	7720	6780	8220	7720	5780	7850	8040	7970
	2	7220	7720	5840‡	7970	7780	5840*	8100	8600*	6970
	3	7280	7410	7720	7600	7720	5840	7910	8350	7410
1966	1	6530*	4080†	4330†	6910*	3580†	3770†	8040*	6150	5520†
	2	6840	4580†	4650	5210	3520†	3330†	3520†	6530	5900
	3	3520	4900†	5270	4650	6400	2830†	5710	6780	5840†
1967	1	7090*	5590	1820†	5840	5460	1880†	7910*	6340	5150
	2	6720	5340†	3140†	6840*	4900†	1440†	7780*	5650	2260†
	3	6340*	6650	5150	6280*	6150	**	6910	7470*	3390†
1968	1	8220	8910	9230	9790	9290	8790	8910	9730	11170
	2	8660	8850	9100	9100	9540	8660	9610	9670	10670
	3	9040	9350	9350	10360	10300	**	9790	9350	9170
1969	1	10040*	8850	7470	9040	11170	8100	9920	9170	10110†
	2	8220	10170	8790	10740*	9480*	10860	10300	9290	9730†
	3	9480*	9290	8480‡	9610	9540	**	10360*	11300	12300
1970	1	9770*	7700†	3110†	9690	10040	8050†	10790	9130	††
	2	10360	8190†	4160†	10310*	10050	8640†	9540	8930	††
	3	8510	8930	6410†	11460*	8660*	**	10560	10660	††
1971	1	7660	‡‡	8040	‡‡	6840†	8350	8220	‡‡	††
	2	7030	‡‡	7160	7720	6780	6590	8220	8790	‡‡
	3	7720	7160†	8410	8600	8220	‡‡	9230	7970	‡‡

*Stand for these plots caused treatment average to exceed overall average stand for the year by at least 1,800 plants/ha.
†Stand for these plots caused treatment average to be less than overall average stand for the year by at least 1,800 plants/ha.
‡Weed competition was believed to reduce corn yield (estimated before harvest).
**NT plots were plowed by mistake in 1967.
††NT plots were plowed by mistake in 1970.
‡‡Missing data.

TABLE XII.—Corn Stand After Thinning, 1962-1971.

Year	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
		CT	MT	NT	CT	MT	NT	CT	MT	NT
		Thousands/ha								
1962	1	44.2	44.7	44.2	44.2	44.7	44.7	44.7	44.7	44.7
	2	42.0	42.0	42.0	42.0	42.0	41.5	42.0	42.0	41.5
	3	40.8	41.5	40.8	41.5	41.5	41.5	41.5	41.5	40.8
1963	1	50.7*	48.9*	33.9†	50.7*	50.7*	49.4*	49.4*	49.4*	35.6†
	2	41.5	41.5	40.8	41.5	41.5	41.5	40.3	41.5	40.3
	3	38.8	38.9	32.9†	39.8	39.4	39.3	39.3	39.3	39.3
1964	1	39.8	43.0	44.7	44.2	41.5	44.7	49.9*	44.7	43.0
	2	45.2	43.0	47.9*	45.2	34.3†	47.4	44.2	47.4	38.8
	3	44.2	44.2	44.7	45.2	41.5	39.8	45.7	39.8	43.5
1965	1	37.6	37.1	36.1	37.6	38.3	40.3	36.6	40.3	37.6
	2	35.6	37.1	37.6	36.6	37.1	42.5*	40.8	42.5*	34.8
	3	34.8	38.3	38.3	36.6	37.1	37.6	35.6	37.6	36.1
1966	1	47.9*	24.2†	19.3†	50.7*	19.3†	23.7†	49.9*	37.1	27.9†
	2	43.5	24.7†	24.7	33.4	17.8†	18.8†	30.1†	31.6	33.4
	3	23.2	29.2†	40.3	34.8	36.1	17.8†	33.4	37.1	30.1†
1967	1	47.4*	30.1	12.8†	36.1	31.1	20.0†	51.6*	29.2	34.6
	2	37.1	23.7†	19.3†	42.0*	23.7†	17.3†	50.7*	38.8	20.0†
	3	48.4*	39.3	34.3	43.5*	40.8	**	36.6	48.4*	26.9†
1968	1	46.0	54.6	53.9	55.8	56.1	57.3	52.4	47.9	55.8
	2	56.6	57.3	57.3	55.8	53.9	54.6	57.3	60.3	56.6
	3	60.3	55.8	49.4	56.5	58.1	**	58.6	58.8	53.1
1969	1	52.4*	35.8	49.5	46.0	45.2	35.9	45.2	44.5	38.8†
	2	44.5	48.2	40.9	48.2*	43.7	50.9	45.9	41.5	38.8†
	3	48.2*	48.2	37.3	46.0	41.5	**	53.1*	46.6	44.5
1970	1	55.9*	38.7†	8.6†	50.2	53.1	40.2†	54.0	43.0	††
	2	51.6	43.0†	19.4†	56.7*	48.1	43.0†	43.0	41.6	††
	3	50.2	50.9	23.7†	57.4*	63.8*	**	61.0	63.0	††
1971	1	34.4	‡	32.8	‡	28.0†	32.8	32.2	‡	33.4
	2	32.7	‡	32.2	32.8	32.8	32.8	35.5	35.5	‡
	3	31.7	31.2†	34.4	35.0	30.7	**	35.5	33.9	‡

