

UNITED STATES DEPARTMENT OF AGRICULTURE

Part 1
Soil Survey
of
Blackford County, Indiana

By
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and
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Part 2
The Management
of **Blackford County Soils**

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PREFACE

This report consists of two parts. Part 1 is designed to be descriptive and in a measure a technical discussion of the soils. Part 2 is intended to furnish information about the treatment and management of the soils to county agents, farmers, and others interested in the use of the soils. The soil map serves both parts of the report.

PART 1. SOIL SURVEY OF BLACKFORD COUNTY, INDIANA

By W. E. THARP, in Charge, and S. R. BACON

COUNTY SURVEYED

Blackford County is in the east-central part of Indiana. (Fig. 1.) The eastern boundary is about 22 miles from the Ohio-Indiana State line. Hartford City, the county seat, is about 40 miles south of Fort Wayne and 50 miles northeast of Indianapolis. The county is approximately square and includes 168 square miles, or 107,520 acres. The general elevation above sea level is a little less than 900 feet.

About 90 per cent of the county is open farm land, and the remainder consists chiefly of small wood lots. The greater part is a very gently undulating plain, with local differences in elevation in a few places exceeding 10 or 15 feet. Much of the plain is a succession of sags and swells very irregularly disposed and merging one into the other by gentle slopes and long inclines. Absolute flatness of the higher ground is limited to a few spots of a few acres each on the crests of broad divides. Most of the smaller depressions are shallow basins, but the larger ones are flat or nearly so, and some of them form long irregular and rather ill-defined sloughs, or shallow valleys. Near the larger streams these surface inequalities are in general, more pronounced, although in many places the somewhat flat plain persists to the very crest of the slope above a stream valley.

A few square miles in the extreme southwestern corner of the county are marked by strongly rolling or somewhat hilly surface relief. In many places short steep slopes border the flood plain of Lick Creek and the narrow valleys of its larger tributaries. These sharp differences in elevation in few places exceed 40 feet in the lower part of the valley and decline to 10 or 15 feet on the upper branches. Below Hartford City the rolling land in most places does not extend more than one-fourth or one-half mile back from the valley which averages about one-fourth mile wide, including a few low bench lands. Above Hartford City the valley of the north branch of Lick Creek, known as Little Lick Creek, is little more than a slough about one-fourth mile wide, until it expands into the wider areas of "black land" and muck soil in the northern part of Jackson Township. Lick Creek, for several miles west of Dunkirk, flows through a flat valley from 10 to 15 feet lower than the bordering upland.

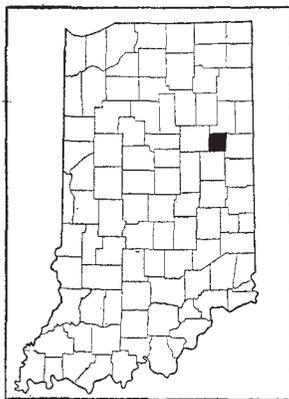


FIGURE 1.—Sketch map showing location of Blackford County, Ind.

The flood plain of Salamonie River is from one-fourth to one-half mile wide and from 30 to 50 feet below the general level of the uplands. On the north side of the valley slopes of moderate gradients prevail, but in many places along the south side the inclines are too steep for convenient tillage and are incised by short ravines. Toward the eastern county line the uplands descend more gradually and the valley becomes wider. On the south side there are no well-defined erosional valleys, but on the north a number of such valleys extend for a mile or two into the uplands and each has a narrow strip of alluvium along its lower course.

The master streams of this region, Salamonie and Mississinewa Rivers, flow in an almost due northwest course, but drainage of the county is chiefly from northeast to southwest. This is true of the small streams having well-defined courses and also of those lines of immature drainage determined by the trend of local surface inequalities. Many of the structural depressions now connected by ditches have their major axes along northeast-southwest lines. Except in the vicinity of the largest streams, natural drainage was very poorly developed. The surface water in rainy seasons escaped chiefly by overflow from one depression into another, until it reached some one of the comparatively few channels extending back from one of the larger streams.

The present systems of surface drainage reach every farm, and only a few small depressions have no outlet. Although much tile drainage has been installed, much more is needed to insure more prompt removal of excess water from the flat spots during seasons of high rainfall. As a result of artificial drainage and some natural changes, the former high average level of the ground water in all the depressions of the plain has been lowered several feet.

The county was originally covered by a magnificent forest, in which hard maple, beech, white oak, tuliptree, American elm, black walnut, hickory, and sycamore were prominent. Only a very few small areas of muck or Clyde soils may have been open grassland.

Most of the water for farm use is obtained from wells. It is plentiful, wholesome, and in general of good quality, but some of it is extremely hard.

The first recorded entry of land in the country now included in Blackford County was in 1831. It included a part of section 6 in the southwest corner of Licking Township. The county was organized in May, 1839. In 1840, the total population was 1,226, of which number 316 men were engaged in agricultural pursuits and 22 in other occupations.

According to the census report of 1930, the population of the county is 13,617.¹ Hartford City, the county seat, has a population of 6,613. Montpelier, with a population of 1,859, is near the north county line. A small part of the city of Dunkirk is in the extreme southeast corner of the county.

No part of the county is more than 8 or 10 miles from a railroad. The Pennsylvania, the New York, Chicago & St. Louis, and the Indiana Railroad (an electric interurban line) cross the county. The public-road system reaches nearly all farms with improved roads, most of which are surfaced with gravel or crushed limestone.

¹ Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given when possible.

Schools and churches are accessible to all the rural population. Most of the farm homes are supplied with telephones and many of them with electricity for light and power.

CLIMATE

The mean annual precipitation of about 37 inches is ample for the crops commonly grown in this county. Its distribution throughout the growing season is very important, and any marked departure therefrom affects crops in some degree, but with one or two exceptions all soil types have considerable capacity for enduring seasonal extremes. Wheat seems to do better when there is a slight deficiency in rainfall, particularly on the dark-colored soils. Oats may do best if the April and May rainfall is above the average amount. Sub-normal temperature seems to be favorable to all the small grains and grasses. As corn makes its best growth in warm weather and will endure a light rainfall early in the season, its condition is not usually in close agreement with that of grass and small grain. Corn is particularly sensitive to moisture supplies during July and August, and during this period the normal amount is absolutely necessary and a considerable excess may be beneficial.

The average length of the frost-free season is 150 days, from May 8 to October 5. The latest recorded date of killing frost is June 9, and the earliest is September 5.

Table 1, compiled from the records of the United States Weather Bureau station at Marion, Grant County, 20 miles northwest of Hartford City, gives the more important climatic data which may be considered representative of conditions in Blackford County.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Marion, Grant County, Ind.

[Elevation, 850 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1895)	Total amount for the wettest year (1892)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	30.3	66	-13	2.76	3.27	1.60	6.6
January.....	26.8	68	-25	2.79	1.84	1.41	9.5
February.....	27.6	76	-20	2.11	.51	3.21	7.2
Winter.....	28.2	76	-25	7.66	5.62	6.22	23.3
March.....	39.3	86	-2	3.42	2.16	2.87	5.1
April.....	50.9	91	15	3.42	1.71	5.63	1.2
May.....	61.1	100	26	3.71	.81	10.65	.1
Spring.....	50.4	100	-2	10.55	4.68	19.15	6.4
June.....	70.5	101	35	3.85	1.37	7.52	0
July.....	74.3	105	37	3.11	.80	6.18	0
August.....	72.4	103	38	3.17	1.37	5.46	0
Summer.....	72.4	105	35	10.13	3.54	19.16	0
September.....	66.1	101	29	3.39	2.46	5.53	0
October.....	53.7	91	15	2.61	.91	(1)	.1
November.....	40.9	77	2	2.85	5.42	4.52	1.7
Fall.....	53.6	101	2	8.85	8.79	10.05	1.8
Year.....	51.2	105	-25	37.19	22.63	54.58	31.5

¹ Trace.

AGRICULTURE

Corn, wheat, and oats have been the principal crops in Blackford County since the first settlement by white people nearly 100 years ago. In the first half of this period, wheat was relatively of greater importance than in the last half. A number of causes for the decrease in the relative acreage devoted to wheat may be mentioned, chief of which perhaps was the steadily increasing acreage of dark-colored soils reclaimed by drainage and used for growing corn. Contributing causes were the occasional crop failures due to insect pests, bad seasons, and declining productivity of the light-colored soils which were the first soils brought into agricultural use. Oats have varied in acreage to a considerable extent but not so much as wheat. In recent years, and even before the World War period of crop stimulation, the comparative importance of these crops was declining. Corn has steadily increased in acreage, and for many years it has held first place among the crops of the county, both in acreage and in agricultural value.

Both wheat and oats are used as nurse crops for clover and timothy by all farmers of the county, and this use is no small factor in the value of these crops. Small-grain crops so frequently fail to show a profit that farmers have expressed the opinion that the omission of the small grains from the rotations could be considered if any substitute crop served as well in seeding ground to clover.

The annual acreage of tame grasses ranges from 12,000 to 16,000 acres, or about one-fifth of the crop acreage. The 1930 census reports hay grown on 12,263 acres in 1929 with a total yield of 15,081 tons. Clover does not always reseed the ground the second year, and timothy alone occupies the land for the remaining period of the grass rotations. The comparatively small acreage of soybeans adds to the soil-improvement crops. Most of this crop is removed according to usual practice, but sweetclover is commonly pastured or turned under as green manure.

Patches of buckwheat are occasionally grown, and the total rye and barley acreage is small.

Table 2, compiled from the United States census reports, shows the general trend in the acreage and production of important field crops during the last 50 years.

TABLE 2.—*Acreage and yield of the principal crops in Blackford County, Ind., in stated years*

Crop	1879		1889		1899	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	14, 211	417, 079	20, 931	533, 400	26, 153	1, 137, 950
Oats.....	1, 614	45, 093	4, 835	133, 784	3, 873	120, 080
Wheat.....	8, 950	152, 879	9, 345	99, 011	14, 040	183, 330
Rye.....	69	795	880	12, 922	587	8, 830
Barley.....			6	159	179	2, 660
Potatoes.....		28, 385	842	69, 194	391	15, 646
Hay.....	6, 006	<i>Tons</i> 5, 730	8, 288	<i>Tons</i> 9, 917		<i>Tons</i>
Tame grasses—						
Clover.....					3, 150	4, 203
Alfalfa.....					15	24
Other tame grasses.....					8, 683	9, 469
Grains cut green.....					330	370
Coarse forage.....					189	297

TABLE 2.—*Acreage and yield of the principal crops in Blackford County, Ind., in stated years—Continued.*

Crop	1879		1889		1899	
	<i>Trees</i>	<i>Bushels</i>	<i>Trees</i>	<i>Bushels</i>	<i>Trees</i>	<i>Bushels</i>
Apples.....			21, 454	22, 193	38, 977	43, 738
Peaches.....			1, 186	100	4, 720	19
Grapes.....						
	<i>Vines</i>	<i>Pounds</i>	<i>Vines</i>	<i>Pounds</i>	<i>Vines</i>	<i>Pounds</i>
					11, 110	110, 400

Crop	1909		1919		1929	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	26, 026	1, 046, 914	24, 251	961, 366	17, 929	411, 959
Oats.....	13, 040	313, 715	11, 872	416, 094	12, 961	312, 341
Wheat.....	2, 266	24, 770	8, 562	144, 771	3, 089	56, 395
Rye.....	457	6, 080	1, 528	19, 481	196	2, 330
Barley.....	28	758	1, 392	28, 508	99	1, 704
Potatoes.....	458	34, 436	219	7, 644	158	11, 501
Hay.....						
	<i>Tons</i>		<i>Tons</i>		<i>Tons</i>	
					12, 263	15, 081
Tame grasses.....	11, 632	15, 309	10, 820	12, 260		
Timothy.....	8, 549	11, 045	6, 428	6, 981		
Timothy and clover.....	2, 173	2, 902	3, 003	3, 994	8, 868	10, 551
Clover.....	748	955	1, 265	1, 060	2, 063	2, 786
Alfalfa.....	93	269	85	186	403	651
Other tame grasses.....	69	138	39	39	50	52
Wild grasses.....	10	10	2	4		
Grains cut green.....	20	20	191	216	25	27
Legumes for hay.....			5	9	854	1, 014
Silage crops.....			763	6, 387		
Coarse forage.....	2, 150	3, 155	6, 398	10, 606		
Apples.....						
	<i>Trees</i>	<i>Bushels</i>	<i>Trees</i>	<i>Bushels</i>	<i>Trees</i>	<i>Bushels</i>
	22, 098	9, 724	14, 361	2, 034	7, 363	158
Peaches.....	4, 085	574	454	17	947	10
Pears.....	3, 239	326	1, 643	215	1, 389	110
Grapes.....						
	<i>Vines</i>	<i>Pounds</i>	<i>Vines</i>	<i>Pounds</i>	<i>Vines</i>	<i>Pounds</i>
	4, 420	30, 763	3, 803	37, 128	2, 337	23, 978

¹ In addition to corn harvested for grain, 342 acres yielded 2,222 tons of silage; 297 acres were cut for fodder and 2,823 acres were hogged off.

² In addition, 202 acres cut and fed unthreshed.

