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MANAGEMENT OF SOILS
IN SOUTHEASTERN MINNESOTA
A Correspondence Course

Unit 8: Major Soils

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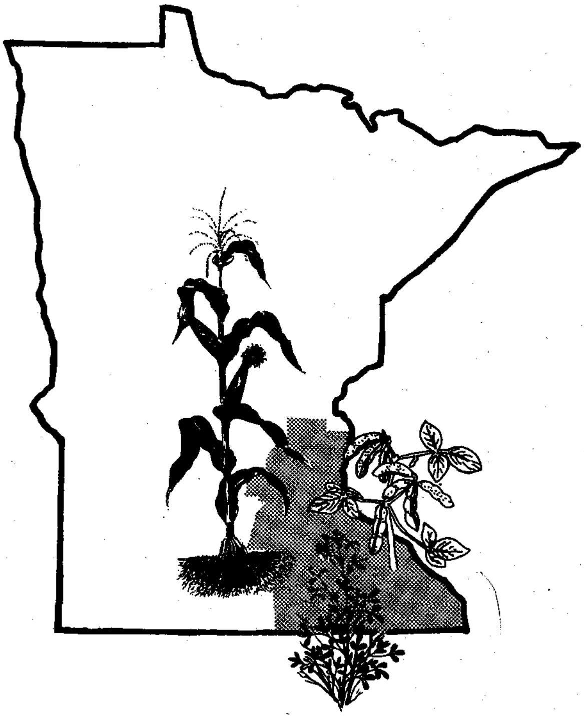
Objectives

- Understand soil formation in southeastern Minnesota.
- Understand important soil properties.
- Become familiar with distribution and properties of major soils.
- Relate soil properties to management.



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WHY LEARN ABOUT SOILS?

To make the most efficient use of the inputs to crop production, it is necessary to know the differences among the kinds of soil being managed. This is one of the aims of the Minnesota Cooperative Soil Survey, which intends to have detailed soil surveys available in all Minnesota counties by the mid-1990s. If farmers pay close attention to the kinds of soils on their farms, they maybe able to save money (or at least spend it more wisely) by managing soils instead of fields, which are based on an arbitrary land survey.

While it may not always be practical to manage each soil separately there are many areas where within fields there are dramatic soil differences. In these fields management practices can be modified according to soil changes for more efficient crop production.

SOIL FORMATION

Many kinds of soil occur in southeastern Minnesota (Dakota County, for example, has 70 soil series). In addition, some soil series have a range in properties (phases) that are critical to use and management. The Port Byron series, for example, is divided into three phases based on slope. Dakota County has 151 soil phases. In contrast, Mower County has 55 soil series and 74 phases.

Why are there so many soils in southeastern Minnesota? The reason is that a wide range exists in the factors affecting the formation of soils—native vegetation, relief, parent material, climate, and time.

Native vegetation in the area ranged from tall grass prairie to deciduous forest; soils formed under prairie have more organic matter than those formed under forest. Relief, or lay of the land, affects the movement of water on and in the soil. Most of the water falling on level land moves into the soil, while soils on slopes may lose water through runoff and are subject to erosion. Thus, soils on level land are thicker than soils on slopes.

Parent materials in this area include loess, glacial sediments, bedrock, and alluvium. The parent material determines the texture and kinds of minerals in the soil. For example, soils formed in loess are silty and have a high capacity to hold water and plant nutrients, but soils formed in sandstone are sandy and have a low capacity to hold water and plant nutrients.

The macroclimate of the area is fairly uniform. However, significant differences in climates occur within short distances in the hilly parts of the area. Steep southwest-facing slopes are warmer in the summer than are steep northeast-facing slopes. Soils formed on those southwest-facing slopes are thinner than on the northeast-facing slopes.

The time period during which the soil parent materials are affected by the other factors also determines the properties of the soil. Soils formed in loess in level slopes are about 14,000 years old. They have distinct layers or horizons. Soils formed in recent alluvial sediments lack distinct soil horizons.

IMPORTANT SOIL PROPERTIES

The following soil properties are basic in identifying and classifying soils. They also determine the basic productivity of soils, and, more importantly, affect the soil's response to our use and management.

Texture

Soil texture refers to the amount of clay, silt, sand, and larger particles in a mass of soil. The basic textural classes in order of increasing proportion of finer particles are: sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided into coarse, fine, or very fine based on the dominant size of sand.

The texture of a soil of known composition may be identified using Figure 1. For example, to determine the texture of a soil that contains 70 percent silt, 20 percent clay, and 10 percent sand, pick out the line on the right side of the triangle that shows 70 percent and follow it to the southwest to where it intersects the line of 20 percent clay or the line of 10 percent sand (see arrows). The texture is silt loam.

Soil texture is a major determinant of the soil's nutrient and available water capacity. It also influences cultural practices: sandy soils will bear a load (farm equipment) without disruption under nearly wet conditions, but some finer textures will not. The erodibility of a soil also is related to texture. Silt loam is more subject to erosion by water than are other textures.

Organic Matter

The amount of organic matter affects a soil's capacity to hold nutrients and water and its tilth. Soils high in organic matter have higher capacities and better tilth than do soils low in organic matter.

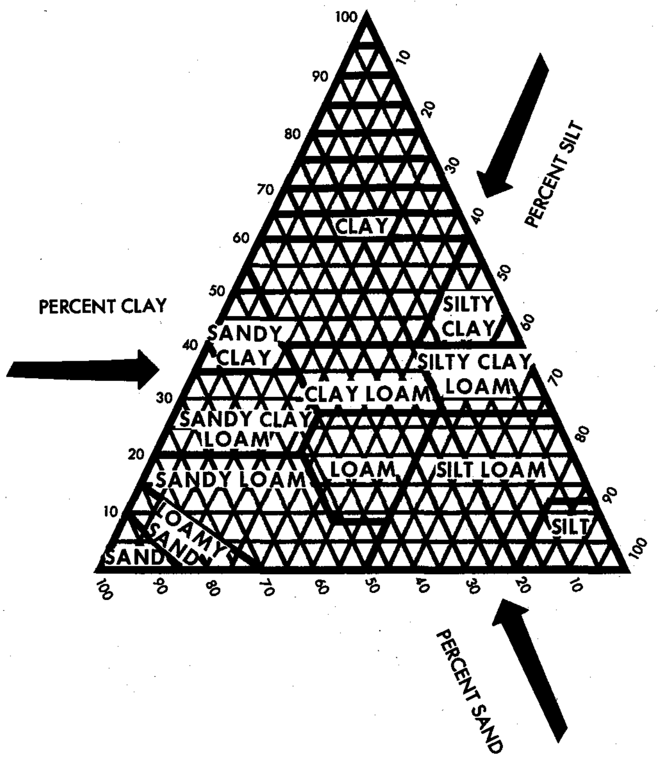

Figure 1. Graph for determining the texture of soil.

The amount of organic matter primarily determines the color of the surface layer of the soil:

Organic Matter (%)	Color
<2 (low)	light
2-4 (moderate)	moderately dark
>4 (high)	dark

Bulk Density

Bulk density is the weight per unit volume of dry soil. It is related to the kind and shape of soil particles and how closely they are packed. It is commonly expressed as grams per cubic centimeter. In southeastern Minnesota, a well-aggregated surface layer high in organic matter such as Maxfield silty clay loam has a bulk density of about 1.3 grams per cubic centimeter. In contrast, the loamy substratum of that same soil, which has only a trace of organic matter and is not aggregated, has a bulk density of about 1.8 grams per cubic centimeter. For comparison, water has a density of 1 gram per cubic centimeter and individual mineral soil particles have a density of about 2.6 grams per cubic centimeter.

The fact that the bulk density of a soil is much less than the density of the mineral particles means that the soil has space for other components, primarily air and water. Both are necessary for plant growth.

Each layer comprising a given soil has a characteristic bulk density. This bulk density controls the available water capacity of the soil, water movement, and the ability of plant roots to penetrate the soil. For example, Port Byron silt loam, with a bulk density of about 1.3 in the upper part and about 1.4 in the lower part, has more space for air, water, and roots than does the Maxfield soil described above.

Cultural practices may affect the bulk density of the upper layers of the soil. Tilling the soil when it is wet increases the soil's bulk density. Also, continual use of a moldboard plow may increase the bulk density of the layer beneath the plow layer. Other tillage practices may lower the bulk density.

Soil Climate

Soil climate refers to annual variations in temperature and water content. Properties of the soil greatly influence the soil climate.

The temperature of the soil is affected by the color of the surface layer. Dark soils absorb more radiation from the sun than do light-colored soils and so warm sooner in the spring.

Internal soil properties and position on the landscape affect the water content. Soils that seldom are saturated with water in any part are called well-drained. Soils in which water is removed so slowly that they are saturated periodically during the growing season or remain wet for long periods of time are called poorly drained. Such soils warm more slowly than well-drained soils. Also, saturated or near-saturated soil layers inhibit the growth of roots.

Soil Slope

The slope of a soil's surface greatly affects use and management. It influences the amount of water that enters or runs off the soil. It also affects the soil's potential for erosion. The following terms are used to describe slope.

Slope (%)	Term
0-2	Nearly level
2-6	Gently sloping or undulating
6-12	Sloping or gently rolling
12-18	Strongly sloping or rolling
18-24	Moderately steep or hilly
24-36	Steep
>36	Very steep

Available Water Capacity (AWC)

The Available Water Capacity (AWC) of a soil is its ability to hold water usable by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point, in inches of water per inch of soil. The AWC in a 60-inch profile or to a limiting layer is expressed as:

Term	AWC (inches)
Very low	0-3
Low	3-6
Moderate	6-9
High	>9

AWC is primarily related to soil texture, content of organic matter, and bulk density. Silt has higher AWC than sand or clay. Organic matter enhances AWC. Also, a soil of a given texture with high bulk density has less AWC than a soil of the same texture with lower bulk density. Soils with the highest AWC in the area are Mt. Carroll, Port Byron, and Joy. They have a high content of organic matter, texture of silt loam in all layers, and rather low bulk density.

If the soil varies with depth, AWC values are given for each layer. An example of computations to determine the AWC to depths of 60 inches follows.

Properties		
Depth (inches)	AWC (inches/inch)	AWC per layer
0-14	0.22	14 × 0.22 = 3.08
14-23	0.19	7 × 0.19 = 1.33
23-30	0.17	7 × 0.17 = 1.19
30-60	0.04	30 × 0.04 = 1.20
		Total = 6.80

The AWC for the 0-to-60 inch zone is equal to (3.08 + 1.33 + 1.19 + 1.20) = 6.80 inches. This soil would be rated at having moderate AWC.

Nutrient-Holding Capacity

The soil's capacity to hold positively charged nutrients (potassium, calcium, and ammonium, for example) is related primarily to the kind and content of clay and content of organic matter. The clay minerals in southeastern Minnesota soils are reasonably similar. Organic matter has the capacity to hold about four times as many nutrients per unit weight as do these clays. Therefore, we can compare the nutrient-holding capacities of different soils in the area based on their content of organic matter and clay. Computations of the relative nutrient-holding capacity of the surface layer of two different soils follow.

Soil	Content		Computations of Comparative Nutrient-Holding Capacities			
	Clay (%)	Organic Matter (%)	Fraction	Amount	Factor	Capacity
A	30	6	Clay	30	1	30
			Organic Matter	6	4	24
			Total			54
B	10	3	Clay	10	1	10
			Organic Matter	3	4	12
			Total			22

To compute the comparitive nutrient-holding capacity of two different soils to depths of 60 inches, we would have to take into account the thickness of each layer.

DISTRIBUTION AND PROPERTIES OF MAJOR SOILS

Southeastern Minnesota can be divided into broad areas based on the comparative uniformity of soil-forming factors. Soils occur in such areas in a characteristic repeating pattern and are called soil associations. Soil associations are named according to the major soils. Figure 2 shows the distribution of soil associations in southeastern Minnesota. A legend and a brief description of some properties and management considerations of the major soils in