*Stand for these plots caused treatment average to exceed overall average stand for the year by at least 1,800 plants/ha.
†Stand for these plots caused treatment average to be less than the overall average stand for the year by at least 1,800 plants/ha.
‡Missing data.
**NT plots were plowed by mistake in 1967.
††NT plots were plowed by mistake in 1970.

TABLE XIII.—Corn Grain Yield for 1972 Corrected to 15.5 Percent Moisture Reported for Previous Cropping and Tillage History.

1972 Tillage	1971 Crop	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
			CT	MT	NT	CT	MT	NT	CT	MT	NT
							kg/ha				
Plow	Corn	1	10680	10600	11000	11360	10050	10540	9790	11530	10550
		2	11450	11200	10160	11130	10500	9520	10820	11680	10040
		3	9350	9660	11550	9670	9860	11190*	10880	11830	11550
		Mean	10490	10490	10900	10720	10140	10030	10500	11680	10710
	Soybeans or Oats	1				10620	9950	11170	10820	10720	12120†
		2				10910	10410	9750	9960	10300	10200†
		3				10300	9350	9050*	10260	11250	10730†
		Mean				10610	9900	10460	10350	10760	11020†
	Hay	1							11170	10790	10540
		2							10870	11680	8650
		3							9940	10930	11150
		Mean							10660	11130	10110
No Til	Corn	1	8920	11010	10860	6630	11430	6990	8450	8390	2390
		2	10040	10110	7430	9640	9150	3570	8680	7880	1670
		3	9790	10090	7310	10980	10700	5630*	11330	10350	4200
		Mean	9580	10400	8530	9080	10430	5280	9490	8870	2750
	Soybeans or Oats	1				7910	7610	9660	8090	6480	7980†
		2				6390	9700	9500	9430	8820	8930†
		3				9440	9390	7850*	8230	9310	7430†
		Mean				7910	8900	9580	8580	8200	8110†
	Hay	1							9210	10420	11410
		2							13150	10240	8530
		3							7620	9750	11400
		Mean							9990	10140	10450

*Plowed by mistake in 1967.

†Plowed by mistake in 1970.

TABLE XIV.—Corn Stand After Thinning for 1972 Reported for Previous Cropping and Tillage History.