Nearly all the wheat is sold direct from the farm. A considerable part of the oat crop is used for feeding work animals, and much of it is marketed. All hay and corn stover are used on the farm, but on many farms straw is sold to the paper mills.

Nearly all the corn is consumed in the county, the small quantities for sale usually being purchased by neighboring farmers. On most of the farms the sale of fattened hogs constitutes the largest single item of income. A somewhat definite relationship exists between returns from this source and the proportion of black land included in a farm. As a rule the predominance of such soils encourages corn production and its utilization in hog feeding.

On a few of the larger farms cattle feeding is a part of the regular farming operations, but on the average farm (90 acres) a large number of cattle can not be handled. Very few calves of the beef breeds are raised to maturity. Dairying as a special industry has developed near the towns, but most of the milk produced in the county is obtained from the many farms on which a few cows are regularly maintained. By keeping a few cows, the farmers are insured profitable utilization of much of their pasturage and forage. Many farms which have a large acreage in grasses maintain small

flocks of sheep. A few landholdings are devoted entirely to pasture. Such farms are made up chiefly of the rougher areas of the light-colored soils.

Sugar beets and tomatoes for the canneries are special cash crops grown on the dark-colored soils. In 1928, approximately 400 acres of sugar beets were planted, and the acreage for the last three or four years has ranged from 300 to 400 acres. The average yield in normal seasons is about 9 tons an acre. Farmers receive about \$7 a ton, regardless of sugar content, but if the sugar content is above a certain percentage a bonus is paid.

In 1928, about 215 acres were planted to tomatoes for the cannery at Hartford City, but a small part of the crop was abandoned on account of the wet season. The best yields in that year were about 7 tons an acre, for which the growers received an average of about \$14 a ton. Nearly all the tomatoes were grown on the dark-colored soils, and much of the fertilizer used was a 2-12-8² mixture. A rather large acreage in the southern part of the county was planted to tomatoes for the cannery at Eaton, Delaware County. Yields ranging from 4 to 10 tons an acre were reported, and the price ranged from \$9 to \$17 a ton, according to quality of the fruit.

The acreage devoted to potatoes is less than it was about 20 years ago, when some large fields were regularly planted on the muck land south of Roll. Many other kinds of vegetables are grown in gardens but not on a commercial scale.

The number of farms in Blackford County, according to the 1930 census figures, is 975, and the average size is 97.5 acres. There has been no notable change in the number and average size of farms in the last 50 years, but the present tendency is toward an increase in the number of smaller holdings along State highways and near the larger towns. Some economic factors seem to favor an increase in the size of farms located elsewhere. One man, with modern equipment and a little extra help during harvest, can handle 200 or more acres in the usual farm crops, and this is often done by tenant farmers, or by the owners of small holdings, who rent additional land. The tendency on these farms is toward an increase in the acreage of corn and small grains and a corresponding reduction in the grass acreage.

In 1930, 30.1 per cent of the farms were operated by tenants, 69.1 per cent by owners or part owners, and 0.8 per cent by managers. From one-half to three-fifths of the grain is the customary rental for cultivated land, with additional rent for grassland and buildings. Many of the larger farms are operated on a partnership basis and more livestock is handled than is usual under other forms of lease.

So few farms have changed owners in recent years, except on terms imposed by previous contracts, that it is difficult to state the present price of farm lands with any degree of correctness. Owing to high prices for labor, equipment, and upkeep, large farms are at some disadvantage, if offered for sale, compared with smaller farms which one man can easily manage.

² Percentages, respectively, of nitrogen, phosphoric acid, and potash.

SOILS AND CROPS

The greater part of Blackford County consists of two general kinds of soil, dark colored and light colored. The two are so intimately associated that few farms consist of one kind only. The larger part of the group of dark-colored soils, known as "black lands," is made up of Brookston silty clay loam, and Crosby silty clay loam comprises the greater part of the light-colored group. Each soil is representative, respectively, of these two large and important soil groups, which prevail throughout the north-central part of the State. In this county both are of silty clay loam texture and contain little sand or other coarse material. This heavy texture also prevails in the adjoining counties north and east of Blackford County, but south and west of this county somewhat lighter-textured soils, or silt loams, are dominant.

In this county all the soils were originally forested, but approximately 90 per cent of the area now consists of smooth open fields allowing efficient use of labor-saving implements.

Crosby silty clay loam and most of the other light-colored soils have fair surface drainage but poor underdrainage. Brookston silty clay loam and the associated dark-colored soils were originally very poorly drained, but this condition has been greatly improved. Only an occasional small spot, rarely more than a few acres in extent, remains untilled on account of wetness.

The dark-colored soils bear considerable resemblance to the wet prairie soils of the western part of the State, and their influence on the agriculture of the county is similar in some respects to that of the prairie soils. They encourage the growing of corn on an extensive scale and allow economical production of other crops by reason of their productivity and comparatively easy management when thoroughly drained. Although the same crops are regularly grown on the light-colored soils, these soils require more care in management, particularly with respect to crop rotations and the use of fertilizers. A larger proportional acreage of the gray soils must be annually devoted to small grains and grasses than is necessary of the dark-colored soils. A mixed type of agriculture has thus developed with its major features impressed on it by the light-colored soils, but with some characteristics due to the extent and importance of the dark-colored soils. According to the Federal census, about 40 per cent of the total acreage of tilled land is annually planted to corn. As the dark-colored soils constitute 44.1 per cent of the land in the county, this indicates the extent to which these fertile soils are used in the production of this valuable crop. In 1929, according to the United States census report, 3,089 acres were devoted to wheat and 13,163 acres to oats. Clover and timothy hay and minor crops comprise most of the remainder of the field products grown. A rather large acreage, partly in wood lots, consists of permanent bluegrass pastures. In the annual distribution of crops it is not practical to observe soil requirements so closely as is desirable, owing chiefly to the mixed occurrence of the soils and also to the cultural methods in common use. The soil requirements, however, are very generally recognized by farmers, but, as previously mentioned, the fields con-

sisting largely of dark-colored soils are frequently cropped for several successive years to corn. On the greater number of farms, most of the barnyard manure is spread on the gray soils. In the distribution of such commercial fertilizers as are used, no very close distinction can be made between the different soils occurring in the same field, but the light-colored soils are, in general, favored.

In the following pages of this report the soils of Blackford County are described in detail, and their agricultural relationships are discussed; their distribution and location are shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Blackford County, Ind.*

Type of soil	Aces	Per cent	Type of soil	Aces	Per cent
Brookston silty clay loam.....	36, 224	33. 7	Fox silt loam.....	512	0. 5
Clyde silty clay loam.....	6, 272	5. 8	Fox loam.....	320	. 3
Abington silty clay loam.....	2, 240	2. 1	Genesee silt loam.....	1, 984	1. 8
Muck.....	2, 688	2. 5	Eel silty clay loam.....	1, 088	1. 0
Crosby silty clay loam.....	48, 064	44. 7	Wabash clay.....	512	. 5
Bethel silty clay loam.....	896	. 8	Gravel pits.....	64	. 1
Miami silty clay loam.....	6, 144	5. 7			
Miami silt loam.....	128	. 1	Total.....	107, 520	-----
Miami silt loam, slope phase.....	384	. 4			

DARK-COLORED SOILS

Owing to their topographic position the dark-colored soils receive and retain much of the surface washings from the higher ground. In many places considerable silty deposits from local sources have occurred, whereas erosional loss from the black lands is comparatively slight. After heavy rains the water in the large ditches is very turbid, and it reaches the rivers in that condition. To what degree this accelerated drainage may be increasing the rate of removal of some of the elements of fertility has not been studied.

Several other dark-colored soils which occur in the county do not differ greatly in agricultural value from Brookston silty clay loam, the dominant dark-colored soil. All are rich in organic matter, and the clayey texture is thus very favorably modified with respect to moisture conditions and tillage requirements. They are comparatively rich in all the essential elements of fertility, and wherever adequate drainage is provided their productivity is as high as that of the Brookston soil. In general the crop adaptations are similar, and these soils are now managed in about the same way as Brookston silty clay loam.

Brookston silty clay loam.—Brookston silty clay loam, the most extensive of the so-called black lands, is characterized by the dark color of the surface soil and its location in flat, slightly depressed situations. Its remarkable productivity is owing in part to its large content of organic matter which in many places constitutes as much as 6 or 8 per cent of the soil to a depth ranging from 6 to 12 inches and is so intimately mixed with the mineral constituents as to be an integral part of the soil body. This organic material is very large-

ly in such form, or condition, that it does not disappear under tillage nearly so rapidly as barnyard manure or fresh plant residues, and in this respect is like the organic matter of the prairie soils. The crumbly structure of this clayey soil, which is of such great importance in tillage, is caused by the presence of the high content of organic matter; and in addition, aeration and comparatively equable moisture conditions are favored, with consequent regularity in the release of plant food to the growing crop.

The subsoil is clay with a little coarse material scattered through it, but its permeability to air and water is owing in large measure to the granular structure. When partly dry, innumerable minute fissures, or cleavage planes, become apparent, and the moist material is easily separable into small angular lumps. The roots of most of the forest trees extended deep into the subsoil, even under original conditions of drainage, and now cultivated plants similarly establish themselves. The subsoil material is rather easily penetrated with a spade or other implement, and tile drains can be satisfactorily installed. The drains operate well and are effective to considerable distance to each side. The physical characteristics of the subsoil material to a depth of several feet are favorable to the maintenance of good moisture conditions throughout the entire growing season.

The Brookston soils will endure considerable trampling by livestock when wet, and they recover from the effects of injudicious tillage more quickly than the light-colored soils. Doubtless some diminution in the organic-matter content, as compared with original conditions, has taken place, but this has not as yet seriously impaired tillage properties or, apparently, had much effect on average grain yields. Grain yields are improved by a change for a year or two to clover or grass, and farmers state that manure has a beneficial effect. The increase in crop returns following the application of commercial fertilizer is not so clearly apparent. The experience of farmers is varied, and opinions differ as to the value of commercial fertilizers for ordinary crops. Much of this soil has had very little if any commercial fertilizer used on it, except with wheat and sugar beets, and a rather large acreage has had no soil amendments of any kind except manure or crop residues.

Complete chemical analyses of samples of this soil from other counties indicate a higher content of nitrogen in the surface layer of Brookston silty clay loam than in the light-colored soils. The difference with respect to potash is not so marked but in the case of phosphorus is generally in favor of the dark soil. The distribution of lime in this soil is also much more uniform in both the surface soil and subsoil, although the depth to free lime may be several feet. Of course, the availability of these elements is of more importance than the total quantities contained, but the physical characteristics of the soil material, as already indicated, are very favorable in this respect.

The surface soil gives a neutral or slightly acid reaction, but in few places is it so much as medium acid, according to colorimetric field tests. Such exceptions as occur are usually on the light-colored areas where the heavy yellow subsoil may be within plow depth. Small narrow areas which extend into the light-colored soils have, in many places, received enough surface wash from the light-colored

soils to render the soil somewhat acid. A few farmers have applied lime to the land before seeding to alfalfa, but otherwise they have given little attention to acidity and as yet it presents no serious problem on this or related soils.

Under favorable conditions the yield of corn on Brookston silty clay loam ranges from about 50 to 70 bushels an acre, and on some farms 80 bushels or more are obtained. Yields of less than 35 or 40 bushels an acre are generally attributable to locally poor drainage, improper tillage, or to a very unfavorable season. Commercial fertilizers are seldom used on corn, and, as previously stated, this soil receives, on most farms, but little barnyard manure. Corn matures nearly as early as on the light-colored soils and the quality of grain is usually good.

The normal moisture content of Brookston silty clay loam seems to be too high for the best wheat-growing conditions. A deficiency in rainfall and somewhat lower temperature than normal in the spring, favor this crop. Farmers attributed the almost total failure in 1928 largely to wet weather the previous fall. Heaving and the accumulation of water and ice in low spots are frequent causes of injury to the plants. Under very favorable conditions, yields ranging from 25 to 30 bushels an acre are obtained, but the average is much less.

Yields of oats are somewhat more dependable than those of wheat, but seasonal influences are strongly marked. The rather wide variations in oat yields in a series of years are not easily correlated with the rainfall and temperature. In general, rainfall and temperature rather lower than normal seem to favor this crop on the Brookston soil.

In early spring, oat and wheat plants are often of a lighter shade of green on Brookston silty clay loam than on the adjoining light-colored soils, a condition evidently attributable to the high moisture content of the Brookston soil and the slower development of available nitrogen. A little later in the season the color differences are less noticeable or may be reversed. All the clovers commonly grown in this region thrive well on this dark-colored soil, and in normal seasons little difficulty is experienced in obtaining a stand with wheat or oats as a nurse crop. Winter killing by heaving of the plants sometimes occurs on the heaviest areas.

Soybeans do well, but they need special inoculation where grown for the first time. Potatoes, tomatoes, cabbage, pumpkins, and squash, in addition to a great variety of other vegetables, thrive on the Brookston soil. The frost hazard is slightly greater than on the adjacent higher ground, but the more rapid growth lessens this risk.

Clyde silty clay loam.—Clyde silty clay loam occurs in local depressions where the drainage originally was less effective than in Brookston silty clay loam. Some of the "buttonwood" ponds and margins of shallow muck deposits are good examples of this soil.

The nearly black color of the surface soil is caused by a high content of organic matter. The dark-drab clay subsoil grades into light bluish-gray clay at a depth ranging from 30 to 40 inches. In nearly all areas of this soil the former high water table has been effectively lowered, and crops may be as safely grown on most of this land as on the Brookston soils.

With such limitations as the slightly greater liability to flooding imposes, Clyde silty clay loam is otherwise almost identical in crop adaptations and tillage requirements with the Brookston soils. Corn, clover, grasses, and sugar beets give large yields.

Included on the soil map with Clyde silty clay loam is a very dark crumbly soil with a stiff waxy subsoil. The heavy waxy subsoil is within reach of the plow in many places and is locally termed "Jack wax" or "gumbo." When saturated with water it is sticky and tenacious, and on drying it becomes hard and difficult to penetrate with a spade. Within a rather narrow range of moisture content, the clay subsoil when plowed up breaks into small angular aggregates that mix with the surface soil in a very desirable condition of tilth. Alternate freezing and thawing leaves a loose mass of small angular granules or coarse crumbs which are retained throughout the season provided care is taken not to cultivate the land when wet.

These heavy clay areas occur in only a few distinctive places, such as $2\frac{1}{2}$ miles south of Roll and in sections 34 and 35, T. 24 N., R. 11 E., but smaller areas with similar waxy subsoils are of rather common occurrence in all dark-colored soils. Spots of Jack wax are even reported in areas of Brookston silty clay loam where the subsoil is little more than stiff drab clay not especially difficult to till except when very wet. Areas of this variation are of common occurrence in Clyde silty clay loam, but in few places are the areas more than a few acres in extent. This included soil also occurs in and near some of the areas of shallow muck. The areas in the northern part of Jackson Township are of this character, and here the surface layer of black muck makes them much more easy to till than they would be were the muck removed.

In a Clyde silty clay loam area $2\frac{1}{2}$ miles south of Roll, sugar beets are very successfully grown. In the somewhat unfavorable season of 1928 good yields of corn, clover, and oats were obtained on all areas of this soil where adequate drainage was provided.

Although small spots are difficult to handle and the tillage requirements of the larger areas increase the labor of cultivation, this is a strong durable soil and is highly esteemed for growing corn, sugar beets, clover, and alfalfa.

Abington silty clay loam.—Abington silty clay loam occurs along the larger ditches and in the wider parts of the valley of Lick Creek.

The high content of organic matter and generally favorable physical condition give this soil a high value for corn, clover, potatoes, and tame grasses. The possibility of overflow prevents its safe use for fall-sown crops, but some of the slightly sloping areas at the foot of the adjoining slopes are almost free from danger of this kind. The areas south and southwest of Hartford City have received more or less clayey deposits in recent times and may be a little less friable than those east of the town, which include some shallow muck with a calcareous clay subsoil.

The subsoil of Abington silty clay loam in most places is dark-drab clay with a granular structure. The many cracks and fissures in the exposed material in the sides of ditches indicate a granular structure down to the beds of underlying sand and gravel, which are from 8 to 10 feet below the surface. Although the material is very

retentive of moisture, underdrainage is very efficient since the stream channels have been deepened. Many yellow stains and yellowish-brown mottlings occur in the upper part of the subsoil, but above the underlying sand the clay is strongly mottled and highly calcareous. The reaction of the surface soil and of the upper subsoil layer is slightly alkaline.

In sections 4, 5, 8, and 9, T. 23 N., R. 11 E., the original high content of organic matter in the surface layer has been reduced by fires that occurred many years ago and by recent cultivations. In section 10 and thence eastward the soil is very similar to Clyde silty clay loam, although it includes a few patches of shallow muck. All these areas are under tillage and will yield successive crops of corn with little decrease in yields. Crop rotations are not observed very closely, and no fertilizer or lime is used. The areas immediately west of Dunkirk include some slightly gravelly patches, and in these the subsoil may contain more coarse material, and gravelly clay occurs at a depth ranging from 40 to 60 inches below the surface. Elsewhere the surface soil and subsoil are similar to the corresponding layers in the northern part of Jackson Township. From Millgrove westward the land is subject to rather frequent overflow, but it is highly esteemed for corn, clovers, and grasses.

Muck.—The aggregate area of muck in Blackford County is 2,688 acres. Much of it occurs in small areas of a few acres each, but a few bodies are much larger. Two of the largest are the area in which Little Lick Creek originates, and the area 2 miles southeast of Mollie. Nearly all areas of muck in the county are under cultivation or form parts of bluegrass pastures.

With the exception of the lowest spots in the larger areas and the small isolated patches which are difficult to connect with adequate drainage outlets, the normal ground-water level ranges from 2 to 4 feet below the surface, although in all areas it fluctuates more or less with the seasonal rainfall. The water level, however, has been so generally lowered as a result of improved drainage that the surface of these organic deposits is commonly as dry as that of the adjacent black soils. A few small forested patches and a very few buttonwood ponds and small cattail marshes remain, but elsewhere bluegrass has generally succeeded the original coarse grasses, and ragweed, wild hemp, and different kinds of tall weeds thrive vigorously along the ditches and fence rows.

The material in the surface layer is prevailingly very dark brown finely divided material having a somewhat grainy or fine lumpy feel. It is heavy enough, or has sufficient weight, to possess fairly good tillage properties, as it packs slightly after rains and seldom becomes so dry as to be easily moved by the wind. The surface layer in most places contains some old woody débris, but in few places is it abundant. Very little of the muck is fluffy or loose, but it has attained a somewhat mellow condition. This is especially apparent in the areas of shallow muck where a little clay from the subsoil has become mixed with the surface layer. Almost everywhere some clayey material from the surrounding mineral soils has been added as a result of surface wash and by wind action. In permanent pastures considerable compaction of the surface layers has occurred, which, with additions of manure and by oxidation processes, has greatly

modified the material. In such places the muck is very dark colored and less loose than in the few places where original conditions have not been modified.

Below the prevailing ground-water level more fibrous material occurs in most places, but, in general, the proportion of very fine, or colloidal, material is sufficiently large to render the subsurface layers somewhat sticky and to improve the moisture conditions, as compared with those of coarse fibrous peat.

The areas at the head of Little Lick Creek include a rather large proportion of shallow muck overlying very dark colored clay, at a depth ranging from a few inches to 2 feet below the surface. The clay is, in many places, decidedly stiff, or waxy. The shallow surface layer has suffered much waste by fires, which were rather frequent many years ago, and tillage operations have resulted in more or less reduction of the material in more recent times. On account of the waxy subsoil further shrinkage of the surface layer is to be regarded as detrimental and should be guarded against as much as possible. The mixing of clayey material with the surface layer tends to improve the workability of these areas of shallow muck.

Nearly all areas of muck under tillage are devoted to corn. No fertilizer or other soil amendments are used, and about the same cultural methods are employed as on the dark-colored mineral soils. Planting in many places has to be delayed somewhat in spring but rapidity of growth compensates for the later start. Damage by frost is more frequent than on the adjoining dark-colored mineral soils, chiefly by reason of slower maturity of the crop. Corn almost invariably remains green a little longer than on the adjoining mineral soils. Yields of 70 or 80 bushels an acre of corn are sometimes obtained, but the average yield of sound corn is considerably lower, and the quality, in general, is not so good as that of corn grown on upland soils.

Sugar beets, tomatoes, and onions are successfully grown on muck, and there seem to be no soil conditions that would prevent more extensive use of muck areas for such crops. Potatoes do not yield so well as they did many years ago. Red clover and alfalfa thrive on the areas of shallow muck, but a stand is not so easily obtained as on the dark-colored mineral soils. In bluegrass pastures the rankness of the growth compensates for the somewhat inferior quality of the grass.

In places small areas of muck have received so much clayey overwash from surrounding higher land that the original surface materials have been entirely changed. In some places more or less mineral matter is mixed with the upper few inches of muck, and in a few areas the deposit is an almost purely mineral soil ranging from a few inches to more than a foot in depth. An area in section 23, T. 24 N., R. 11 E., southeast of Montpelier, and several others in this vicinity have a surface layer of dark-brown crumbly clay overlying dark-brown muck which extends to a depth of several feet. The roadside and field ditches are not large enough to accommodate all the flood water, and occasional inundations still contribute to the clayey layer. This clay layer when cultivated assumes a somewhat granular struc-

ture, is easy to till, and the moisture conditions are very good, provided the ground-water level is not too high.

Most of the small included areas have a sufficiently deep deposit of clayey material to require tillage operations similar to those used on the Clyde soils. In many places muck consists of a layer of soft black material less than 12 inches thick, with stiff clay just below it. In nearly all places all the muck material gives an alkaline reaction.

The utilization of these areas is entirely a question of drainage, and where this requirement is met the new soil proves very satisfactory for corn and is equally well adapted to most other crops.

LIGHT-COLORED SOILS

The group of light-colored soils includes Crosby silty clay loam, Bethel silty clay loam, Miami silty clay loam, Miami silt loam, Miami silt loam, slope phase, Fox silt loam, and Fox loam.

The soils of this group cover 52.5 per cent of the area of the county. In general, they are not so productive as the soils of the dark-colored group, and most of them are much in need of organic matter and nitrogen. The surface soils of most of them are of fine silty texture, and they are easily worked and maintained in a condition of good tilth. Surface drainage over all of them is good, and subdrainage is good except where impeded by a tight heavy subsoil.

Most of these soils range from neutral to moderately acid in reaction, and the addition of lime is necessary on most of them to insure good stands of clover and alfalfa. Bluegrass thrives on most of them, and more of the soils of this group are used for hay and pasture than of the soils of the dark-colored group.

Crosby silty clay loam.—Crosby silty clay loam includes the greater part of the light-colored soils in Blackford County. It occurs on undulating or very gently rolling uplands and is the predominant soil on all the broad divides and slopes of mild gradient, but it gives place to Brookston silty clay loam in the intervening depressions. In well-cultivated fields the dry friable surface soil has a yellowish-gray cast tending toward ash gray on somewhat flat spots and to light brownish yellow on the more pronounced slopes. The subsoil to a depth ranging from 16 to 28 inches is heavy mottled gray, yellow, and brown silty clay, and the substratum is calcareous firm glacial till. On the better-drained slopes this soil resembles Miami silty clay loam, and in the flatter places it resembles the Bethel soils. These variations are everywhere more or less in evidence, in many places well developed in a tract as small as a 5-acre field, and they must be kept in mind in considering the soil as a whole. Farmers recognize these variations chiefly by the slightly different way in which the soil responds to tillage and is affected by seasonal conditions, but it is not practical to make much adjustment of tillage operations and crop distribution to these variations. In normal seasons such adjustment is not necessary, but any marked departure from normal rainfall affects the soil in these spots in a different manner.

Drainage of the Crosby soils is less effective than is desirable for most satisfactory tillage. This is owing in part to mild relief, but

the character of the soil material is the dominating factor. The silty surface layer absorbs rainfall very readily, but the downward movement of moisture is rather slow, particularly after the subsoil becomes saturated.

The humus supply in this soil is low, particularly in fields that have been tilled for a period of more than 10 or 15 years. The wood lots and old bluegrass pastures that have been brought into cultivation within the period mentioned constitute but a small part of the total acreage, so that similarity of conditions in this respect generally prevail. Because the surface soil consists so largely of silt particles it is very friable under normal moisture conditions, regardless of the deficiency in humus. This silty texture facilitates tillage and favors the maintenance of a physical condition favorable to nitrification of such organic matter as is present. The supply of nitrates available at any time is doubtless less than in the dark-colored soils. This is indicated by the rate of growth of corn which starts rather slowly in the spring, but as the season advances the corn improves in color and grows more rapidly. A similar effect on other crops is more or less apparent. In a field previously in clover, or to which manure has been applied, the surface soil is slightly darker and less compact than is similar soil on which corn has been grown for a number of years.

The results of chemical analyses³ show less phosphorus in this soil than in the dark-colored soils, but the difference in potassium content is less marked. In all areas of this soil the availability of these elements, so far as they are determined by tillage, drainage, and other factors, is the important consideration.

The surface soil gives an acid reaction, ranging from slight to medium, in the areas of typical soil, with a tendency toward increased acidity in the light-colored spots. At a depth ranging from 10 to 15 inches, or in the upper part of the heavy subsoil, the degree of acidity is usually greater. At a depth ranging from 15 to 22 inches a neutral reaction may be obtained, and the parent material which lies just below this contains so much free lime that it effervesces vigorously when tested with hydrochloric acid. In some spots all layers of the soil are practically neutral in reaction.

In few areas of this soil is the acidity of sufficient consequence to affect corn, small grains, and most of the minor crops. In some seasons red clover either fails entirely or makes a poor growth, due in part to soil acidity. Unfavorable weather conditions aggravate the trouble. Lime has not been extensively used on this soil, but a number of farmers have reported results of apparent benefit to red clover, whereas other reports have indicated negative results. This seems to be true also with regard to sweetclover, although this crop has been grown only in recent years, and it shows marked partiality for dark-colored spots in the field. Some of the more successful fields of alfalfa on the light-colored soils have been previously limed.

As the usual rotation of clover, corn, and small grain is seriously interrupted by a failure of the clover, the use of lime seems to be

³ See results of chemical analyses on p. 29.

a desirable form of insurance and is worthy of consideration in the management of this and other light-colored soils.

A large proportion of the annual corn crop in Blackford County is grown on this soil. The average acre yield is probably between 35 and 40 bushels. Yields ranging from 50 to 60 bushels an acre are very frequently obtained under favorable conditions, but such yields are much above the average. Corn responds most noticeably to an increase in organic matter, either from manure or the turning under of clover or bluegrass sod. Methods of tillage and seasonal conditions are important factors, but humus renewal seems indispensable for profitable returns. The third of three successive crops of corn is usually very poor unless liberally fertilized. Commercial fertilizers are not in general use, but many farmers apply from 200 to 300 pounds of a complete mixture at time of corn planting. The nitrogen in such mixtures is in general not more than 2 per cent, with 10 or 12 per cent of phosphorus, and different percentages of potash.

Wheat ordinarily does well on this soil, but this crop requires at least some superphosphate and is usually benefited by a complete fertilizer which at present seems to be in general favor with farmers. As so many factors enter into crop yields, the effect of soil influence alone is not very easily determined. Sometimes wheat does well on adjoining areas of Crosby and Brookston soils, and in other seasons the crop shows considerable difference on the two soils. Both wheat and oats often ripen unevenly in fields of mixed soils.

Oats are an important crop on this soil and, like corn, show the effect of any increase in organic matter. Where the soil is very deficient in organic matter the surface layer becomes much compacted before the crop matures. Yields, however, are very noticeably influenced by the distribution of rainfall. An excess of rain in early spring, followed by a deficiency, may seriously affect the oat crop, but light and rather frequent rainfalls with subnormal temperature seem to favor the crop.

Soybeans do not thrive so well as on the dark-colored soils, the difference being very apparent in most places. Some consideration must be given the fact that soybeans are often grown on ground which may have produced several successive crops of corn, or has not been well managed otherwise.

As so many farmhouses are located on areas of the Crosby and Miami soils, these soils have been subjected to long and varied tests with respect to adaptability to fruit trees, shrubs, and ornamental plants. Their adaptability to apple, cherry, peach, and pear trees seems to be well established, and this seems true of many less important trees and shrubs. Plants requiring a sandy soil are at a greater disadvantage than those needing a high degree of fertility, because fertility can be supplied to a great extent. Bluegrass makes less vigorous growth than on the dark-colored soils, but it commonly displaces the clover and many kinds of weeds in yards and pastures.

Table 4 gives the results of mechanical analyses of samples of the surface soil, the subsurface soil, and several layers of the subsoil of Crosby silty clay loam.

TABLE 4.—*Mechanical analyses of Crosby silty clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
284358	Surface soil, 0 to 4 inches							
	-----per cent.	0.4	1.6	2.0	4.4	3.9	58.9	28.9
284359	Subsurface soil, 4 to 10 inches							
	-----per cent.	.3	1.2	1.9	4.0	3.3	59.3	29.9
284360	Subsoil, 10 to 18 inches...do.	.1	.5	1.1	2.6	2.4	42.3	51.0
284361	Subsoil, 18 to 30 inches...do.	.5	1.1	1.8	4.2	5.1	35.9	51.5
284362	Subsoil, 30+inches...do.	1.4	2.3	1.2	2.4	5.6	46.3	40.9

Bethel silty clay loam.—Within all the larger areas of Crosby silty clay loam, flat spots occur, in which the elevation and degree of slope is just sufficient to prevent the accumulation of rain water on the surface. The soil in these spots has been correlated as Bethel silty clay loam. In such locations the surface soil is distinctly light gray, and in a well-tilled field may be very pulverulent and have an ash-gray cast. After a heavy rain, the surface soil in such spots dries slowly and a firm crust forms, which is more easily broken into rather hard porous clods than reduced to the former fine tilth. These are locally called "clay spots," and by some are compared to "post-oak flats," but they hardly merit the latter designation. In many places the color and tillage peculiarities are not quite so pronounced as in the foregoing description, and the soil is essentially a gradation between this very light gray soil and the typical Crosby soil.

A far greater acreage is included in these intermediate variations than can be assigned to typical Bethel silty clay loam. Every large area of Crosby silty clay loam includes some areas of Bethel silty clay loam, but in many places none of the Crosby soil areas, or only a small part of them, presents the ash-gray surface soil and tight subsoil of well-developed Bethel silty clay loam.

An ash-gray layer of firm but rather porous silty material occurs just below plow depth. This gives place within a few inches to mottled clay which is stiff and somewhat sticky when wet, somewhat gummy when moist, and very resistant to penetration when dry. Although the fissure planes are very evident when the soil is dry, they do not allow even as free moisture movement as normally occurs in the subsoil of the Crosby soil. The downward and lateral movement of excess rainfall is therefore very slow, and much of the moisture escapes through evaporation.

Both the surface soil and subsurface soil give a medium or strong acid reaction with Soiltex. In most places the subsoil is similarly acid in the upper part, but in the lower part it is neutral or only slightly acid. At a depth ranging from 15 to 25 inches from the surface highly calcareous material occurs.

The naturally low content of organic matter implies that available nitrogen is low. Except where this deficiency has been remedied by manure, crop residues, or a nitrogen-carrying fertilizer, young corn plants have a light-green color and develop slowly. Wheat and oats start somewhat more quickly than on the dark-colored soils but nowhere make such a rank growth as on those soils. The growth of

these grains is usually less vigorous than on Crosby silty clay loam. Clover frequently fails, or makes a poor stand, and it almost invariably reveals the spots of this soil, although the timothy mixed with it may be thriving as well as on the surrounding soils. In seasons of rather light but frequent rainfall all these crop differences are less noticeable.

Tile drainage is fairly effective in those areas where lines have been installed, but in very few places have enough laterals been laid to these flat spots to insure good tillable conditions in wet seasons. It is the subsoil layer between depths of 12 and 22 inches which commonly causes the trouble. The extremely acid condition of this soil leaves little question as to the advisability of applying ground limestone, although few farmers have done so.

Miami silty clay loam.—Miami silty clay loam is the better-drained soil of the uplands. The surface soil is grayish-brown heavy but friable silt loam, the subsoil is yellowish-brown silty clay, and the substratum is heavy calcareous glacial till.

Miami silty clay loam includes most of the strongly undulating or somewhat hilly lands along the larger streams. Along Salamonie River much of this soil occurs as moderately steep slopes bordering the valley and extending back to the heads of the short tributaries. Only a small proportion has such slight slope as to allow convenient tillage, although nearly all the land, except the very steepest slopes, has been cleared, and on these a forest growth remains.

The areas of this soil are used almost exclusively for pasture. Bluegrass thrives in all places not shaded by trees. It forms permanent pastures and, considering the fact that it is self-seeding and requires no care, it doubtless gives a much higher net return than is commonly credited to it.

The areas in the vicinity of Hartford City have a somewhat uneven surface relief, with, in most places, a short sharp decline to the adjoining stream valley. A very large proportion of the land is tillable with ordinary farm implements, and the common field crops are regularly grown on the milder slopes.

About four sections of land in the southwestern corner of the county consist chiefly of this soil, divided by a strip of alluvial soils along Lick Creek. These rolling lands are used almost exclusively for pasture, and a little larger proportion is in wood lots than of corresponding areas of smooth land.

On most of the steepest slopes the original surface soil has been more or less removed by erosion, and the yellowish-brown silty clay is exposed. This material is fairly easy to till when at the proper moisture content, but if too wet or too dry it is difficult to cultivate, and as it absorbs rainfall rather slowly the susceptibility to dry weather is greatly increased. Little or no humus remains in the soil of these eroded spots, but a compensating factor is the slight depth at which abundant lime is present. Any of the clovers, if a stand can be obtained, make a heavy growth on the slopes.

Table 5 gives the results of mechanical analyses of samples of the surface soil, the subsurface soil, and several layers of the subsoil of Miami silty clay loam.

TABLE 5.—*Mechanical analyses of Miami silty clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
284300	Surface soil, 0 to 4 inches							
	-----per cent.	0.9	2.5	3.4	8.0	6.9	45.6	32.8
284301	Subsurface soil, 4 to 7 inches							
	-----per cent.	.7	2.3	3.3	8.0	7.1	45.6	32.0
284302	Subsoil, 7 to 11 inches...do	1.0	2.5	3.2	7.5	6.7	39.4	39.8
284303	Subsoil, 11 to 18 inches...do	.6	2.2	2.4	5.8	5.3	25.0	58.7
284304	Subsoil, 18 to 23 inches...do	.6	2.0	2.5	6.2	5.6	26.0	57.0
284305	Subsoil, 24+ inches...do	2.5	3.4	2.7	6.2	6.8	32.0	46.5

Miami silt loam.—Miami silt loam differs from Miami silty clay loam in its somewhat coarser texture and in the greater depth to the heavy subsoil. The friable surface and subsurface layers of the silt loam may have a combined thickness ranging from 12 to 18 inches, and they contain a little more coarse material than the typical silty clay loam. In the silty clay loam areas the plow in many places reaches the clayey subsoil, whereas in the areas of silt loam this occurs only on somewhat eroded slopes. Otherwise the two soils are similar. The small areas of Miami silt loam in the southwestern part of the county have the same crop adaptations and tillage requirements as Miami silty clay loam. Farther south, in Grant County, the differences become more pronounced.

Miami silt loam, slope phase.—The slope phase of Miami silt loam in Blackford County has lost more or less of the original surface soil, and the yellow clayey material forms the present surface soil on the steeper slopes. These areas have the same agricultural value as the more sloping areas of Miami silty clay loam.

Fox silt loam.—Fox silt loam occurs on the high bench lands of Lick Creek. It is a brown soil containing more fine sand than Crosby silty clay loam. It is not much better supplied with humus than the Crosby soil, although the color is somewhat darker. In only a few places is the surface free of scattered gravel, and on the marginal slopes gravel and small stones may be very abundant. The upper subsoil layer is decidedly heavier than the surface soil, and it consists of brown or reddish-brown clay loam. The lower subsoil layer is dark neutral gravelly clay. At a depth ranging from 3 to 4 feet, the upper limit of a deep bed of loose gray gravel is reached. In the swales and local depressions it may lie deeper, but everywhere it influences the underdrainage. As a rule the soil mass is thick enough to retain moisture sufficient for all crops under normal seasonal precipitation, except on the more stony slopes and on a few gravelly mounds, but these areas are of very small extent.

The surface soil is slightly acid, the reddish-brown sticky layer in the subsoil is usually less acid than the surface soil, and the underlying gravel contains an abundance of free lime.

The areas between Dunkirk and Millgrove lie on level benches from 10 to 15 feet higher than the bottom land to the south. Here the soil is somewhat gravelly, but it retains moisture well. The northern part of each area merges into the dark-colored soils which contain considerable organic matter.

Fox silt loam is an excellent wheat soil, in which moisture conditions meet the requirements of that crop better than in the heavier soils. Manure or commercial fertilizer is necessary for best results with wheat and corn. Good success with alfalfa without previous liming is reported in a few places.

Fox loam.—A few small areas of low second bottoms, in which the soil is brown loam or sandy loam, containing considerable sand and gravel, occur in the valley of Lick Creek. The subsoil and substratum are like the corresponding layers of Fox silt loam. Some of the areas are well-defined terraces, from 10 to 15 feet high, along the creek, and others are low uneven ridges. These areas are not entirely above overflow, and renewal of soil fertility by this means doubtless compensates for the occasional damage to crops. Applications of manure and changes to clover and grass are beneficial, especially on the higher and more sandy areas. All the land is in cultivation.

ALLUVIAL SOILS

Nearly all the bottom lands of Blackford County have been cleared, and they annually produce grain and grasses. Along the immediate banks of Salamonie River some strips of uneven ground are occupied by trees and weeds, and a few patches of forest are too dense to allow a grassy undergrowth, but with these exceptions tillable fields extend from the foot of the upland to the banks of the stream. Similar conditions prevail in the valley of Lick Creek below Hartford City. The narrow strips of alluvium along the small branches are mostly in permanent bluegrass pastures.

These soils are fertile, very easily tilled, and require no regular crop rotations to insure continued productivity. Wherever fields of sufficient size for convenient cultivation can be laid out, corn is the principal crop. Wheat, oats, and tame grasses are rather extensively grown on all the larger tracts, but the ratio of their combined acreage to that of corn is not so high as on the uplands. Alfalfa and soybeans thrive exceptionally well in many places, but they have not displaced the common field crops to any great extent.

The amounts of organic matter in these soils differ considerably, judging from the colors which range from brown to nearly black. This color difference is not of great importance, because in all the soils the organic matter is rather deeply distributed and influences the color to a depth of 20 or more inches. In many places the occurrence of a dark silty subsoil layer marks the original surface of the ground. Much deposition has occurred in recent times, and many old depressions have been partly filled with clayey sediments. Heavy soils predominate, except on the immediate banks of the larger streams, sandy loams are almost entirely absent, and friable silt loams have no extensive development.

Genesee silt loam.—Genesee silt loam of the larger stream valleys has a dark-brown silty surface soil overlying somewhat lighter brown silty material. Evidences of good drainage and aeration to a depth of several feet are apparent in most places. In some places the surface soil gives a slightly alkaline reaction, but in most places the material to a depth of several feet is neutral or very slightly acid. Along small streams most of this soil is heavy silty clay and consists largely of recent wash from the adjoining uplands.

In the vicinity of Montpelier small areas of alluvial soil are underlain by limestone at a depth of a few feet. Along the river bank the soil consists chiefly of brown silty deposits, and a little farther back from the streams it is dark-brown heavy silty loam, consisting in part of deposits from backwater. Some waste dirt from abandoned quarries, which are now permanent ponds, is included with this soil in mapping.

Areas of the deeper phase of Genesee silt loam are sufficiently retentive of moisture to render this soil productive, but the shallow areas are somewhat droughty.

Eel silty clay loam.—Areas in which the ground water level is frequently high are characterized by a mottled brown and gray subsoil coloration. The surface layers may contain more or less organic matter, with a consequent dark color and crumbly structure. Such areas are mapped as Eel silty clay loam which is a very productive soil where artificial drainage has rendered it safely tillable. All of this soil is subject to overflow.

Wabash clay.—Wabash clay is characterized by a dark-colored crumbly surface soil. The desirable physical condition is owing to the rather high content of organic matter and to the alkaline character of the soil. The drab subsoil extends to a depth of several feet and, as it has a more or less granular structure, internal drainage and aeration are effective. Although the land is subject to rather frequent overflows, the ground water level is sufficiently low to allow its use for farm crops. Although planting may be delayed and cultivation limited to rather short periods, corn grows very rapidly, and yields of 75 bushels an acre are often obtained.

SOILS AND THEIR INTERPRETATION

The soils of Blackford County are included in two principal groups, dark-colored soils and light-colored soils, and a third group which includes the recent-alluvial deposits of comparatively small extent and some small areas of organic soils. The light-colored soils comprise 52.5 per cent of the total area of the county, and the dark-colored soils embrace 44.1 per cent.

All the soils, except some of the muck areas, were formerly forested. Oak, hickory, and sugar maple predominated on the light-colored soils, and elm, ash, and soft maple formed much of the cover on the dark-colored soils. Sycamore is a characteristic tree on the recent alluvial soils. Before artificial drainage had been introduced, trees and shrubs occupied much of the muck land, and coarse grasses and purely aquatic plants were restricted to comparatively small areas.

One of the less extensive light-colored soils dominates the extreme southwestern part of the county, and two of the dark-colored soils are limited to rather well-defined locations, but otherwise the individual areas of the principal soils show little regional grouping, and they have a comparatively uniform distribution throughout the county.

With respect to topographic position, however, the limits of each of these two soil groups are very closely drawn. The dark-colored soils occur only in the slight depressions and in wide somewhat flat areas slightly lower than the surrounding land, but the light-colored soils prevail on the local elevations, broad divides, and steeper slopes

bordering the valleys. Not only is each group restricted to its appropriate topographic position, but in the light-colored soil group a comparatively close relationship exists between the soil type and the degree of surface inclination. In the light-colored soil group the Miami soils predominate on the rolling or somewhat hilly areas, the Crosby soils prevail wherever undulatory or very gently rolling relief occurs, and the Bethel soils are restricted to those nearly level spots having just sufficient convexity of surface to prevent the accumulation of surface water. In the dark-colored soil group the relation between the soil type and the surface relief is not so close, but a somewhat similar relationship is observable. The Brookston soils not only dominate the larger depressions but may extend a very little way up the adjoining slope, or may extend entirely over a slight local elevation. Clyde soils are characteristically developed only in pronounced depressions and in other poorly drained situations which are favorable to the accumulation of organic matter.

In both groups of soils, each soil type is largely the expression of the average, or prevailing, moisture conditions that formerly existed where the soil now occurs. The close and consistent relationship between these average moisture conditions and topographic position is owing to the remarkable uniformity in the character of the parent material which consists of firm rather dense light-colored till composed chiefly of silt and clay particles, with only a very small proportion of sand and stones. Over wide areas it seems to have very similar physical characteristics, offering considerable resistance to the movement of water and yielding rather slowly to downward extension of those weathering processes that tend to loosen or disintegrate it. This till is a rock flour to which the underlying Silurian limestones evidently contributed much material, as it is highly calcareous. Leaching, oxidation, and other alteration processes have affected the till to a depth ranging from 3 to 4 feet.

In all the light-colored soils the A and B horizons, which correspond to the surface soil and subsoil, are well developed and distinctly set off from each other and from the parent material by physical and chemical differences. Eluviation has resulted in the highly silty texture of the surface layers and the clayey character of the subsoil layers. Ferruginous constituents have increased considerably in the subsoil layers as compared with the till, and silica has accumulated in the surface layers. Calcium carbonate has almost entirely disappeared from both the A and B horizons. Under pre-cultural conditions meager accumulations of organic matter occurred, with consequent limited development of the crumb structure so characteristic of the dark-colored soils.

The Miami soils doubtless represent the most mature type of soil development in well-drained situations in this region. In Blackford County the Miami soils are not so extensive as in Grant and Delaware Counties, as stronger relief prevails over a larger proportion of those counties and the parent material seems a little coarser in texture. The Miami soil on the steeper slopes in Blackford County has a thin A horizon due to erosion, and on slopes of less than 8° or 10° the retentive character of the materials tends to the development of Crosby characteristics.

In the true Miami profile the several horizons grade one into the other without sharp contrasts in texture, structure, or color. The

color below the dark-gray surface layer is yellowish brown, indicative of very uniform oxidation and distribution of the iron. In the extreme lower part of the B horizon some segregation of the iron, and possibly manganese, has resulted in dark-brown spots, but elsewhere mottled coloration or concretionary forms are absent.

The profile of Miami silty clay loam as observed on a wooded hillside ranging from 10° to 15° inclination, about 1½ miles southeast of Montpelier, is as follows:

From 0 to 2 inches, dark-gray loose silt loam mixed with well-decomposed organic matter.

From 2 to 6 inches, pale yellowish-gray friable silt loam which is soft and crumbly. The lower half of the layer contains very little organic matter.

From 6 to 12 inches, heavier silt loam which is rather firm but porous and has little or no definite structural arrangement.

From 12 to 24 inches, moderately hard silty clay loam which breaks into aggregates from one-eighth to one-fourth inch in diameter. The granules separate easily when moist. Brown is the dominant color in this layer, with some darker interior specks but very little gray coloration on the outside. Below a depth of 18 or 20 inches these subangular lumps are somewhat larger and cleavage planes are well developed, especially some vertical planes. More rust-brown coloration is seen in the lower part of this layer.

From 24 inches downward the material is somewhat fissured, and yellow stains occur along the cracks and through the otherwise dense and lighter-colored massive till.

All the layers above a depth of 24 inches seem to allow comparatively free internal drainage and good aeration along the cleavage lines, and the interior of the structural separates is porous rather than dense. The till is highly calcareous, but the soil layers give a slightly acid reaction, except a neutral zone about 6 inches thick above the till.

The profile of the Crosby soils differs from that of the Miami in the predominance of gray coloration in the profile. In the B horizon, or subsoil, most of this gray coloration may be on the outside of the soil aggregates, but a sample of the B horizon brought up on a soil auger is a mixture of grayish-brown and yellowish-brown material. The textural differences between the layers is in most places very pronounced and may be accentuated by the tendency to a single-grain structure in the A₂ horizon, and by the occurrence of considerable colloidal material in the fissures in the lower part of the B horizon.

A profile of Crosby silty clay loam observed about 1 mile northeast of Hartford City in the wood lot on the north side of the electric railway in the NE. ¼ SE. ¼ sec. 2, T. 23 N., R. 10 E., is as follows:

From 0 to 2 inches, a very thin layer of forest litter underlain by moist brown forest mold.

From 2 to 4 inches, a mixture of rather loose well-decomposed organic matter and silt, which is very dark colored, with the organic content decreasing with depth. The pH value is 7.58.⁴

⁴ Determinations of pH values are by E. H. Bailey, Bureau of Chemistry and Soils, U. S. Department of Agriculture.

From 4 to 10 inches, yellowish-gray silt loam, grading to grayish-yellow silt loam which consists of fine soft crumbs. This material has a somewhat laminated structure, especially in the upper part, and it is slightly compacted below. The pH value is 4.62.

From 10 to 18 inches, granular material breaking easily into angular aggregates from one-eighth to one-fourth inch in diameter. The aggregates are more or less coated with gray powdery soil grains, evidently leached silt carried down from above. The interior of the granules is a mixture of yellow and brown material without definite segregation of iron. The granules are larger and harder in the lower part of the layer. Most of the material in this layer is silty clay loam, but it is heavier in the lower part than in the upper part. This is a transitional layer between the A and B horizons. The pH value is 4.89.

From 18 to 30 inches, darker-colored material than in the layer above, and heavier silty clay loam of coarse blocky or granular structure, in which the aggregates are from one-half to 1 inch in diameter. The exterior of the aggregates is dull brown or dingy brown, with some darker colors in places where a film of colloidal material covers the granules. The granules are rather hard, somewhat porous but not friable, and the interior shows much yellow and rust-brown coloration. The pH value of the soil material in this layer is about 6.80. Tree roots penetrate this layer, and the aggregates separate easily on partly drying. Underdrainage does not seem so effective as in the corresponding layer of the Miami soils. This may be owing in part to the characteristics of the underlying till.

From 30 inches downward the till is hard, rather dense, and not easily penetrable by water, except along cracks that become less numerous with increase in depth. Some oxidation along the fissures and in the mass between them is evidenced by the yellow and brown stains. At this point the till contains some sand, a little quartzose gravel, and some small stones. The pH value is 8.19.

The profile of the Bethel soils resembles that of the Crosby soils, but several of the characteristics are more strongly pronounced in the Bethel. The degree of acidity is higher, especially in the A horizon and the upper part of the B horizon. The organic matter occurs only in the 2 or 3 inch surface layer. There is a noticeable tendency to a single-grain, or deflocculated, structure between the humus layer and the upper layer of the B horizon, which shows much gray coloration in a freshly exposed surface, but close inspection shows the exterior of the structural aggregates to be well coated with gray, or bleached, grains that evidently have filtered down from the A horizon. The interiors of the aggregates are mostly yellowish-brown silty clay containing some dark rust-brown specks.

In the lower part of the B horizon the soil lumps are larger and the gray coating is less evident. More or less dark-brown colloidal material is in the fissures, in places filling the larger joint planes, or it may form a varnishlike coating on the sides of the fissures. In

the extreme lower part of the B horizon the iron and manganese is much segregated into very dark brown spots and small lumps of concretionary material. The concretionary material does not form a continuous belt but marks, in an irregular way, the contact of the neutral zone with the highly calcareous C horizon just below it.

The podzolic processes, whereby a gray or leached subsurface layer developed, seem to be stronger in this than in any other of the light-colored soils.

As previously stated, the Bethel soils are inextensively developed in Blackford County, as the necessary topographic situations for their development in few places include more than a few acres, and areas of transitional soil between the Bethel and Crosby silty clay loams are more common. This is true also of other counties in north-central Indiana where small spots of Bethel soils occur within large areas mapped as Crosby silt loam and Miami silt loam, flat phase. It is a noteworthy fact that a number of areas in Blackford County and other eastern Indiana counties have soils resembling Crosby silty clay loam and Bethel silty clay loam, which are neutral in all horizons, whereas the normal soils are acid.

The terraces in the valleys of Salamonie River and Lick Creek are water-laid deposits of highly calcareous sand, gravel, and glacial rubble, together with a few large boulders. The low ridges in the flood plains are of similar character, but they contain some surface material of more recent deposition.

On the higher terraces, the A and B horizons are well developed. In the B horizon the clay and colloidal material feebly cements the more resistant coarse material into a dark reddish-brown mass ranging from a few inches to 3 feet in thickness. About the same conditions are evident in the younger material that forms the low ridges. Some acidity has developed in all the horizons, but the content of organic matter is small.

Very little eluviation has taken place in the dark-colored soils, so that these soils have no well-defined soil horizons. The frequent periods of submergence to a slight depth or of saturation prevented as much oxidation and leaching as occurred in the better-drained soils. The accumulation of organic matter, especially as alkaline conditions prevailed, would tend to produce a granular structure which still further resists removal of fine particles. Thus these dark-colored soil types are generally high in clay and colloids, and most of them are still alkaline or very slightly acid in reaction.

The profile of Brookston silty clay loam, the dominant dark-colored soil, shows a dark grayish-brown surface layer overlying a slightly less dark subsoil layer having some faint rust-brown mottling. The structure is rather coarsely granular. At a depth ranging from 2½ to 4 feet below the surface, the lime-bearing till may be present. The distribution of the mineral constituents shows less difference between the different horizons than occurs in the light-colored soils. The pH values are also comparatively uniform throughout the profile.⁵

⁵ These statements are based on a comparison of the analyses taken from records of the Bureau of Chemistry and Soils pertaining to samples of this soil from Wells, Decatur, Wayne, and Hancock Counties, Ind.

The profile of Brookston silty clay loam as observed in a small area 1 mile northwest of Hartford City, in the NE. $\frac{1}{4}$ sec. 3, T. 23 N., R. 10 E., is as follows:

- From 0 to 4 inches, very dark grayish-brown heavy silt loam composed of soft friable crumbs. The organic matter is well decomposed and intimately mixed with the mineral constituents. The pH value is 6.49.
- From 4 to 10 inches, material similar to that in the layer above, but in which the granules are somewhat harder and contain gray and yellow specks in the interior. The pH value is 6.40.
- From 10 to 15 inches, a layer of slightly lighter colored material. The angular aggregates, which are from one-eighth to one-fourth inch in diameter, are dull gray on the outsides and darker colored in the interiors. The pH value is 6.40.
- From 15 to 30 inches, heavy silty clay loam with a rather coarse, or "blocky," structure. The vertical fissures seem better developed than the horizontal ones, giving a somewhat columnar arrangement of individual masses. Some dark colloidal filling is seen, but the interior of the lumps is dark drabish gray with some yellow spots. The pH value is 6.43.
- From 30 to 42 inches, material similar to that in the layer above, except that much more yellow and rust-brown mottling appears in and on the individual lumps, the dominant color being gray or dark drab. The pH value is 7.42.

When these observations were made, in November, 1928, the ground-water level was not reached at a depth of 50 inches from the surface.

The Clyde soils are similar to the Brookston, but they contain a little more organic matter, and oxidation of the iron in the lower part of the subsoil has been retarded by the prevailing high water table. Under present drainage conditions the depth to the water table fluctuates greatly, but formerly the water table was so high that rather frequent saturations of the surface layers must have occurred. In the surface layer the soft crumb structure changes with increase in depth to a granular condition, and in many places the soil material occurs as small hard angular aggregates ranging from the size of shot to that of a small pea. Below the direct influence of the organic matter, the light-colored clay shrinks and swells with changes in moisture content, and it breaks into more or less coarse angular blocks separated by fissures. As a rule highly calcareous material is present at less depth than in the Brookston soils.

The heavier clay spots mapped with Clyde silty clay loam in many places contain from 50 to 60 per cent of clay and about 40 per cent of silt. To these large proportions of the finer particles constituting this soil are due in large measure those undesirable tillage qualities, on account of which the local terms "Jack wax" and "gumbo" have come into use. The surface material in cultivated fields may give a slightly acid reaction, but the subsoil is alkaline and an excessive amount of calcium carbonate occurs in many places at a depth of less than 30 inches.

A sample taken near Washington Consolidated School, in Washington Township, contained 18.58 per cent of organic matter in the surface soil, and 6.63 per cent between depths of 5 and 12 inches. No organic matter occurred at and below a depth of 28 inches, but at this depth the soil material contained more than 11 per cent of calcium carbonate.

As the alluvial soils consist so largely of local material, they are of heavy texture. With the exception of a few areas of silty sand along the channel of Salamonie River, all the bottom-land soils are silty clay loams or clays. The Abington soils are derived from alluvium older than that along the larger creeks and rivers of the county. Their slow drainage and the grassy vegetation that probably preceded the forest cover were conducive to the accumulation of organic matter, and the alkalinity, which still marks these soils, favored preservation of the organic matter and flocculation of the clay.

The more recent alluvial deposits and those areas of older deposits contiguous to well-developed drainage channels are characterized by the small amount of organic matter in the surface layer and the uniformly brown, or well oxidized, color which prevails to a depth ranging from 3 to 4 feet. This stage of development is evident in the Genesee soils, particularly those of silty or slightly sandy texture, but even in areas of Genesee silt loam most of the soil material is well oxidized and contains no calcium carbonate within a depth of several feet from the surface.

Eel silty clay loam is recent alluvium, marked by dark-brown or grayish-brown surface soils underlain by mottled rust-brown and gray materials, indicating by their mixed colors the frequent periods of saturation to which the soil is still subject.

Since the removal of the forest cover, surface wash from the light-colored soils has modified the older alluvium in many places. As a rule, this postcultural deposit is grayish-brown crumbly silty clay material having a slightly acid reaction, and in many places along the small branches it is of such depth as to determine the soil characteristics.

SUMMARY

Blackford County is in the east-central part of Indiana. The surface relief is that of an undulating plain, with some hilly lands immediately bordering the few stream valleys. About 90 per cent of the land is in cleared fields and pastures, and the rest is in small wood lots.

Light-colored soils of about the same types as in adjoining counties, occupy 52.5 per cent of the total area of the county, and the dark-colored mineral soils occupy most of the remainder. The alluvial soils are of small extent.

The average size of farms is 97.5 acres, and about two-thirds of the farms are operated by the owners. The methods of farming center around the production of corn, oats, and wheat as the principal field crops. Tame grasses and clovers are important, and soybeans, alfalfa, sugar beets, and tomatoes are common products, although they are not extensively cultivated.

PART 2. THE MANAGEMENT OF BLACKFORD COUNTY SOILS

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INTRODUCTION

The farmer should know his soil and have a sound basis for every step in its treatment. Building up the productivity of a soil to a high level, in a profitable way, and then keeping it up is an achievement toward which every farmer should strive. The business of farming should be conducted as intelligently and as carefully as a manufacturing business, in which every process must be understood and regulated in order to be uniformly successful. The farmer's factory is his farm, and a knowledge of the soil is highly important. Different soils present different problems as to treatment, and these must be studied and understood in order that crops may be produced in the most satisfactory and profitable way.

The purpose of the following discussion is to call attention to the deficiencies of the several soils of the county and to outline in a general way the treatments most needed and most likely to yield satisfactory results. No system of soil management can be satisfactory unless in the long run it produces profitable returns. Some soil treatments and methods of management may be profitable for a time but ruinous in the end. One-sided or unbalanced soil treatments have been altogether too common in the history of farming in this country. A proper system of treatment is necessary in making a soil profitably productive.

CHEMICAL COMPOSITION OF BLACKFORD COUNTY SOILS

Table 6 gives the results of chemical analyses of the different types of soil in Blackford County, expressed in pounds of elements in 2,000,000 pounds of plowed surface soil of an acre.

TABLE 6.—*Chemical composition of Blackford County soils*

[Elements in pounds per acre of surface soil 6 to 7 inches deep]

Element	No. 2, Miami silt loam	No. 6, Miami silty clay loam	No. 29, Crosby silty clay loam	No. 18, Bethel silty clay loam	No. 43, Fox loam	No. 8, Fox silt loam	No. 21, Brook- ton silty clay loam
Phosphorus ²	960	1,225	1,050	950	1,225	1,400	1,575
Potassium ²	7,050	6,550	6,550	5,375	6,050	6,200	11,275
Calcium ²	5,100	6,000	9,450	6,000	6,430	5,860	14,300
Magnesium ²	7,000	5,900	8,450	4,600	6,400	6,275	9,400
Manganese ²	1,000	1,300	1,000	1,150	1,440	2,000	720
Aluminum ²	42,900	44,000	44,000	45,000	39,250	46,000	67,500
Iron ²	39,000	44,000	31,000	38,000	39,000	44,000	48,700
Sulphur ²	480	500	400	300	480	480	500
Phosphorus ³	14	18	19	18	45	19	139
Potassium ³	168	185	168	219	286	118	235
Nitrogen ⁴	3,000	2,800	2,800	2,400	3,000	4,200	4,600
Potassium ⁴	34,100	31,300	33,300	29,900	35,800	34,300	37,300

² Soluble in strong hydrochloric acid (specific gravity 1.115).

³ Soluble in weak nitric acid (fifth normal).

⁴ Total elements.

TABLE 6.—*Chemical composition of Blackford County soils*—Continued.

[Elements in pounds per acre of surface soil 6 to 7 inches deep]

Element	No. 35, Clyde silty clay loam	No. 56, Abington silty clay loam	No. 14, Genesee silt loam	No. 10, Eel silty clay loam	No. 28, Wabash clay	No. 30, Muck	No. 60, Muck ¹
Phosphorus ²	3, 050	2, 100	1, 575	1, 575	2, 275	2, 880	1, 530
Potassium ²	13, 450	19, 500	9, 250	10, 000	17, 600	17, 650	2, 775
Calcium ²	22, 900	14, 860	22, 000	22, 000	16, 000	24, 500	17, 500
Magnesium ²	11, 825	9, 650	12, 800	4, 700	9, 050	12, 300	2, 900
Manganese ²	430	720	1, 440	1, 440	725	575	150
Aluminum ²	86, 500	104, 000	73, 200	56, 000	101, 700	103, 400	30, 500
Iron ²	49, 200	47, 700	44, 200	54, 800	61, 000	58, 000	10, 000
Sulphur ²	800	960	320	480	550	1, 525	1, 200
Phosphorus ³	340	218	122	56	190	160	83
Potassium ³	336	500	353	168	336	252	46
Nitrogen ⁴	9, 600	6, 000	4, 800	3, 600	5, 600	13, 200	21, 400
Potassium ⁴	32, 100	40, 360	38, 000	33, 400	40, 700	32, 600	7, 650

¹ Based on 1,000,000 pounds of surface soil to the acre.² Soluble in strong hydrochloric acid (specific gravity 1.115).³ Soluble in weak nitric acid (fifth normal).⁴ Total elements.

Three groups of analyses are given as follows: Total plant-food elements, elements soluble in strong (specific gravity 1.115) hydrochloric acid, and elements soluble in weak (fifth-normal) nitric acid.

The total plant-food content is more indicative of the origin and age of a soil than of its fertility. This is particularly true of potassium. The amount of total potassium in a soil is seldom an indication of its need for potash. Some Indiana soils which have more than 30,000 pounds of total potassium to the acre in the 6-inch surface layer fail to grow corn without potash fertilization, because so little of the potassium they contain is available.

The total content of nitrogen is generally indicative of the need for nitrogen, although some soils with a low total may have a supply of available nitrogen sufficient to grow a few large crops without the addition of that element. Soils having a low total nitrogen content soon wear out, as far as that element is concerned, unless the supply is replenished by growing and turning under legumes or by the use of nitrogenous fertilizer. The darker-colored soils are usually higher in organic matter. Organic matter and nitrogen are closely associated in soils, hence it is a rule that the darker a soil is the richer it is in nitrogen.

The amount of total phosphorus in ordinary soils is usually about the same as that shown by a determination with strong acid. For this reason a separate determination of total phosphorus has been omitted. The supply of total phosphorus usually indicates the general need of a soil for phosphatic fertilizers.

The amount of phosphorus soluble in weak acid is considered by many authorities as a still better indication of the phosphorus needs of a soil. The depth of a soil may modify its need for phosphates. Everything else being equal, the more soluble phosphorus a soil contains, the less it is apt to need phosphate fertilizers. Where the soluble phosphorus runs less than 100 pounds to the acre, phosphates are usually needed for high crop yields.

The quantity of potassium soluble in strong or weak acid is to some extent significant. This determination, however, is not so reliable an indicator as is the determination of phosphorus, particularly with

soils of high lime content. Sandy soils and muck soils are more often in need of potash than clay and loam soils. Poorly drained soils and soils with impervious subsoils usually need potash more than well-aerated, deep soils.

The use of strong or weak acid in the analysis of a soil has sometimes been criticized as having little or no value, yet such analyses can more often be correlated with crop production than can analyses of the total elements of the soil. For this reason acid solutions have been employed in these analyses.

It must be admitted, however, that no one method of soil analyses will definitely indicate the deficiencies of a soil. For this reason these chemical data are not intended to be the sole guide in determining the needs of the soil. The depth of the soil, the physical character of the subsoil and the surface soil, and the previous treatment and management of the soil are all factors of the greatest importance and should be taken into consideration. Pot tests indicate that nitrogen and phosphorus are much less available in the subsurface soils and subsoils than they are in the surface soils. On the other hand, potash in the subsoil seems to be of relatively high availability. Crop growth depends largely on the amount of available plant food with which the roots may come in contact. If the crop can root deeply it may be able to make good growth on soils of relatively low analysis. If the roots are shallow the crop may suffer for lack of food, particularly potash, even on a higher-analysis soil. The better types of soils and those containing large amounts of plant-food elements will endure exhaustive cropping much longer than the soils of low plant-food content.

The nitrogen, phosphorus, and potassium contents of a soil are by no means the only chemical indications of high or low fertility. One of the most important factors in soil fertility is the degree of acidity. Soils which are very acid will not produce well, even though there be no lack of plant-food elements. Though nitrogen, phosphorus, and potassium are of some value on acid soils, they will not produce their full effect where lime is deficient. Table 7 shows the percentage of nitrogen and the acidity of the various soils in Miami County. The acidity is expressed as pH or intensity of acidity. Neutrality is expressed by pH 7. For example, a soil with a pH value of 7 contains just enough lime to neutralize the acidity. If the pH is more than 7, it means that there is some excess of carbonate of lime. From pH 6 to pH 7 shows slight acidity and from pH 5 to pH 6 medium acidity. If the pH runs below 5 the soil is strongly acid. As a rule the stronger the acidity the more a soil needs lime. Samples were taken from the surface soil (0 to 6 inches) from the subsurface soil, and from the deeper subsoil. It is important to know the reaction not only of the surface soil but of the lower layers of the soil as well. Given two soils of the same acidity, the one with the greater acidity in the subsurface layer is in greater need of lime than the other. Furthermore, the more organic matter and nitrogen a soil contains and the greater the depth to which these elements extend, the less will be the need for lime. The slighter the depth of acid soil, the less it is apt to need lime. So in determining how badly an acid soil may need lime, it is necessary to know the pH, or intensity of acidity, also the amount of nitrogen and organic matter which

the soil contains. The less phosphorus, calcium, and magnesium in the soil, the more apt it is to need lime. It is well to remember that sweetclover, alfalfa, and red clover need lime more than other crops. As it is advisable to grow these better soil-improvement legumes in rotation, it is in many places desirable to lime the land so that sweetclover or alfalfa will grow.

TABLE 7.—*Nitrogen and acidity of Blackford County soils*

Soil No.	Type of soil	Depth	Nitrogen		pH	Average depth of acid soil	Indicated lime requirement per acre
			Inches	Per cent			
2	Miami silt loam.....	0-6	0.15	6.3	26	1-2	
		6-12	.11				
		12-21	.08				
6	Miami silty clay loam.....	0-6	.14	6.0	23	1-2	
		6-12	.08				
		12-19	.06				
29	Crosby silty clay loam.....	0-6	.14	5.9	23	1-2	
		6-12	.08				
		12-18	.05				
18	Bethel silty clay loam.....	0-6	.12	5.5	21	1-2	
		6-10	.06				
		10-21	.05				
43	Fox loam.....	0-6	.15	6.2	26	0-1	
		6-12	.12				
		12-20	.07				
8	Fox silt loam.....	0-6	.21	6.5	24	0-1	
		6-13	.14				
		13-18	.08				
21	Brookston silty clay loam.....	0-6	.23	6.7	(1)	None.	
		6-15	.16				
		15-19	.08				
35	Clyde silty clay loam.....	0-6	.48	7.0	(1)	None.	
		6-18	.28				
		18-26	.08				
56	Abington silty clay loam.....	0-6	.30	6.9	(1)	None.	
		6-16	.20				
		16-34	.08				
14	Genesee silt loam.....	0-6	.23	7.3	(1)	None.	
		6-18	.23				
		18-36	.17				
10	Eel silty clay loam.....	0-6	.18	7.3	(1)	None.	
		6-20	.16				
		20-34	.07				
28	Wabash clay.....	0-6	.28	7.2	(1)	None.	
		6-17	.20				
		17-24	.09				
30	Muck.....	0-6	.66	6.5	-----	None.	
		6-12	.50				
		12-36	1.94				
60do.....	0-6	1.18	5.4	-----	None.	
		6-18	2.15				
		18-36	2.02				

¹ Nearly neutral.

In interpreting the soil survey map and soil analyses, it should be borne in mind that well-farmed, well-drained, well-fertilized, and well-manured soil which is naturally low in fertility will produce larger crops than a poorly farmed soil naturally higher in fertility.

SOIL MANAGEMENT

For convenience in discussing the management of the several soils of Blackford County, they have been arranged in groups according to certain important characteristics which indicate that in many respects similar treatment is required. For example, several of the light-colored upland soils, which have practically the same require-

ments for their improvement, may be conveniently discussed as a group, thus avoiding the repetition that would be necessary if each were discussed separately. Where different treatments are required these are specifically pointed out. The reader should study the group including the soils in which he is particularly interested.

LIGHT-COLORED UPLAND AND TERRACE SOILS

The group of light-colored upland and terrace soils includes the silty clay loams of the Crosby, Bethel, and Miami series; Fox loam; and the silt loams of the Fox and Miami series. Crosby silty clay loam occupies 44.7 per cent of the total area and is the most extensive soil in the county, Miami silty clay loam occupies 5.7 per cent, Bethel silty loam 0.8 per cent, Miami silt loam 0.1 per cent, Miami silt loam, slope phase, 0.4 per cent, Fox silt loam 0.5 per cent, and Fox loam 0.3 per cent. Soils of this group occupy a combined acreage of 52.5 per cent of the total area of the county.

All these soils are naturally deficient in phosphorus, nitrogen, and organic matter. They are, in general, low in available potash, especially the Bethel and Crosby soils, and all soils of the group are acid and more or less in need of lime.

Drainage.—The Fox and Miami soils have fair or good natural drainage, but the more level and heavier areas of the Miami soils would be benefited by tile drainage. Wherever there is a tight subsoil the land should be tiled. Without underdrainage surface erosion is more apt to occur. Surface run-off should be prevented as much as possible because it carries away large quantities of available plant food which should go into the production of crops. Rain water should be absorbed by the soil, and the surplus should pass away through underdrainage. Tile drainage increases the capacity of heavy soils to absorb water and thus lessens surface run-off and consequent erosion. It also facilitates soil aeration which helps to render the plant food in the soil available, and it encourages deeper rooting of crops, which enables them to better withstand drought, as well as to obtain more plant food.

The Bethel and Crosby silty clay loams are naturally poorly drained and are more or less seriously in need of tile drainage. Their generally flat surface retards run-off, and their tight subsoils make natural underdrainage very slow and difficult. A gray or mottled subsoil is always an indication of insufficient natural drainage. Without tile drainage these soils can not be satisfactorily managed, and no other beneficial soil treatment can produce its full effect. Results on experiment fields on other soils of similar texture and surface relief indicate that tile lines laid 30 inches deep and not more than 3 rods apart will give profitable results. Where the land is very flat, great care must be exercised in tiling, in order to obtain an even grade and uniform fall. Grade lines should not be established by guess or any rule-of-thumb method. Nothing less accurate than a surveyor's instrument should be used, and the lines should be accurately staked and graded before the ditches are dug, to make sure that all the water will flow to the outlet with no interruption or slackening of the current. The rate of fall may be increased toward the outlet, but it should never be decreased without

inserting a silt well, as checking the current may cause the tile to become choked with silt. It is an excellent plan, before filling the ditches, to cover the tile to a depth of a few inches with straw, weeds, or grass. This prevents silt from washing into the tile at the joints while the ground is settling, thus insuring perfect operation of the drains from the beginning.

Liming.—Most of these soils will respond profitably to liming. A very acid soil will not respond properly to other needed treatments until it has been limed. A strong indication of the need of liming will be found in the failure of clover to do well on land that is otherwise in a fair state of fertility. However, the need for liming is so easily determined that tests should be made in each particular case. If the farmer himself can not make the test, he should have it made by the county agricultural agent or by the agricultural experiment station at La Fayette. Ground limestone is the most economical form of lime to use in most places. Where liming is needed, the first application should, as a rule, be about 2 tons to the acre. After that a ton to the acre every second or third round of the crop rotation will keep the soil in good condition for most crops. Where alfalfa or sweetclover is to be grown on acid soil, heavier applications of lime may be needed.

Organic matter and nitrogen.—All the soils of this group, except some small areas of the Fox soils, are naturally low in organic matter and nitrogen. Constant cropping without adequate returns to the land is steadily making matters worse, so that in many places the original supplies of organic matter have become so reduced that the soil has lost much of its native mellowness and easily becomes puddled and baked. This condition, in a large measure, accounts for the more frequent clover failures and the greater difficulty in obtaining proper tilth where the land has been cropped for a long time without adequate returns of organic matter. Wherever these evidences of lack of organic matter and nitrogen occur, the only practical remedy is to plow under more organic matter than is used in the processes of cropping. Decomposition is constantly going on and is necessary to maintain the productivity of the soil. Decomposing organic matter must also supply the greater part of the nitrogen required by crops. For this reason legumes should provide as much as possible of the organic matter to be plowed under. To do this satisfactorily, the land must be put in condition to grow clover and other legumes. This means the application of lime wherever the soil is acid. Wet lands must also be tile drained. Clover or other legumes should appear in the rotation every two or three years; as much manure as possible should be made from the produce that can be utilized for livestock; and all produce not fed to livestock, such as cornstalks, straw, and cover crops, should be returned to the land and plowed under. It must be remembered that legumes are the only crops that can add appreciable quantities of nitrogen to the soil, and these only to the extent to which top growth is plowed under, either directly or in the form of manure. Wherever clover-seed crops are harvested, the threshed haulm should be returned to the land and plowed under. Cover crops should be grown wherever possible to supply additional organic matter for plowing under. Sowing sweetclover or soybeans between the corn rows at the time

of the last cultivation and seeding rye as a cover crop early in the fall on cornland that is to be plowed the following spring are good practices for increasing the supplies of both nitrogen and organic matter. It is desirable to have some kind of a growing crop on the soil during the winter to take up soluble nitrogen which would otherwise be lost through leaching. Without living crop roots to take up the nitrates from the soil water, large losses may occur between crop seasons through drainage. Loss of surface soil by erosion in times of heavy rains is also lessened by the presence of cover crops.

Crop rotation.—With proper fertilization, and liming and tile drainage where needed, these soils will satisfactorily produce all the ordinary crops adapted to the locality. On account of the prevailing shortage of organic matter and nitrogen, every system of cropping should include clover or some other legume to be returned to the land in one form or another. Corn, wheat or oats, and clover constitute the best short rotation for general use on these soils, especially when the corn can be cut and the ground can be disked and properly prepared when wheat is the small-grain crop. Corn, soybeans, wheat or oats, and clover constitute an excellent 4-year rotation for these soils. The two legumes in the rotation will build up the nitrogen supply. The soybean straw, if not used as feed, may be spread on the wheatland in the winter or spread elsewhere for plowing under. If spread on the wheatland, it will not only help the wheat and lessen winter injury but it will help to insure a stand of clover. The soybean is a valuable crop, and when properly inoculated, adds some nitrogen to the soil and improves the land for the crop that follows. If more corn is wanted, as on livestock farms, the 5-year rotation of corn, corn, soybeans, wheat or oats, and clover may be used satisfactorily where the second corn crop can be given a good dressing of manure. In all these rotations, timothy may be seeded with clover to help out the hay crop in case clover should not do well. Where corn follows corn, as in the 5-year rotation, and where soybeans follow corn, as in both the 4-year and 5-year rotations suggested, cover crops of sweetclover or rye for plowing under the following spring can be seeded in each corn crop to help maintain fertility.

Alfalfa and sweetclover may be grown on the better-drained and more friable soils of this group, if the soils are properly inoculated and sufficiently limed to neutralize harmful acidity. The Fox and Miami soils are better adapted to these crops than the Crosby or Bethel. Alfalfa is preferable for hay, and sweetclover is excellent for pasture and for soil-improvement purposes. Special literature on the cultural requirements of these crops can be obtained from the Purdue University Agricultural Experiment Station at La Fayette.

Fertilization.—All the soils of this group are naturally low in phosphorus, and the available supplies of this element are so very low that the phosphorus required by crops should be wholly supplied in applications of manure and commercial fertilizers. The nitrogen supplies in these light-colored soils are also too low to satisfactorily meet the needs of corn, wheat, oats, and other nonleguminous crops, and provision for adding nitrogen should be an important part of the program for their improvement. The total quantities of potas-

sium in these soils are large, but the available supplies, especially in the surface soil, are generally low, and in most places the addition of some potash fertilizer would be profitable, especially where little manure is applied.

The problem of supplying nitrogen has been discussed in connection with provisions for supplying organic matter. Legumes and manure are the logical and only really practical means of supplying the greater part of the nitrogen needed by crops, and they should be largely relied on for this purpose. A livestock system of farming with plenty of legumes in the crop rotation, is, therefore, best for these soils. However, it will generally pay to have some nitrogen in the fertilizer for wheat, regardless of its place in the rotation. Even though wheat follows soybeans or other legumes, it should receive some nitrogen in the fertilizer applied at seeding time to properly start the crop, because the nitrogen in the residues of these legumes does not become available quickly enough to be of much help to the wheat in the fall. The material must first decay, and that does not take place to any considerable extent until the following spring.

Phosphorus is the mineral plant-food element in which all these soils are most deficient. The only practical way to increase the supply is through the application of purchased phosphatic fertilizers. It will pay well to supply the entire phosphorus needs of crops in this way. In rotations of ordinary crops, producing reasonable yields, it may be counted that 20 pounds of available phosphoric acid to the acre are required each year. It will pay well to apply larger amounts at first so as to create a little reserve. Enough for the entire rotation may be applied at one time or the application may be divided according to convenience. Where manure is applied, it may be counted that each ton supplies 5 pounds of phosphoric acid, so that a correspondingly smaller quantity will need to be provided in the form of commercial fertilizer.

On the experiment field on the Herbert Davis forestry farm, belonging to Purdue University and located on Crosby silt loam in Randolph County (which is similar to the Crosby silty clay loam in Blackford County), highly profitable returns have been obtained wherever available phosphate has been applied. During the eight years since this experiment was begun, applications of 75 pounds to the acre of 16 per cent superphosphate in the row for corn and 225 pounds for wheat in a corn, wheat, and clover rotation, have produced crop increases averaging 8.3 bushels of corn, 8.6 bushels of wheat, and 555 pounds of hay to the acre, at a cost of \$3.60 for the phosphate. Manure applied for corn at the rate of 6 tons to the acre has produced crop increases averaging 12.7 bushels of corn, 4.5 bushels of wheat, and 278 pounds of hay to the acre. But manure alone is not sufficient to produce the most profitable returns. On land receiving 6 tons of manure to the acre, 225 pounds of superphosphate applied for wheat only has increased the crop yields over manure alone by 3.6 bushels of corn, 7 bushels of wheat, and 362 pounds of hay to the acre. These experiments demonstrate the importance of using liberal applications of phosphate on this type of soil, both with and without manure. Where manure is not available, a good complete fertilizer should be used for wheat and a phosphate-potash mixture for corn. On this experiment field, applications of

300 pounds to the acre of a 2-12-6 fertilizer for wheat have produced crop increases averaging 11.7 bushels of wheat and 771 pounds of hay to the acre. One hundred pounds of 0-12-6 in the row for corn has produced an average increase of 8.2 bushels per acre.

The quantity of potash that should be applied as fertilizer depends on the general condition of the soil and the quantity of manure used. The flat poorly drained areas of the gray soils are the ones most likely to be in need of potash fertilizer. On soils that have become run down, any program for their improvement should include potash fertilizer, at least until such time as considerable quantities of manure can be applied or until the general condition of the soil has materially improved. Although large total supplies of potassium are present in these soils, the readily available potash is low in many places. Its availability may be increased by good farm practices, including proper tillage, tile drainage, the growing of deep-rooted legumes, and the plowing under of liberal quantities of organic matter. The better these practices are carried out and the larger the quantity of manure applied, the less potash fertilizer will have to be purchased.

In the fertilization of these soils, the manure should usually be plowed under for the corn crop but a part, about 2 tons to the acre, may be applied profitably on wheat as a top-dressing during the winter. Such use of a part of the manure not only helps the wheat and lessens winter injury, but it also helps to insure a stand of clover or other crop seeded in the wheat. As a rule, the manured corn should also receive some available phosphate in the hill or row at the rate of 100 to 150 pounds to the acre. Without manure, a phosphate and potash mixture may be preferable. Wheat should always be given from 200 to 300 pounds to the acre of a high-analysis complete fertilizer, such as a 2-12-6 mixture at seeding time. A top-dressing ranging from 15 to 20 pounds of soluble nitrogen applied in April when the wheat is 2 or 3 inches high may be expected to cause an increase of 5 or 6 bushels to the acre. Where properly fertilized corn and wheat are included in the rotation, there will be little need for fertilizer on other crops.

DARK-COLORED UPLAND AND TERRACE SOILS

The group of dark-colored upland and terrace soils includes the silty clay loams of the Brookston, Clyde, and Abington series. Brookston silty clay loam occupies 33.7 per cent of the total area of the county and is the most extensive dark-colored soil in the county. The Clyde soil occupies 5.8 per cent and the Abington 2.1 per cent of the total area. These are the best agricultural soils of the county. They are all well supplied with nitrogen. The supplies of phosphorus are higher than in the light-colored soils. However, these supplies should not be drawn on to any considerable extent, especially in the Brookston areas, and as a rule most of the phosphorus required by the crops should be supplied to the land. Where little manure is applied, some potash fertilizer should be used. A common natural defect is poor drainage. For the most part, these soils are only slightly acid and are not in need of liming.

Drainage.—These soils are all more or less in need of artificial drainage. Their dark color indicates a swampy origin where natural

drainage was poor. Where more drainage is needed, the same procedure should be followed as is suggested for the light-colored silty clay loam soils.

Organic matter and nitrogen.—For the most part, these soils are naturally sufficiently well supplied with organic matter and nitrogen to meet the needs of most crops, and with reasonable care in their management no special provisions for supplying these constituents will be necessary for a long time. However, the heavy areas will be easier to handle if considerable amounts of organic matter are worked in.

Crop rotation.—These soils are among the best in the county and will produce all the ordinary crops adapted to the region. They are especially well suited to corn, and this should be the major crop in most places. Among the rotations that may be satisfactorily employed are the following: Corn, wheat or oats, and clover; corn, corn, wheat or oats, and clover; corn, soybeans, wheat or oats, and clover; or corn, corn, soybeans, wheat or oats, and clover. To guard against the hazards of winterkilling of clover, it is often advisable to seed some timothy with the clover. These soils are also adapted to alfalfa and sweetclover where sufficient drainage has been provided. Whenever clover fails, the soybean makes a satisfactory substitute crop for legume hay.

Fertilization.—These soils are naturally fairly well supplied with nitrogen, and with legumes in the crop rotation the fertilizer need not contain nitrogen for the ordinary field crops, except for wheat. Corn should generally receive some available phosphate in addition to manure. On farms having both light-colored and dark-colored soils, the manure should generally be applied to the light-colored soil in which the organic matter and nitrogen of the manure are most needed. Wheat should always receive a good complete fertilizer, such as a 2-12-6, to start it properly in the fall. Without manure, considerable amounts of commercial fertilizer will be profitable. Corn should receive from 100 to 150 pounds to the acre of superphosphate or of a phosphate and potash mixture in the hill or row, and wheat should receive from 200 to 300 pounds to the acre of a complete fertilizer. Such fertilization will also provide for the needs of the clover crop. Oats will seldom respond to nitrogen in fertilizer, and where this is the small-grain crop a phosphate and potash mixture will generally be sufficient.

MUCKS

Muck includes all the highly organic soils of the county and constitutes 2.5 per cent of the total area. The muck soils are slightly acid, but being so high in organic matter they are not in need of liming. The profitable management of these soils involves the following points: Careful drainage, the growing of suitable crops, and the application of large quantities of potash. Usually some phosphate also will be profitable, especially after several years of cropping. The potash fertilizer needs are especially urgent on the typical muck areas which are naturally very low in both total and available potassium. The more silty muck is much better supplied with both phosphorus and potassium and may not require much fertilizer for some time.

The question is sometimes asked if muck soils can be improved by burning. Mucks can not be permanently improved by burning, and they may be seriously injured. Burning adds nothing; on the other hand it destroys much valuable organic matter and nitrogen. The mineral plant-food elements concentrated in the ash remains are not to be considered as gain. These ash elements are soon exhausted and the land is left in a poorer condition than before burning, because of the destruction of organic matter and the consequent lowering of the land level to such an extent, in many places, as to make drainage more difficult.

Drainage.—In improving muck soils, the first requisite is proper drainage. As a general rule the water table should be lowered to a depth ranging from 30 to 40 inches below the surface, but not more than 4 feet. For meadows, 2 feet to the water table may be enough for best results. Most of these lands will drain freely if the water has a chance to get away. It is not necessary for ditches and tile lines to be so close together as in the fine-textured soils. Ordinarily, the distance between tile lines or lateral ditches should be about 100 feet. Whether tile or open ditches should be used depends on local conditions. If the subsurface material is sufficiently firm to hold tile in place, tiling is to be preferred, since open ditches are always a nuisance. In extensive areas, large open outlet ditches may be necessary to keep the water table at a proper level to meet the needs of crops.

Most muck areas receive considerable surface and seepage water from the higher lands adjoining, and the plan of drainage should provide for the removal of such waters as well as the excess water that falls on the muck areas. The first thing to be done is to cut a ditch or lay a line of tile along the edge of the marsh next to the higher land adjoining. This will catch the seepage from the higher land and make the drainage of the rest of the muck area comparatively easy.

It has been stated that muck soils should not be too deeply drained, because the crops grown on them are apt to suffer from lack of water. However, where tile drainage is used, the lines of tile must be placed deep enough so that subsequent settling of the soil will not leave them too near the surface, as after drainage muck settles considerably within the first few years, and allowance for this should be made. The tile should be laid from $3\frac{1}{2}$ to 4 feet below the surface, unless the muck is already well settled, owing to several years of drainage with open ditches. The aim should be, ultimately, to have the water table at a depth of about 3 feet below the surface. Great care should be exercised in establishing an even grade for each line of tile, so that the flow of water will be uniform. Fine materials which wash in at the tile joints settle easily and will soon clog the tile if the grade line is uneven. As a rule, nothing smaller than 5-inch tile should be used for muck soils. It is a good plan to cover the tile with a few inches of straw or grass before filling the ditches. This will keep much fine material out of the tile while the ground is settling.

In some places it may be desirable to raise the water table when the dry season of the year approaches, especially for shallow-rooted crops. This can be done by temporarily damming up the outlets

of the ditches or by blocking the tile outlets, thus holding the water table up until sufficient rains come again.

Fertilization.—In the fertilization of muck soils potash is of first importance. Nitrogen is present in great abundance; hence the addition of nitrogenous fertilizers is not required, except for early truck crops which need quickly available nitrogen, especially in late seasons when nitrification, the bacterial action which makes nitrogen available, does not begin early enough to supply these crops. For the grain and hay crops, the natural soil supplies of nitrogen become available fast enough to meet all needs. Some mucks when first brought under cultivation may produce a few good crops without the addition of potash, but the available potassium soon becomes exhausted and the only recourse is to supply this element from outside sources. The more silty muck is much better supplied with potash, and the phosphorus supplies are fair to begin with.

For the common field crops, about 100 pounds of muriate of potash to the acre should be applied each year, or 200 pounds every other year. In many places, especially after several years of cropping, it will pay to add some available phosphate, and a fertilizer, such as 0-8-24, may be desirable.

For truck crops the application rate of fertilizer should be much greater than for grain crops. For celery some growers use as much as 2,000 pounds of fertilizer to the acre. For early-planted crops, such as onions, lettuce, and cabbage, large quantities of complete fertilizer, such as a 3-9-18, are used by many farmers.

Farm manure may be used to supply potassium and phosphorus to these soils; however, on farms including both organic and mineral soils the manure should preferably be applied to the mineral soils, because the organic soils do not need the nitrogen and organic matter it supplies, whereas the mineral soils especially need these constituents. In some places the application of manure on raw muck soils will be helpful in supplying beneficial bacteria which may be lacking, especially if the material is very raw or the land has always been very wet.

Crops for muck soils.—Muck soils, when properly drained and fertilized, may be satisfactorily used for all the field and garden crops adapted to the climatic conditions of the region, including many crops not adapted to the common upland soils. Most of the truck and small garden crops will do better on properly managed organic soils than on mineral soils. It may be said, therefore, that the farmer who has muck soil has a much greater range in the choice of crops that he may grow.

For the general farmer, corn is the best crop for muck soils, as these soils can endure cropping with corn longer than any other soil, except rich overflow bottom lands. With the addition of plenty of potash and some phosphate, corn may be grown on muck fields most of the time. It is necessary, however, to use early varieties of corn in order to escape early frosts. For a change in the cropping system, such crops as soybeans, rye, and mixed timothy and alsike for meadow or pasture are suggested. Potatoes also may be fitted into the rotation.

On the Pinney-Purdue muck experiment field near Wanatah, a 4-year rotation of corn, corn, soybeans, and potatoes is giving good results. During the seven years since this experiment was begun, this

rotation has averaged 52 bushels of corn, 23 bushels of soybeans, and 148 bushels of potatoes to the acre. The fertilizer used is 0-8-24, applied at the rate of 150 pounds to the acre in the row for corn and 300 pounds to the acre for potatoes. On a part of this field, where the amount of potash was doubled, the average yield of potatoes has been increased to 174 bushels to the acre, but increases of the other crops have been small, averaging 4 bushels of corn and 2.8 bushels of soybeans.

The small grains are the least suitable crops for muck soils because they are apt to produce a rank growth of weak straw and lodge badly. Liberal applications of potash will aid materially in producing stiffer straw. Other crops adapted to muck soils are mint, hemp, Sudan grass, millet, sorghum, buckwheat, sugar beets, turnips, and mangels. Of the truck crops, onions, cabbage, cauliflower, kale, rutabagas, celery, lettuce, parsnips, beets, and carrots do well on this kind of land.

Importance of compacting muck soils.—One of the difficulties in managing muck soils is that they are apt to be too loose on the surface. In preparing the seed bed, therefore, it is important to pack the ground thoroughly by the use of a heavy roller, going over the field several times if necessary. Thorough compacting of the muck is not only better for crop growth, but it also aids materially in lessening the danger of early frosts.

BOTTOM LANDS

The bottom lands of Blackford County consist of Genesee silt loam, Eel silty clay loam, and Wabash clay. Together they constitute 3.3 per cent of the total area of the county. Genesee silt loam predominates.

The greatest difficulty in the management of these soils is to provide adequate drainage and to prevent damage from flooding. The heavier areas should be tiled wherever suitable outlets can be provided, in order that surplus water may drain away more readily. With the exception of the lighter-colored areas of Eel silty clay loam, these soils are reasonably well supplied with organic matter and nitrogen. A light color of the soil indicates lack of these constituents, and on such areas provision should be made for increasing the organic matter and nitrogen supplies by manuring and by the incorporation into the soil of such other organic materials as crop residues and especially grown cover crops or intercrops. Lining is not required.

Most of this land, when brought under cultivation, is best adapted to corn, but wherever excess water is not troublesome some other crop, such as wheat, oats, clover, and soybeans, should occasionally be included in the cropping system. On certain areas not damaged by flooding, alfalfa, and some truck crops also will do well.

Much of this land receives rich sediments from periodic overflows of the streams and hence requires little fertilizer. The poorer areas, however, will respond to applications of available phosphates and potash. For truck crops, the use of some nitrogen also will prove profitable.

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