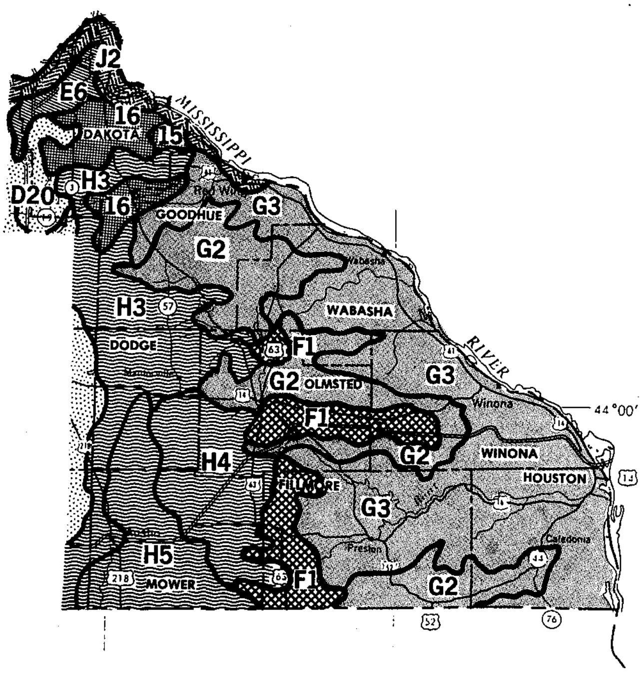

Figure 2. Distribution of major soils in southeastern Minnesota (see text for key).

each association follow. Some physical and chemical properties of these soils are shown in Table 1.

Many other kinds of soil occur within each association. *Thus, information on the kinds of soils on a specific tract of land can only be obtained from the county soil survey report.*

Lester-Blooming-Merton Association (D20)
(formed mainly in calcareous loamy glacial till)

Properties. Soils in this association are found mostly on gently sloping to moderately steep glacial moraines. Native vegetation was mixed prairie and deciduous forest. Lester is on the tops and sides of hills. Blooming is on the broader tops of low hills, slopes, and on the sides of low hills. Merton is on nearly level slopes on the tops of broad low hills. Lester is well-drained and has a loam surface soil and a loam and clay loam subsoil. Blooming is well-drained and Merton is moderately well-drained. Blooming and Merton have a silt loam surface layer and mostly loam or clay loam subsoils. Lester and Blooming have moderately thick dark surface layers. Merton has a thick dark surface layer.

Management Considerations. These soils have a potential for high crop yields because of high nutrient- and water-holding capacities. Major concerns are control of erosion on the Lester and Blooming soils and maintaining proper levels of plant nutrients in all soils.

Kingsley-Mahtomedi Association (E6)
(formed in loamy glacial till and in glacial outwash)

Properties. Soils in this association are found mostly on gently undulating to very steep glacial moraines. Native vegetation was mixed prairie and deciduous forest. Both Kingsley and Mahtomedi are on the sides and tops of irregularly shaped hills. Kingsley is well-drained and has a loamy sand surface layer and sandy loam subsoil. Mahtomedi is excessively drained and has a loamy sand surface layer and a gravelly coarse sand and coarse sand subsoil. Kingsley has a moderately thick dark surface layer. Mahtomedi has a thin moderately dark surface layer.

Management Considerations. These soils have a low potential for use as cropland because of the complex slopes and associated erosion problems. Conservation tillage will lessen erosion. The low nutrient-holding and available water capacities of Mahtomedi soils further limit their productivity.

Maxfield-Klinger-Ostrander Association (H3)
(formed in a mantle of loess and in underlying glacial till)

Properties. The soils in this association are on nearly level to gently sloping old eroded glacial moraines. Native vegetation was tall grass prairie. Maxfield is on broad flats and in drainageways. Klinger is on low slightly convex ridges and on footslopes. Ostrander is on summits and shoulders of slopes on the highest parts of the landscape. Maxfield is poorly drained and Klinger is somewhat poorly drained. Both soils have a silty clay loam surface layer and silty clay loam and loam subsoil. Ostrander is well-drained. It has silt loam or loam surface soil and a silt loam, loam, or sandy clay loam subsoil. Maxfield and Klinger have thick dark surface layers. Ostrander has a moderately thick dark surface layer.

Management Considerations. These soils have a potential for high crop yields because of high nutrient-holding and available water capacities. However, excess surface and subsurface water must be removed for the Maxfield soils to reach that potential. Conservation tillage is needed on the Ostrander soils to control erosion. Proper levels of plant nutrients must be maintained for all soils.

Tripoli-Readlyn-Kasson Association (H4)
(formed in a thin mantle of loess or loamy sediments and in underlying glacial till)

Properties. The soils in this association are on nearly level to gently sloping old eroded glacial moraines. Native vegetation was tall grass prairie and mixed prairie and deciduous forest. Tripoli is in drainageways, shallow swales, and flats. Readlyn and Kasson are on low ridges. Tripoli is poorly drained and has a silty clay loam surface soil and a clay loam or loam subsoil. Readlyn is somewhat poorly drained and has a loam surface layer and subsoil. Kasson is moderately well-drained and has a silt loam surface soil and silty clay loam or loam subsoil. Tripoli and Readlyn have thick dark surface layers. Kasson has a moderately thick dark surface layer.

Management Considerations. These soils have a potential for high crop yields because of high nutrient-holding and available water capacities. Excess surface and subsurface water must be removed from the Tripoli and Readlyn to reach that potential. Proper levels of plant nutrients must be maintained for all soils.

Sargeant-Brownsdale-Marshan (H5)
(formed in a thin mantle of loess or loamy sediments and in underlying loamy glacial till and sandy sediments)

Properties. The soils in this association are on nearly level old eroded glacial moraines. Native vegetation was mixed prairie and deciduous forest and tall grass prairie. Sargeant is on low ridges. Brownsdale is in shallow depressions and drainageways. Marshan is on low-lying parts of the stream terraces and on flats in the uplands. Sargeant is somewhat poorly drained and Brownsdale and Marshan are poorly drained. Sargeant has a silt loam surface and a silt loam and loam subsoil. Brownsdale has a silt loam and silty clay loam surface and subsurface layer and a loam subsoil. Marshan has a loam surface layer and a subsoil that is loam in the upper part and sand in the lower part. Sargeant has a moderately thick light-colored surface layer. Brownsdale has a moderately thick dark surface layer. Marshan has a thick dark surface layer.

Management Considerations. These soils have a potential for medium to high crop yields. Excess surface or subsurface water or both must be removed. Sargeant and Brownsdale soils have high nutrient-holding and available water capacities. However, they are commonly strongly acid and plant nutrients including lime must be added for high yields. The moderate available water capacity of Marshan limits its potential.

Rockton-Channahon-Atkinson Association (F1)
(formed in loamy glacial sediments with bedrock beginning within depths of five feet)

Properties. The soils in this association are on gently

Table 1. Physical and chemical properties of major soils in southeastern Minnesota.

Soil Series	Surface Layer				Rooting Zone	
	Organic Matter[a] (%)	Texture	Relative Nutrient Holding Capacity[b]	Typical Reaction[c]	Drainage	AWC (in/60 in)
Soils formed mainly in calcareous loamy glacial till (D20)						
Lester	2.7	loam	35	slightly acid	well	10.1
Blooming	3.5	silt loam	40	slightly acid	well	11.5
Merton	5.0	silt loam	46	slightly acid	mod. well	11.8
Soils formed in loamy glacial till and galcial outwash (E6)						
Kingsley	2.5	sandy loam	20	medium acid	well	8.1
Mahtomedi	0.9	loamy sand	8	medium acid	excessively	4.2
Soils formed in a mantle of loess and in underlying glacial till (H3)						
Maxfield	6.0	silty clay loam	54	neutral	poorly	12.7
Klinger	5.5	silty clay loam	51	medium acid	somewhat poorly	12.0
Ostrander	3.3	silt loam	35	medium acid	well	11.3
Soils formed in a thin mantle of loess or loamy sediments and in underlying glacial till (H4)						
Tripoli	6.0	silty clay loam	54	medium acid	poorly	12.0
Readlyn	5.7	loam	48	medium acid	somewhat poorly	11.3
Kasson	3.0	silt loam	34	strongly acid	mod. well	11.0
Soils formed in a thin mantle of loess or loamy sediments and in underlying loamy glacial till and sandy sediment (H5)						
Sargeant	3.4	silt loam	30	strongly acid	somewhat poorly	11.0
Browndsdale	5.0	silt loam	44	strongly acid	poorly	11.0
Marshan	5.3	loam	45	neutral	poorly	6.9
Soils formed in loamy glacial sediments with limestone bedrock beginning within depths of five feet (F1)						
Rockton	3.3	loam	40	slightly acid	well	5.7
Channahon	2.5	loam	33	neutral	well	3.4
Atkinson	2.8	loam	30	slightly acid	well	7.8
Soils formed in sandy glacial outwash (I5)						
Hubbard	1.9	loamy sand	10	medium acid	excessively	3.7
Sparta	1.6	loamy fine sand	11	medium acid	excessively	4.5
Plainfield	1.4	loamy sand	9	strongly acid	excessively	3.2
Soils formed in glacial outwash consisting of a loamy or silty mantle and in underlying sandy and gravelly sediments (I6)						
Waukegan	3.5	silt loam	34	medium acid	well	8.0
Wadena	3.3	loam	32	slightly acid	well	6.1
Hawick	2.5	coarse sandy loam	22	slightly acid	excessively	3.5
Soils formed in loess (G2)						
Mt. Carroll	4.0	silt loam	32	medium acid	well	14.0
Port Byron	4.6	silt loam	39	slightly acid	well	14.5
Joy	4.7	silt loam	41	slightly acid	somewhat poor	15.9
Soils formed in loess, in colluvium from bedrock, and in alluvium (G3)						
Seaton	3.0	silt loam	27	medium acid	well	14.0
Lacrescent	6.0	silty clay loam	40	neutral	well	8.0
Arenzville	3.7	silt loam	30	neutral	mod. well	11.3
Soils formed in recent alluvium (J2)						
Colo	6.0	silty clay loam	59	neutral	poor	11.8
McPaul	3.0	silt loam	28	neutral	mod. well	13.2

[a] Content is for uneroded or slightly ended soils. Eroded soils contain less organic matter.
[b] Value equals content of clay + (4 × content of organic matter).
[c] Value may vary considerably because of management.

sloping to sloping uplands. Sinkholes are common in some places. Native vegetation was tall grass prairie. Rockton and Channahon are at the upper end of drainageways and on the sloping parts of summits and side slopes. Atkinson soils are on nearly level to sloping summits. All three soils are well-drained. Rockton has a loam surface soil and a loam or sandy clay loam subsoil with limestone beginning within 20 to 40 inches. Channahon has a loam surface soil and a loam subsoil with limestone beginning within 12 to 20 inches. Atkinson has a loam surface soil and a loam and clay loam subsoil with limestone beginning within 40 to 60 inches. These soils have moderately thick dark surface layers.

Management Considerations. These soils have a potential for only low to medium crop yields because of their low or moderate available water capacity. Erosion control is especially critical because of the shallow depth to bedrock. Nutrients and pesticides must be applied properly because of potential contamination of the ground water.

Hubbard-Sparta-Plainfield Association (I5)
(formed in sandy glacial outwash)

Properties. The soils in this association are on nearly level to sloping outwash plains. Native vegetation was tall grass prairie and mixed prairie and deciduous forest. All of these soils are excessively drained. Hubbard and Plainfield have loamy sand surface layers and loamy sand and sand subsoils. Sparta has a loamy fine sand surface layer and a loamy fine sand and sand subsoil. Hubbard and Sparta have moderately thick moderately dark surface layers. Plainfield has a thin moderately dark surface layer.

Management Considerations. These soils have a limited potential for high crop yields because they have low nutrient-holding and available water capacities. Water management is important for high yields. Wind erosion is a problem if residue is not managed. Proper amounts of plant nutrients must be added for satisfactory yields. A severe hazard exists for polluting the ground water if excessive nutrients and pesticides are applied.

Waukegan-Wadena-Hawick Association (I6)
(formed in glacial outwash consisting of a loamy or silty mantle and underlying sandy and gravelly sediments)

Properties. These soils are on nearly level to gently sloping outwash plains. Native vegetation was tall grass prairie. Waukegan and Wadena are well-drained, and Hawick is excessively drained. Waukegan has a silt loam surface layer and subsoil. Wadena has a loam surface layer and subsoil. Hawick has a coarse sandy loam surface layer and a gravelly loamy coarse sand subsoil. The depth to sandy and gravelly sediments ranges from 20 to 40 inches in Waukegan and Wadena and 10 to 20 inches in the Hawick. These soils have moderately thick dark surface layers.

Management Considerations. Waukegan and Wadena have a potential for producing moderate yields of crops because of moderate available water capacity. Hawick soils have a limited potential because of low available water capacity. Thus, water management is critical on these soils. Proper amounts of plant nutrients must be added for satisfactory yields. A severe hazard exists for polluting the ground water if excessive nutrients and pesticides are used.

Mt. Carroll-Port Byron-Joy Association (G2)
(formed in loess)

Properties. The soils in this association are on nearly level to sloping uplands. Glacial till or limestone bedrock typically underlies the loess at depths ranging from 5 to 10 feet. Native vegetation was prairie and mixed prairie and deciduous forest. Mt. Carroll and Port Byron are on summits and gently sloping and sloping hillsides. Joy is on nearly level to gently sloping areas at heads of drainageways. Mt. Carroll and Port Byron are well-drained. Joy is somewhat poorly drained. All of these soils have a silt loam surface soil and subsoil. Mt. Carroll has a moderately thick dark surface layer. Joy and Port Byron have thick dark surface layers.

Management Considerations. These soils have a potential for producing high crop yields because of their high available water capacity. Control of erosion by proper tillage is especially critical on Mt. Carroll and Port Byron because of slope and surface soil texture. Proper amounts of plant nutrients must be added for high yields.

Seaton-Lacrescent-Arenzville Association (G3)
(formed in loess, in colluvium from bedrock and in alluvium)

Properties. This association comprises the most hilly part of the area. Seaton formed in loess and is the dominant soil on nearly level to sloping hilltops and upper hillsides. Lacrescent formed in a thin mantle of loess and in underlying colluvium from bedrock on steep and very steep hillsides. Arenzville formed a recent alluvium on flood plains. Native vegetation was deciduous forest. Seaton and Lacrescent are well-drained. Seaton has a silt loam surface layer and subsoil. Lacrescent has cobbly silty clay loam surface layer and very cobbly silt loam subsoil with bedrock beginning between 3½ and 10 feet. Arenzville is moderately well-drained and has a silt loam surface layer and subsoil. Seaton and Arenzville have a moderately thick light-colored surface layer. Lacrescent has a moderately thick dark surface layer.

Management Considerations. The Seaton soils have a potential for producing high yields of crops because of their high available water capacity. Control of erosion by proper tillage is especially critical because of slope and surface soil texture. Proper amounts of plant nutrients including lime must be added for high yields. The steep slopes of the Lacrescent series render it unsuitable for cropland. Its potential for forestry is high. The control of periodic flooding on Arenzville soils is a major management consideration.

Colo-McPaul (J2)
(formed in recent alluvium)

Properties. These soils are on nearly level floodplains. Native vegetation was deciduous forest. Colo is on the lower-lying parts of floodplains. McPaul is on the higher parts of floodplains. Colo is poorly drained and has silty clay loam surface and subsoil layers. McPaul is moderately well-drained and has silt loam surface and subsoil layers. Colo has a thick dark surface layer. McPaul has a moderately thick moderately dark surface layer.

Management Considerations. The control of periodic flooding is the major management consideration for the McPaul soils. They have a potential for high crop yields if flooding is controlled. The periodic flooding and wetness of the Colo soils severely limit their potential for crops.

SUMMARY

Southeastern Minnesota has many kinds of soils with a wide range of properties. For example, Mt. Carroll, Port Byron, and Joy are among the most productive soils in the world, with high capacities to hold both plant nutrients and water. In contrast, the coarse Hubbard, Sparta, and Plainfield soils have a low capacity to hold plant nutrients and water and so are low in productivity. Wise crop management decisions cannot be made without considering the properties of soils.

Detailed soil survey reports are available for most counties in southeastern Minnesota. The farmer or land manager can use these reports to assess soil variations and decide if changes in management should be made. The reports, combined with a comprehensive soil testing program, can be used to fine-tune fertilizer and herbicide applications and so control costs. Soil survey information can be obtained from the local Soil and Water Conservation District and county extension offices.

GLOSSARY

Drainage class (natural): Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Some classes of natural soil drainage are:

Excessively drained. Water is removed from the soil very rapidly. These soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Well-drained. Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. These soils are commonly medium textured. They are mainly free of mottling.

Moderately well-drained. Water is removed from the soil somewhat slowly during some periods. These soils are wet for only a short time during the growing season, but periodically long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained. Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. These soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination.

Poorly drained. Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination.

Glacial outwash. Gravel, sand, and silt, commonly stratified, deposited by meltwater as it flows from glacial ice.

Glacial till. Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Loess. Fine-grained material, dominantly of silt-sized particles, deposited by wind.

Moraine. An accumulation of earth, stones, and other debris deposited by a glacier. Types are terminal, lateral, medial, and ground.

Outwash plain. A landform of mainly sandy or coarse material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Phase, soil. A subdivision of a soil series or other unit in the soil classification system based on differences in the soil that affect its management but are too small to justify separate series. A soil series, for example, may be divided into phases on the basis of differences in slope, stoniness, or thickness.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

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