1972 Tillage	1971 Crop	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
			CT	MT	NT	CT	MT	NT	CT	MT	NT
							Thousands/ha				
Plow	Corn	1	51.6	53.1	51.6	51.6	45.9	47.3	44.5	51.6	53.1
		2	51.6	51.6	48.8	51.6	50.2	45.9	48.8	51.6	53.1
		3	50.2	47.3	53.1	48.8	47.3	50.2*	50.2	51.6	48.8
		Mean	51.1	50.7	51.2	50.7	47.8	46.6	47.8	51.6	51.7
	Soybeans or Oats	1				50.2	48.8	57.4	48.8	54.5	53.1†
		2				50.2	48.8	50.2	44.5	45.9	50.2†
		3				47.3	48.8	40.2*	50.2	47.3	47.3†
		Mean				49.2	48.8	53.8	47.8	49.2	50.2
	Hay	1							53.1	50.2	50.2
		2							51.6	51.6	40.2
		3							47.3	48.8	47.3
		Mean							50.7	50.2	45.9
No Til	Corn	1	45.9	51.6	53.6	34.4	53.1	31.6	44.5	37.3	8.6
		2	50.2	47.3	37.3	47.3	47.3	18.6	41.6	33.0	7.2
		3	48.8	50.2	33.0	54.5	47.3	27.3*	54.5	47.3	21.5
		Mean	48.3	49.7	41.1	45.4	49.2	25.1	46.9	39.2	12.4
	Soybeans or Oats	1				37.3	38.7	44.5	34.4	31.6	40.2†
		2				34.4	57.4	43.0	40.2	40.2	43.0†
		3				48.8	47.3	35.9*	41.6	47.3	33.0†
		Mean				40.2	47.8	43.8	38.7	39.7	38.7
	Hay	1							44.5	54.5	51.6
		2							61.7	48.8	37.3
		3							34.4	45.9	55.9
		Mean							46.9	49.7	48.3

*Plowed by mistake in 1967.

†Plowed by mistake in 1970.

TABLE XV.—Nutrient Composition of Corn Ear Leaves Sampled at 50% Silking from the Half of Each Plot Plowed in 1972 Expressed as Percent of Dry Tissue and Reported for Previous Cropping and Tillage History.

Nutrient	1971 Crop	Replicate	Continuous Corn			Corn-Soybean Rotation			Corn-Oats-Hay Rotation		
			CT	MT	NT	CT	MT	NT	CT	MT	NT
						Percent					
N	Corn	1	2.70	3.00	3.00	3.15	3.25	2.90	3.05	3.05	2.90
		2	3.45	2.75	3.35	3.35	3.10	3.30	3.05	3.05	3.15
		3	3.15	3.25	3.30	3.55	3.05	3.05*	3.25	2.90	3.30
		Mean	3.10	3.00	3.22	3.35	3.13	3.10	3.12	3.00	3.12
	Soybeans or Oats	1				2.95	3.25	3.00	2.95	2.95	3.35†
		2				3.05	3.35	3.20	3.00	3.15	2.90†
		3				3.00	3.25	2.85*	3.35	3.10	2.90†
		Mean				3.00	3.28	3.10	3.10	3.07	3.05†
	Hay	1							3.05	2.95	3.10
		2							3.20	3.25	2.95
		3							2.80	2.95	3.05
		Mean							3.02	3.05	3.03
P	Corn	1	0.34	0.35	0.40	0.37	0.37	0.36	0.41	0.34	0.33
		2	0.37	0.36	0.32	0.34	0.37	0.38	0.34	0.38	0.34
		3	0.36	0.37	0.36	0.33	0.36	0.36*	0.37	0.35	0.33
		Mean	0.36	0.36	0.36	0.34	0.37	0.37	0.37	0.36	0.33
	Soybeans or Oats	1				0.46	0.34	0.45	0.37	0.33	0.36†
		2				0.38	0.37	0.32	0.49	0.33	0.36†
		3				0.34	0.69	0.35*	0.42	0.34	0.39†
		Mean				0.39	0.47	0.38	0.43	0.33	0.37†
	Hay	1							0.32	0.34	0.35
		2							0.37	0.36	0.44
		3							0.35	0.34	0.45
		Mean							0.35	0.35	0.41
K	Corn	1	2.00	2.01	2.04	2.30	2.21	1.93	1.76	2.07	2.07
		2	2.00	1.84	2.10	2.03	2.12	2.16	2.53	2.01	2.27
		3	2.18	1.65	2.04	2.00	2.21	2.11*	2.02	1.70	1.80
		Mean	2.06	1.83	2.06	2.11	2.18	2.04	2.10	1.93	2.05
	Soybeans or Oats	1				2.02	2.01	1.99	1.87	1.92	1.74†
		2				1.95	1.56	2.31	1.84	2.19	2.32†
		3				1.83	1.43	2.07*	2.21	2.33	2.07†
		Mean				1.93	1.67	2.15	1.97	2.15	2.04†
	Hay	1							1.69	1.91	2.14
		2							1.99	1.98	2.08
		3							2.13	2.32	2.10
		Mean							1.94	2.07	2.11

*Plowed by mistake in 1967.
†Plowed by mistake in 1970.

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Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Agricultural Research Service, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres