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Corn and Soybean Production Potential of Selected Tillage Practices on a Typic Argiaquoll (Brookston) Soil

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INTRODUCTION

This study was begun in 1967 at the Western Branch of the Ohio Agricultural Research and Development Center as part of a continuing effort to determine the relative crop production potential of a wide range of tillage practice-soil property combinations. No single tillage practice will always be the best choice for crop production for all soils (12). However, an evaluation can be made of the most effective tillage methods for the major soil groups in Ohio. This approach can provide the basis for more accurate tillage recommendations for individual farm fields. To be most efficient, this type of research must be conducted in a manner that current shortcomings in technology do not override the results, requiring repetition of the experiments as limiting technology improves.

MATERIALS AND METHODS

Site Characteristics

Experiments reported in this paper were conducted on a Brookston silty clay loam soil.

Soil and Drainage: Quoting from the National Cooperative Soil Survey Report IN0002 (7): "The Brookston series is a member of the fine-loamy, mixed, mesic family of Typic Argiaquolls. Brookston soils typically have very dark gray silty clay loam A horizons about 14 inches (36 cm) thick, gray mottled clay loam II B2 horizons, and brown loam C horizons. They occur on nearly level to slightly depressed areas on till plans and moraines with less than 2% slope. They are formed in loamy glacial drift of Wisconsin age. These soils are very poorly drained. Surface runoff is very slow or ponded; permeability is moderate. Most areas are artificially drained by tile and open ditches." Selected properties of the soil are listed in Appendix Table I.

Tile laterals 10 cm in diameter were installed in 1960 at 12.2 meter lateral spacing about 1 meter deep. Tile line direction was perpendicular to the crop rows.

Crop and Tillage History: The site used for this experiment had been cropped to corn for at least 4 years prior to the initiation of the experiment in 1967. Tillage generally consisted of early spring or late fall plowing with a moldboard plow to a 20 cm depth, followed by one or more passes with a double disk to a 10 cm 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.

Experimental Design (1967 through 1974)

Five of the six tillage treatments were initiated in the spring of 1967. Timing details are listed in Appendix Table III. Treatments were:

1. *Fall plow (FP):* Consisted of plowing to approximately a 20 cm depth with a moldboard plow in November or December preceding planting, plus one pass over the plot with either a spring-tooth harrow or a disk set for approximately 10 cm depth within 1 week of planting.
2. *Spring plow (SP):* Essentially the same treatment as FP except plowing occurred in April or later.
3. *Field cultivator (FC):* Consisted of non-inversion tillage one time per year to a depth of 10 cm with 10 cm wide shovels on curved shanks. Timing varied from December to May. This treatment was initiated in 1968.
4. *Rotary tillage (RT):* Consisted of one pass over the plot with a 1.5 meter wide rotary tiller operating at 600 rpm with a ground speed of 6.4 km/hr at about 13 cm depth, usually in March or April.
5. *Disk only (D):* Consisted of one pass over the plot with a tandem double disk set for approximately 10 cm depth, usually the same day as planting.
6. *No-tillage (NT):* Consisted of no tillage except a band 3 to 5 cm wide performed in and near the row by the fluted coulters and double disk openers of the planter and row fertilizer units.

General Management (For additional details, see Appendix Table III):

1. *Crop:* Corn *(Zea mays* L.) was the test crop from 1967 through 1970, and soybeans [*Glycine max* (L.) Merr.] from 1971 through 1974. A given plot had the same tillage practice all 8 years.
2. *Plot dimensions:* Each plot was 27.5 m long by 4.25 m wide and contained six rows, 76 cm apart. The outside rows of adjacent plots were only 45 cm apart.
3. *Fertilizer:* Most of the nitrogen (NH_4NO_3) was broadcast prior to spring tillage. Some of the P and K material was broadcast after spring plowing but before any other spring tillage. The remaining fertilizer was applied with the planter 5 cm to one side of

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the row and 5 to 10 cm deep. Fertilizer amounts varied from year to year, but all plots within a given year received the same amount.

In the fourth year of the corn portion of the experiment (1970), half of each plot received 224 kg/ha of N and the other half received 336 kg/ha of N.

4. *Planting:* Within a given year, all plots were planted with the same crop variety and the same no-tillage planter having coulters with 5 cm flutes ahead of double disk planter and fertilizer units. Depth of planting was not the same for each tillage treatment. Using a common depth setting, the plowed plots were planted deeper (3 to 5 cm) than the shallow tilled or no-tillage plots (1.5 to 3 cm). Soybean cultivars and corn hybrids were changed from time to time as better genetic material became available.

5. *Weed control:* No post-planting tillage was used for weed control at any time during the experiment. Herbicides were broadcast sprayed the same day as or shortly after planting, with follow-up applications of herbicides as needed to provide satisfactory season-long weed control. All plots received the same materials and rates within a given year. Materials and rates were changed from year to year as new materials became available or as dominant weed species changed.

6. *Insect control:* Insecticides were band applied over the row at planting time (corn) or the seed was treated (soybeans) as listed in Appendix Table III.

7. *Thinning:* Corn plots were thinned to equal stand each year before plants reached 1 m in height. Soybean plots were not thinned.

8. *Plant samples:* In 1969 and 1970, ear leaves of corn were collected between tasseling and silking. Tissue was dried, ground, and analyzed by the Ohio State Plant Analysis Lab for N, P, K and other plant nutrients.

9. *Harvest:* The center 24 m of the center four rows of each plot were harvested for grain yield. All plots within a given year were harvested on the same date. One grain moisture sample was collected per plot. Grain yields were calculated on the basis of 15.5% moisture for corn and 13.5% moisture for soybeans.

Experimental Design (1975)

Half of all 18 plots from the 1967-1974 experiment were plowed and treated as SP treatment. The other half of all plots were treated as NT. Corn was planted on both halves on the same day with the same no-tillage planter used in previous years, same row spacing, planting rate, and variety. Fertilizer and pesticide applications were the same for all plots (Appendix Table III). All SP plots were thinned to approximately 64,000 plants/ha, and all NT plots were thinned to approximately 48,000 plants/ha before plants were 1 m tall. Harvesting was similar to that described previously for each half of each plot (12 m long x two rows wide harvest area per half plot).

RESULTS AND DISCUSSION

1967-1974 Experiment

Relative yields of corn and soybeans are summarized in Table 1. The data are derived from Appendix Table IV for those plots having sufficiently good weed control that weeds were judged not to have reduced corn yields. During the first 2 years, a judgment was required. There was excellent weed control on all plots the remaining 6 years. Corn stands were almost identical for all plots within a given year due to thinning. Stands averaged 47,800, 57,600, 55,900, and 57,500 plants/ha for the 4 consecutive years in corn. Soybean stands were not determined, but all plots in all years visually appeared to have satisfactory stands with few, if any, gaps exceeding 25 to 30 cm.

Yields in Table 1 are expressed as the 4-year average of a given treatment divided by the 4-year average of the highest yielding treatment (SP). This permits easy comparison of the relative order of magnitude of treatment effect on yields within and between the two crops. Average yields differed from year to year, but the treatment-year interactions were

TABLE I.—Relative Corn (1967-1970) and Soybean (1971-1974) Yields as a Function of Tillage. Mean 4-Year Actual Yields Derived from Appendix Table IV for Soybeans and Least Square Analysis for Corn (Good Weed Control Only) for All Treatments Have Been Divided by the Mean 4-Year Actual Value of the SP Treatment.

Crop	Fall Plow	Spring Plow*	Field Cultivate	Rototil	Disc	No Tillage	Probability Level for F Test Significance
Corn means†	0.986	1.000	0.896	0.912	0.914	0.889	0.002
	0.993				0.903		
Soybean means†	0.992	1.000	0.960	0.963	0.983	0.907	0.011
			0.980			0.907	

*4-year mean corn yield=8770 kg/ha; 4-year mean soybean yield=3530 kg/ha.

†Tillage treatment means as listed account for 88% of tillage treatment sum of squares for corn and 79% of tillage treatment sum of squares for soybeans.

not significant for either crop. In other words, the treatment effects on yields shown in Table 1 were approximately the same for all years of the study.

Tillage treatment effects on corn yields differed from treatment effects on soybean yields. Moldboard plowing in the fall or spring (up to late April) followed by disking or equivalent prior to planting produced 9% greater corn yields than the average of all other tillage treatments. No-tillage produced 7% lower soybean yields than the average of all other treatments. No-tillage reduced yields to about the same relative degree for both crops compared with moldboard plowing plus overall seedbed preparation. The intermediate tillage treatments had equal corn yields compared with no-tillage and had equal soybean yields compared with moldboard plowing.

It is not possible to satisfactorily explain why observed yield differences did occur. Weed control and plant stand were not causes for the yield differences. The relationship between corn yields produced by continued use of no-tillage vs. continued use of fall moldboard plowing in the first 4 years of continuous corn is the same as previously found for another poorly drained soil in Ohio [Hoytville silty clay loam, a Mollic Ochraqualf soil (12)]. The explanation given for the reduced corn yields with no-tillage in that experiment was that a concentration of roots occurred in cracks which formed in the same place each year. A subsequent buildup of the numbers of pathogen (*Pythium graminicola* sp.) occurred, and increased root damage and decreased corn yields resulted with continuation of this practice (11). Brookston soil forms cracks on drying, although to a lesser extent than the Hoytville soil. This explanation could be the cause of reduced corn yields with no-tillage, but is not likely the explanation for reduced corn yields with field cultivating, rototillage, or disking. These latter three practices should mix old roots throughout the upper part of the horizon, reduce any concentration of roots and pathogen, and therefore decrease root damage.

The treatment effect on corn yield was apparently not associated with differences in uptake of plant nutrients. Data in Appendix Table V indicate that corn ear leaves from all but two plots in 1969 and 1970 had sufficient concentrations of N, P, and K for satisfactory crop growth. No other nutrient was low (data not presented for Ca, Mg, Mn, Bo, Cu, and Zn) on any plot for either year. An additional 112 kg/ha of N fertilizer applied in the fourth year (1970) had no significant influence on corn yields for any tillage treatment or for the average of all treatments. Evidently the different distribution of plant nutrients inevitably associated with different depths of tillage (9) was not the cause for the observed corn yield differences.

The results with 4 years of continuous corn are similar to those of Griffith, *et al.* (4). With equal stand and good weed control on one Typic Argiaquoll soil (Runneymede loam), relative yields were 1.00, 0.94, and 0.87 for SP, RT, and NT, respectively. The RT treatment differed from the authors' in that rototillage occurred only in 20 cm wide strips over the previous year's corn row. Results from another Typic Argiaquoll soil (Pewamo silty clay loam) showed SP (1.00 relative yield) > RT (0.76 with 15% lower stand) = NT (0.73). Relative yields of the RT and NT treatments were lower than on the Runneymede soil in their study or the Brookston soil in the authors' study in part due to poor weed control.

Grain moisture contents at harvest were not affected by tillage treatments as long as satisfactory weed control was attained. Corn grain averaged 29.0% over all years and treatments (Appendix Table VI), with an average harvest date of Oct. 25, and soybean grain averaged 15.7% (data not shown), with an average harvest date of Oct. 21. Corn grain moisture contents were always greater for plots judged to have had yield reduced by weed growth than for plots with lesser weed growth.

TABLE 2.—Effects of 1967-1974 Tillage History and 1975 Tillage on 1975 Corn Yields. Values Are Means of Three Replicates (Appendix Table IV).

1975 Tillage	Tillage History						
	Fall Plow	Spring Plow	Field Cultivate	Rototil	Disk	No Tillage	Mean*
	kg/ha						
Spring plow	8610	8790	8690	8310	9220	9260	8810
No-tillage	8130	7700	7870	7570	8130	7520	7820
Mean†	8370	8240	8280	7940	8680	8390	

*1975 tillage $LSD_{.001}$=820 kg/ha. Mean plant stands for 1975 tillage were 64,400/ha for spring plowing and 47,900/ha for no-tillage.
†Tillage history effects were not significant at 0.80 probability level (20 chances in 100).

TABLE 3.—Effects of Tillage History and 1975 Tillage on 1975 Corn Grain Water Content at Harvest. Values Are Means of Three Replicates (Appendix Table IV).

Tillage	Fall Plow	Spring Plow	Field Cultivate	Rototil	Disk	No Tillage	Mean*
Spring plow	23.0	22.7	22.9	22.9	23.0	22.9	22.9
No-tillage	24.3	25.2	25.2	26.0	25.7	25.5	25.3
Mean†	23.6	24.0	24.0	24.4	24.4	24.2	

*1975 tillage treatment $LSD_{.001}$ = 1.4 %.
†Tillage history $LSD_{.10}$ = 0.5 % (F test is significant at the 0.15 level of probability).

1975 Experiment

Tillage history had no effect on yields of corn produced by 1975 SP or NT techniques (Table 2). While 1975 SP treatments produced 990 kg/ha greater grain yield and 2.4% lower grain moisture content (Table 3) than the 1975 NT treatment, the 1975 SP treatment averaged 16,500 plants/ha greater stand than 1975 NT treatments (Appendix Table VII). This stand differential probably accounts for most of the 1975 tillage variable yield difference.

Leaf tissue at silking time indicated that P was sufficient for adequate yields for all plots. N and K were low on several plots, but the yield pattern did not follow the leaf tissue nutrient content pattern (compare Appendix Tables IV and V). Evidently the deleterious effects of 8 years of no-tillage were completely ameliorated by moldboard plowing one time and/or by having several years of soybeans precede the final corn crop.

The results of these experiments should be applicable to fields composed predominantly of Brookston or other very poorly drained Typic Argiaquoll soils, *provided* that adequate stand and weed control can be achieved and that adequate supplemental drainage has been provided. Equipment and chemical techlology is continually improving the possibility of achieving desirable stand and weed control with any tillage practice. Extrapolation of these results from Brookston to the two other major Typic Argiaquoll soils in Ohio (Marengo and Pewamo) is based on similarities of: 1) surface structural stability and organic matter content; 2) profile chemistry, water conductivity, and available water-holding capacity; and 3) parent material. Distribution of these soils in Ohio is shown in Figure 1.

Yield reduction associated with continued use of reduced, shallow, or no-tillage in continuous corn or soybeans on Brookston or similar soils may be alleviated by rotating the crops or plowing every other year (2). Often Brookston soil occurs in a field mixed patchwork-fashion with other soils, primarily Crosby (a somewhat poorly drained Aeric Ochraqualf). Corn does not respond to tillage the same way on the two kinds of soil (2). Management of the field may require compromises which depend on the relative occurrence of the soils (1).

SUMMARY

Six tillage treatments were established in 1967 and maintained on the same plots for 8 years. The treatments were: (FP) moldboard plow to 20 cm depth in the previous fall plus spring disking the week prior to planting; (SP) moldboard plow to 20 cm depth in April plus disking the week prior to planting; (FC) field cultivate to 10 cm depth (timing ranged from fall to day of planting); (RT) rotary till to 13 cm depth (timing ranged from fall to date of planting); (D) disk to 10 cm depth the week prior to planting; and (NT) no-tillage. Corn was grown the first 4 years and soybeans the next 4 years. The ninth year (1975) half of all plots were treated as SP and the other half as NT with corn as the test crop. The soil was Brookston silty clay loam, a level Argiaquoll soil having tile at 1 m depth and 12.2 m lateral spacing. The objective, generally achieved, was to create equal stand among all plots each year and weed control such that weeds would not cause reduced crop yields. Results summarized only for plots achieving these goals give the potential crop-producing ability of each tillage treatment without hindrance from inferior planter and herbicide technology.

Corn yields from FP and SP treatments (1967-1970) averaged 9% greater than the average of all other tillage treatments. Soybean yields from the NT treatment averaged 7% less than the average for all other tillage treatments. Grain moisture contents at harvest were not influenced by tillage treatments. Eight years of tillage history had no effects on 1975 corn grain yields. Stand advantage of 16,500 plants/ha probably caused most of the 990 kg/ha yield advantage of the 1975 SP treatments compared with the 1975 NT treatments.

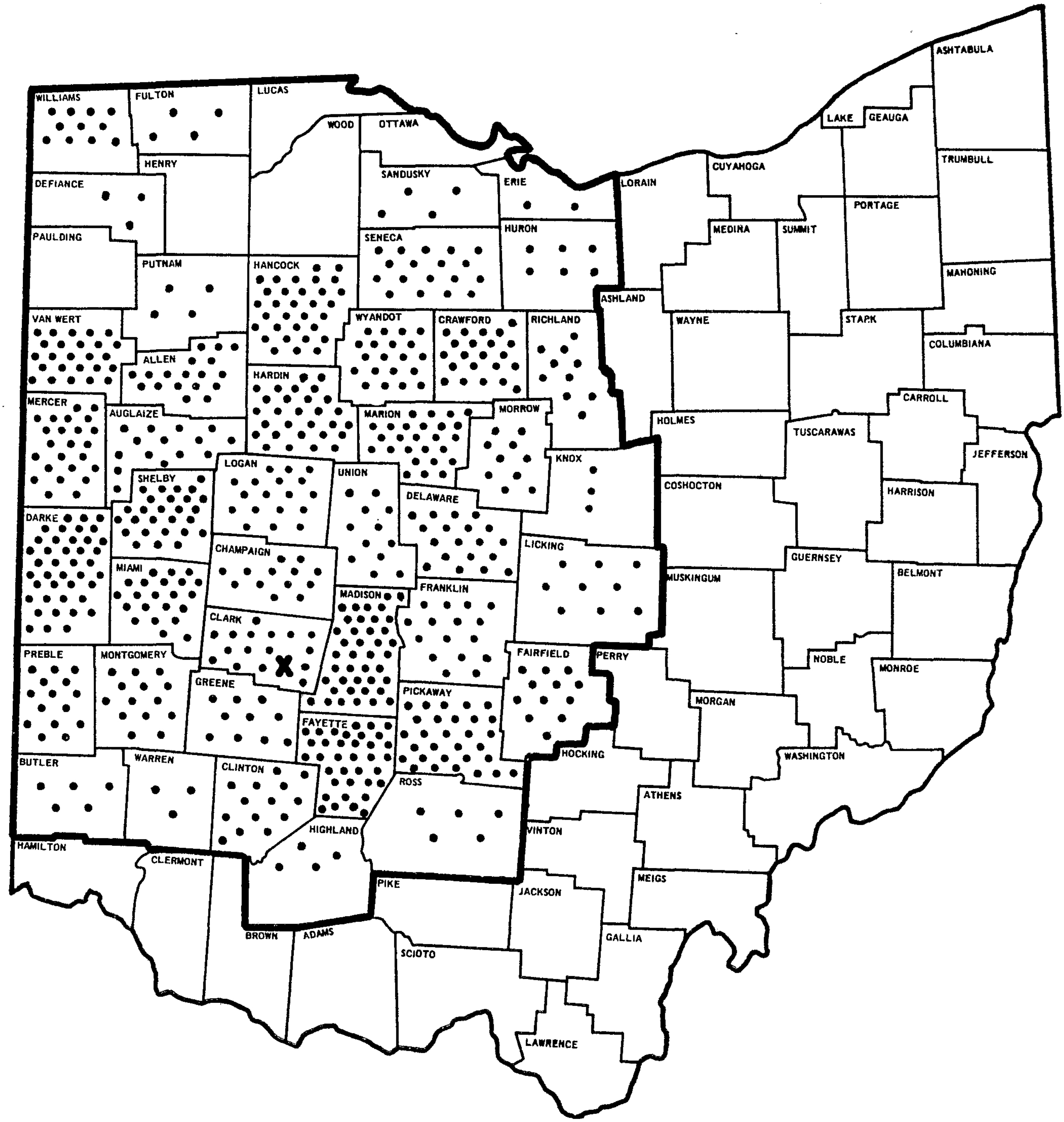

FIGURE 1.—Distribution of 1967 cropland on three Typic Argiaquoll soils in Ohio. Total land in crops was 668,000 ha, with each dot representing 1,000 ha (10). The large cross in Clark County is the location of OARDC's Western Branch.

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APPENDIX

APPENDIX TABLE I.—Physical Characteristics of Brookston Silty Clay Loam at the Western Branch, OARDC, in Clark County, Ohio.*

Horizon	Horizon Depths	Core Depths	Mechanical Analysis† Sand	Silt	Clay	Moisture Retention‡ 0 Bar	0.06 Bar	0.33 Bar	15 Bar	Bulk Density
	cm		Percent			100 x cm^3/cm^3				gm/cm^3
Ap	0-20	5-12	10.4	53.7	35.9	48.8	44.4	41.2	23.9	1.33
B_{21g}	20-36	26-33	10.3	53.0	36.7	49.1	41.4	40.1	25.7	1.32
B_{22g}	36-51	41-48	10.8	52.4	36.8	46.7	41.5	39.9	24.9	1.36
B_{23g}	51-74	58-65	11.7	50.9	37.4	46.7	42.2	40.0	25.9	1.40
B_{31g}	74-107		14.7	53.7	31.6					
B_{32g}	107-152		21.7	53.7	24.6					
C_1	152-		28.0	51.1	20.9					

*Data were obtained by the Ohio Soil Survey Lab from a site within 1 km of the plots.
†Determined essentially as reported in Reference 3 for pipette analysis.
‡Determined during desorption of 7.5 cm long x 7 cm diameter "undisturbed" cylinders of soil essentially as reported in Reference 6 for 0 to 0.33 bar, and of disturbed samples as reported in Reference 8 for 15 bar.

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

Year	Total Rainfall: Planting Date thru May 31	June	July	Aug.	Mean Daily Air Temperature: Planting Date thru May 31	June	July	Aug.
	mm				°C			
1967	195	45	72	16	12.2	20.8	21.1	19.2
1968	287	82	70	119	13.0	19.7	21.2	21.1
1969	95	192	130	99	15.3	18.7	21.9	20.1
1970	110	81	74	41	17.7	21.1	21.9	21.7
4-Year Average	*	100	86	69	*	20.1	21.5	20.5
1971	93	146	102	68	14.7	20.6	20.6	19.6
1972	62	101	48	72	17.8	17.5	21.4	20.5
1973	66	191	152	61	14.3	21.5	22.4	21.5
1974	52	90	33	129	18.7	18.9	22.4	21.6
4-Year Average	*	132	84	82	*	19.6	21.7	20.8
1975	54	106	162	103	17.9	19.9	21.7	22.4
15-Year Average	*	84	101	84	*	20.3	21.7	20.8

*Averages were not computed because the number of days differed from year to year.

APPENDIX TABLE III.—Cultural Practices Details, Dates, and Quantities of Material.

Crop	Year	Fall Plow Dates: Plow	Fall Plow Dates: Disk	Spring Plow Dates: Plow	Spring Plow Dates: Disk	Other Tillage Dates: Field Cultivate	Other Tillage Dates: Rotary Tillage	Other Tillage Dates: Disk Only	Other Dates: Pre-plow Fertilizer	Other Dates: Plant	Other Dates: Harvest
		Julian Days*									
Corn	1967	90	118	110	118	†	118	118	89	118	306
	1968	—13	113	106	107	121	115	121	102	121	300
	1969	—18	115	104	115	115	120	115	101	121	297
	1970	—29	106	103	106	—29	113	106	98	121	288
Soybeans	1971	—10	125	123	125	—10	—10	125	64	125	300
	1972	—45	133	91	133	—29	81	133	91	133	299
	1973	—17	135	125	135	68	73	135	73	135	284
	1974	—48	136	105	136	71	71	136	78	136	295
Corn	1975			62	125					125	274

Crop	Year	Fertilizer: Pre-plowing N	Pre-plowing P	Pre-plowing K	Remainder N	Remainder P	Remainder K	Active Herbicides‡	Active Insecticide
		kg/ha							
Corn	1967	224	0	0	27	108	108	2.2 At+1.1 Si+1.1 Tw	2.2 Aldrin
	1968	224	0	0	34	134	134	3.4 At+1.1 Si+1.7 Tw	4.5 Chlordane
	1969	275	67	67	11	45	45	6.2 At+2.8 Si	4.5 Chlordane
	1970	224	0	0	30	120	120	2.2 Si+3.4 Al+.6 Pa+.1 Di	4.5 Chlordane
Soybeans	1971††	0	206	224	7	52	52	3.4 Al+1.1 Li+.6 Pa	**
	1972	0	77	112	78	70	0	3.4 Al+1.1 Li+.3 Pa	**
	1973	80	80	80	17	167	167	3.4 Al+1.1 Me+.8 Gl	**
	1974	34	134	134	0	0	0	3.4 Al+1.1 Me+.6 Gl	**
Corn	1975	0	0	0	340	27	27	3.4 Al+3.4 Cy+.6 Pa	None

*Days from the first of the year (Jan. 1=1).
†Field cultivate was not done in 1967.
‡Letters are code for the following herbicides:
- Al Alachlor=2-chloro-2', 6'-diethyl-**N**-(methoxymethyl) acetanilide
- At Atrazine=2-chloro-4-(ethylamino)-6-(isopropyamino)-s-triazine
- Cy Cyanazine=2-[[4-chloro-6-(ethylamino)-s-triazine-Zyl]amino]-2-methylpropionitrile
- Di Dicamba=3,6-dichloro-**o**-anisic acid
- Gl Glyphosate=**N**-(phosphonomethyl)glycine
- Li Linuron=3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
- Me Metribuzin=4-amino-6-**tert**-butyl-3-(methylthio)-**2**s-triazine-5-(4**H**)one
- Pa Paraquat=1,1'-dimethyl-4,4'-bipyridinium ion
- Si Simazine=2-chloro-4,6-bis-ethylamino)-s-triazine
- Tw 2,4-D=(2,4-dichlorophenoxy)acetic acid

**Seed treated with 2.25 gm. of Diazinon per kg of seed.
††4,500 kg/ha lime broadcast before spring plowing.

APPENDIX TABLE IV.—Corn and Soybean Grain Yields at 15.5 and 13.5% Moisture, Respectively.

Crop	Year	Replicate	Tillage Treatments (1967-1974)					
			Fall Plow	Spring Plow	Field Cultivate	Rototil	Disk	No-tillage
			kg/ha					
Corn	1967	1	8500	9060	‡	8210	8370	7890
		2	9080	9940	‡	9340	7190**	7700**
		3	7930	8470	‡	7740	7290**	6890**
	1968	1	7240	7290	6750**	7540	7000	7450
		2	7680	7850	6780**	7530**	6410**	7030**
		3	7740	7660	6530**	7400**	6710**	7520
	1969	1	9190	8460	7740	8870	8160	7840
		2	8070	8650	8640	8410	7890	8230
		3	9460	8530	8430	7100	8670	7210
	1970*	1	9770	10440	8060	9200	9190	8870
		2	10260	10320	8450	8350	8470	7980
		3	9000	9670	8980	7910	7960	7990
	1970†	1	9360	8770	6960	8950	8820	9140
		2	9640	10260	8620	7510	9200	8060
		3	9790	9160	8200	8150	8480	7810
Soybeans	1971	1	3680	3980	3690	4010	3820	3700
		2	3930	4000	3840	3920	4220	3670
		3	3680	4020	3840	3970	3830	3930
	1972	1	3850	3750	3370	3620	3490	2820
		2	3210	3490	3860	3450	3560	3420
		3	3740	3860	3620	3450	3430	3310
	1973	1	2800	2970	3110	3260	2870	2980
		2	3640	3040	2980	2650	3340	2980
		3	3340	3270	2970	2970	3390	2450
	1974	1	3340	3230	3310	3100	3330	3040
		2	3470	3490	3090	3390	3290	2980
		3	3370	3260	3020	3050	3060	3190
Corn	1975 (plowed)	1	9350	8570	8720	7480	9460	9700
		2	7500	9410	8220	8530	9270	8890
		3	8970	8380	9130	8910	8920	9200
	1975 (not plowed)	1	8090	8190	7740	7450	7710	7970
		2	6270	7780	8000	7920	8130	7750
		3	10040	8540	7860	7350	8540	6850

*224 kg/ha N.
†336 kg/ha N.
‡Not begun until 1968.
**Weeds were considered to have reduced yield.

APPENDIX TABLE V.—Corn Ear Leaf Tissue Analysis, Sampled Between Tasseling and Silking.

Nutrient	Year	Replicate	Fall Plow	Spring Plow	Field Cultivate	Rototil	Disk	No-tillage
			Percent					
Nitrogen*	1969	1	3.00	2.95	3.00	3.20	2.95	3.05
		2	3.10	2.80	3.05	2.95	3.15	3.15
		3	3.05	3.00	3.60	3.45	2.90	3.25
	1970	1	3.12	3.35	3.13	3.36	3.15	3.13
		2	3.30	3.16	3.18	3.20	3.07	3.12
		3	3.02	3.08	3.10	2.88	2.87	3.10
Phosphorus†	1969	1	0.35	0.31	0.38	0.33	0.36	0.33
		2	0.36	0.46	0.39	0.36	0.32	0.39
		3	0.54	0.40	0.36	0.28	0.43	0.43
	1970	1	0.30	0.38	0.36	0.28	0.29	0.36
		2	0.35	0.30	0.41	0.32	0.39	0.36
		3	0.34	0.48	0.32	0.28	0.32	0.30
Potassium‡	1969	1	2.38	2.40	2.07	2.21	2.40	2.53
		2	2.26	2.28	2.38	2.34	1.97	3.35
		3	3.32	2.28	2.31	2.05	2.58	3.69
	1970	1	1.74	1.72	1.89	1.94	1.47‡	1.74
		2	1.99	1.88	1.77	1.63‡	1.78	2.12
		3	1.85	1.81	2.05	1.76	2.03	1.80
Nitrogen*	1975 (plowed)	1	2.67*	2.87	3.02	2.77	2.92	2.85
		2	3.00	2.81	3.17	2.95	3.01	3.27
		3	2.98	2.88	2.93	2.91	3.27	2.89
	1975 (not plowed)	1	3.01	2.86	2.94	2.92	3.13	2.73*
		2	3.07	3.07	2.94	3.13	2.97	2.74*
		3	2.77	2.95	3.02	2.96	3.10	2.98
Phosphorus†	1975 (plowed)	1	0.37	0.39	0.35	0.32	0.33	0.38
		2	0.34	0.39	0.39	0.37	0.35	0.41
		3	0.33	0.36	0.36	0.36	0.42	0.35
	1975 (not plowed)	1	0.42	0.39	0.37	0.39	0.40	0.39
		2	0.38	0.43	0.34	0.33	0.35	0.37
		3	0.37	0.34	0.34	0.35	0.41	0.37
Potassium‡	1975 (plowed)	1	2.17	2.13	2.16	2.05	1.95	2.07
		2	1.98	2.32	2.18	2.11	2.12	1.99
		3	1.99	2.15	2.07	2.21	1.84	2.05
	1975 (not plowed)	1	2.03	1.77	1.95	1.63‡	1.68‡	1.74
		2	1.99	1.82	2.13	1.87	1.87	2.01
		3	1.98	1.69‡	1.96	1.81	1.70‡	1.95

*$\leq$ 2.45 is considered deficient; 2.46-2.75 is low; 2.76-3.50 is sufficient; 3.51-3.75 is high N for optimum corn yields (5).
†$\leq$ 0.15 is considered deficient; 0.16-0.24 is low; 0.25-0.40 is sufficient; 0.41-0.50 is high P for optimum corn yields (5).
‡$\leq$ 1.25 is considered deficient; 1.26-1.70 is low; 1.71-2.50 is sufficient; 2.51-3.50 is high K for optimum corn yields (5).

APPENDIX TABLE VI.—Corn Grain Moisture Content on a Wet Weight Basis.

Year	Replicate	Fall Plow	Spring Plow	Field Cultivate	Rototil	Disk	No-tillage
				Percent			
1967	1	36.2	36.0	†	33.8	33.6	35.0
	2	34.5	37.1	†	37.2	35.2‡	37.4‡
	3	37.4	38.8	†	38.4	37.8‡	40.2‡
1968	1	30.8	31.4	32.8‡	28.0	32.6	28.8
	2	30.9	29.4	30.4‡	30.6‡	33.0‡	32.0‡
	3	28.2	28.5	32.6‡	30.0‡	33.2‡	29.2
1969	1	25.3	25.3	25.8	25.2	27.4	27.6
	2	27.3	24.7	24.7	25.5	25.2	26.7
	3	24.5	26.6	28.4	25.8	26.6	26.5
1970*	1	24.2	23.3	25.9	24.4	24.6	25.5
	2	24.0	23.6	25.8	23.9	24.6	26.0
	3	23.2	24.0	24.0	24.0	24.9	26.6
1975	1	22.8	23.3	23.4	22.9	22.6	22.4
(plowed)	2	23.4	22.9	23.1	22.7	22.6	23.3
	3	22.7	21.8	22.3	23.2	23.7	23.1
1975	1	24.3	24.7	26.2	26.8	25.8	25.4
(not plowed)	2	25.5	25.4	24.1	24.4	25.7	25.0
	3	23.1	25.6	25.2	26.9	25.6	26.1

*224 kg/ha N.
†Not begun until 1968.
‡Weeds were considered to have reduced yields.

APPENDIX TABLE VII.—Corn Stand in 1975.

		Tillage Treatments (1967-1974)					
1975 Tillage	Replicate	Fall Plow	Spring Plow	Field Cultivate	Rototil	Disk	No-tillage
				Thousands of Plants/ha			
Spring plow	1	63.9	65.6	64.4	65.0	64.4	66.7
	2	63.3	66.1	64.4	63.9	63.3	64.4
	3	61.6	67.2	63.9	61.6	66.7	62.7
No-tillage	1	47.4	48.0	48.0	48.0	48.0	47.4
	2	45.3	49.0	48.0	48.0	48.0	48.5
	3	50.7	45.8	48.0	48.0	48.0	48.0

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BETTER LIVING IS THE PRODUCT

of research at the Ohio Agricultural Research and Development Center. All Ohioans benefit from this product.

Ohio's farm families benefit from the results of agricultural research translated into increased earnings and improved living conditions. So do the families of the thousands of workers employed in the firms making up the state's agribusiness complex.

But the greatest benefits of agricultural research flow to the millions of Ohio consumers. They enjoy the end products of agricultural science—the world's most wholesome and nutritious food, attractive lawns, beautiful ornamental plants, and hundreds of consumer products containing ingredients originating on the farm, in the greenhouse and nursery, or in the forest.

The Ohio Agricultural Experiment Station, as the Center was called for 83 years, was established at The Ohio State University, Columbus, in 1882. Ten years later, the Station was moved to its present location in Wayne County. In 1965, the Ohio General Assembly passed legislation changing the name to Ohio Agricultural Research and Development Center—a name which more accurately reflects the nature and scope of the Center's research program today.

Research at OARDC deals with the improvement of all agricultural production and marketing practices. It is concerned with the development of an agricultural product from germination of a seed or development of an embryo through to the consumer's dinner table. It is directed at improved human nutrition, family and child development, home management, and all other aspects of family life. It is geared to enhancing and preserving the quality of our environment.

Individuals and groups are welcome to visit the OARDC, to enjoy the attractive buildings, grounds, and arboretum, and to observe first hand research aimed at the goal of Better Living for All Ohioans!

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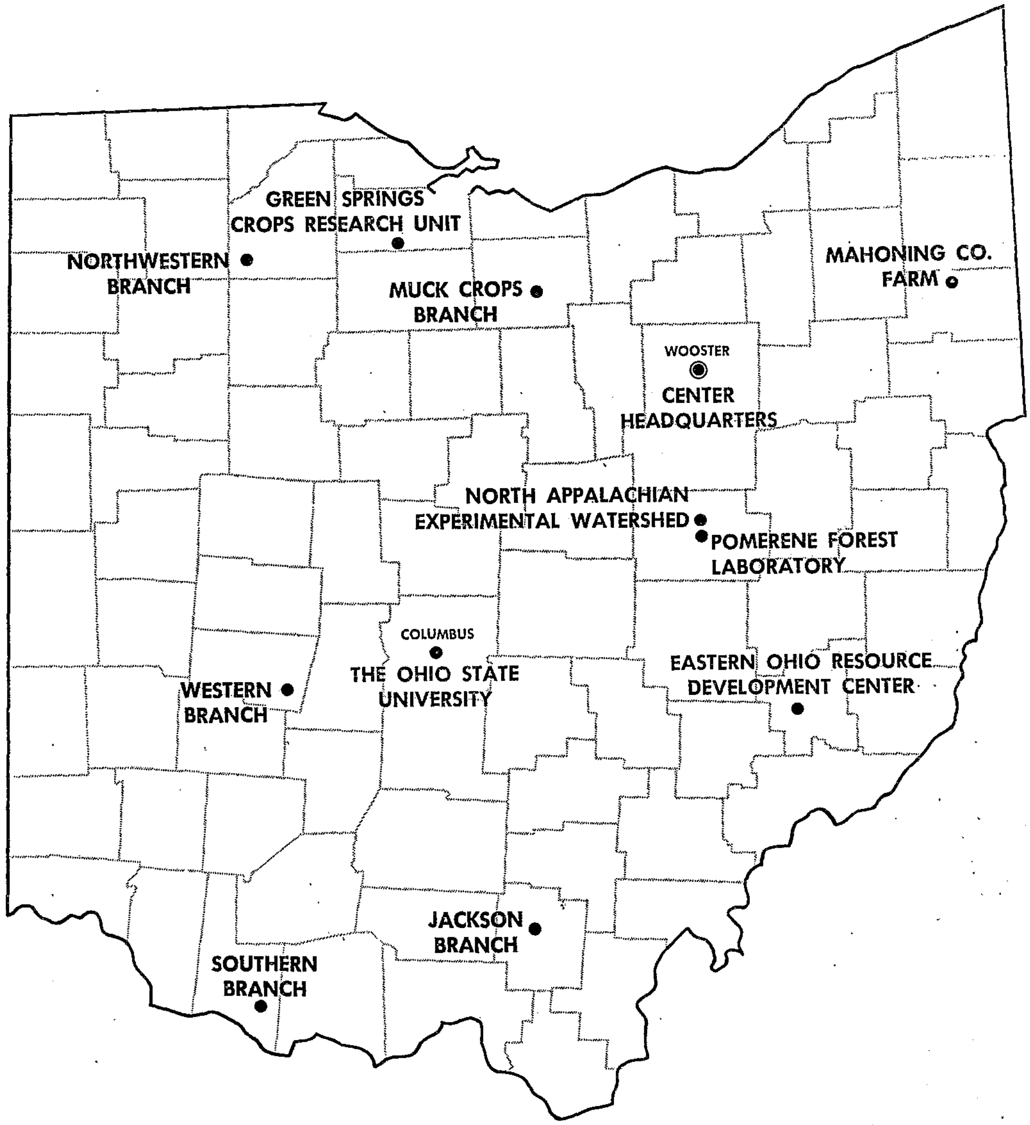

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

Research is conducted by 15 departments on more than 7000 acres at Center headquarters in Wooster, seven branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

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