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ABSTRACT

This curriculum guide is designed for use in teaching a course in basic soils that is intended for college freshmen. Addressed in the individual lessons of the unit are the following topics: the way in which soil is formed, the physical properties of soil, the chemical properties of soil, the biotic properties of soil, plant-soil-water relationships, soil classification, saline seep, and soil sample collection. Each lesson contains some or all of the following: a statement of need; objectives; an interest approach; key questions, problems, and concerns along with pertinent teaching techniques and information; suggested learning activities; a list of references; transparency masters; and handouts. (MN)

BASIC SOILS

Agricultural & Industrial Education, Montana State University, Bozeman
1984 Revision

BASIC SOILS

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Forward

This unit of instruction has been designed especially for use with freshmen vocational agriculture students. For your convenience, the material has been prepared to fit into a three-ring, loose-leaf notebook. Other material that is prepared to accompany this unit of instruction will be prepared in a similar manner.

The instructor should study the entire unit carefully before attempting to teach any of the lessons. The key concepts that should be presented to meet the objectives of the core curriculum are included; however, all material that would be applicable may not be provided. Each instructor should look for ways to include local examples where possible and appropriate.

Some handouts and visual materials are included with each lesson. Here again, each teacher may have additional illustrative material that would be appropriate. It is also important to have available all references listed in the unit plan. The lesson content is based on the references listed at the end of the lessons.

Special thanks is given to Mike Cavey, Vocational Agriculture Instructor, Missoula, Montana for reviewing the material and his valuable suggestions for its improvement.

UNIT PLAN

UNIT: Basic Soils

Situation:

This unit of instruction is designed to introduce freshman and sophomore vocational agriculture students to basic soils. Although it is intended to give each student a considerable amount of hands on experience, it is still introductory in nature. The content is appropriate for all agriculture students regardless of their agriculture career goals. Because most of the students will come to the class with very limited knowledge, it will be advisable to add additional local activities to emphasize the concepts being taught.

General Aims & Goals:

1. To teach students about the formation of soils.
2. To develop a basic understanding of the physical, chemical and biotic properties of soil.
3. To teach students how soil supports plant life.
4. To introduce the soil classification system.
5. To teach the student to take soil samples.
6. To acquaint the student with the problems associated with high salt content soils.
7. To teach the basic mathematical skills that apply to the study of basic soils.

Lesson Titles:

1. How is soil formed?
2. The physical properties of soil.
3. The chemical properties of soil.
4. The biotic properties of soil.
5. Plant-soil-water relationships.
6. Soil classification.
7. Saline seep.
8. Collecting a soil sample.

Student Activities:

1. Each student will collect one or more soil samples.
2. Each student will determine soil textures using the "feel method".
3. Each student will classify soil samples using the soil triangle.
4. Determine the percent of slope for a given location.
5. Prepare a research paper.
6. Test soils for organic content.
7. Carry out laboratory exercises.

Teacher Activities:

1. Collect a group of known soil samples.
2. Gather a group of soil surveys.
3. Gather some soil maps that are appropriate for the area.
4. Prepare an exercise on estimating percent of slope.
5. Gather samples of parent material and soil forming rocks common to the area.
6. Arrange for an SCS person to serve as a resource on soil classification.

7. Gather material needed to do a mechanical analysis of a soil sample.
8. Obtain a soil profile.
9. Obtain or build a soil window box.

Special Equipment:

1. Assorted test tubes, beakers and chemicals
2. Soil sieves
3. Microscope(s)
4. Soil Window
5. Rock Samples

Evaluation:

1. A pre-test would be appropriate
2. A post-test
3. Performance on student activities
4. Research reports

Suggested References:

Veseth and Montagne, "Geologic Parent Materials of Montana Soils", Montana Agricultural Experiment Station, Montana State University, Bulletin 721, November 1980.

Montagne, Munn, Nielson, Rogers & Hunter, "Soils in Montana", Montana Agricultural Experiment Station, Montana State University, Bulletin 744, November 1982.

Harpstead & Hale, Soil Science Simplified, Iowa State University Press, Ames, Iowa, 1980.

Sopher & Baird, Soils and Soil Management, Reston Publishing Co., Inc., Reston, Virginia, 1978.

Bishop, Carter, Chapman & Bennett, Crop Science and Food Production, McGraw Hill, New York, 1983.

Carter, Logan S., Experiment in Soil Science, Instructional Material Program California State Polytechnic College, San Luis Obispo, California.

UNIT: Basic Soils

Lesson: How is Soil Formed?

Need: Each individual is dependent on soil for their existence. Many students do not understand the process by which soil was formed and the length of time required for this process to be completed. Soil can be destroyed faster than it can be formed particularly in the drier regions of the country.

Objectives:

After the lesson has been taught and time provided for individual study and practice has been given, the students will be able to:

1. Define the following terms that relate directly to soil and its formation:

soil	microorganisms	delta
soil profile	minerals	glacial deposits
parent material	alluvial deposits	loess deposits
weathering	flood plain	organic deposits

2. Describe the various factors that play an important part in the formation of soil.

3. Describe the differences among soil horizons in a typical soil profile from the area.

Interest Approach:

Have a display of the common minerals (rocks) from which soil is formed in the area in which you live. Discuss the extent to which these minerals affected the formation of soil in the local area. Also have some soil samples available and discuss with the students how the rocks you have available were changed into the soil. Point out that productive soils are developed only from minerals (rocks) which supply all of the essential elements needed for plant growth.

Key questions, problems, concerns	Teaching techniques and information
1. What is soil?	a. Soil is "A collection of natural bodies on the earth's surface containing living matter and supporting plants."
	b. Show a transparency of the composition of a typical soil by volume. (Overhead 1)
2. Why is a study of soil important to each of us?	a. Soil is one of our most valuable resources.

b. Soil is an integral part of the ecological system that produces food.

1. Medium to anchor roots
2. Reservoir to store H_2O
3. Releases essential chemical elements for plant growth

c. Soil is also a part of our:

1. Foundations for buildings
2. Purification systems
3. Engineering projects

d. Have each student describe how soil affects their daily life. Writing a short paragraph might be appropriate.

3. What are the five (5) agents responsible for soil formation?

a. The following agents are critical in soil formation:

1. Parent material
2. Climatic conditions
3. Relief or topography
4. Vegetation
5. Time

4. How are rocks changed to soil?

a. Weathering

1. Rocks are broken by expansion and contraction caused by fluctuation in heat and cold.
2. Rivers, glaciers and landslides may cause rock fragments to rub together.
3. Wind can blow the smaller particles causing a sandpaper like action.
4. Chemicals tend to eat away at rocks.

b. Small plant life begins to grow.

1. Lichens and moss appear first.
2. When they die and decompose, further decomposition of the rock takes place.
3. This process continues as higher and higher level plants begin to grow.

c. Microorganisms

1. Millions of tiny organisms help break down plant material.
2. As the microorganisms go through their life cycles, some acids are produced which causes further rock breakdown.

5. What are the five (5) general categories of parent material?

a. Minerals and rocks

b. Glacial deposits

c. Loess deposits

d. Alluvial and marine deposits

e. Organic deposits

6. What are the most common kinds of minerals that make up soil?

a. Mineral: Naturally occuring inorganic body.

1. Hand each student a blank copy of handout 1.
2. Hand out student references. Through supervised study, have students complete handout 1.
3. Discuss the students' answers.

7. What are the major types of rocks and their characteristics?

a. Rocks: A complex mineral aggregate.

1. Identify the three rock groups.

   a. Igneous: Rocks formed from cooling of molten materials which have been pushed up from the center of the earth.
   b. Sedimentary: Rocks formed by bringing together sediments and small rock fragments and being cemented together either chemically or by compression.
   c. Metamorphic: Igneous or sedimentary rocks which have been subjected to enough heat, chemical activity and/or pressure to radically alter their characteristics.

2. Have the students complete handout 2 on rocks. You will need to provide references.

8. Describe the various ways soil is deposited?

a. Alluvial and marine deposits: Sediments carried by and deposited in fresh water and sediments carried and deposited in the ocean.

1. Alluvial fan

a. Water moves down the mountain at a high velocity.
b. When water loses its velocity, the sediment drops out in the valley.
*c. Site examples in your area for the students.

2. Flood plains

a. Flood water moves down gentle slopes.
b. As the stream meanders along it causes wide flat bottom-lands called flood plains.
*c. Site examples in your area for the students.
d. Deltas

1. A river empties into a large body of water.
2. As the sediment settles out, a delta is formed.
*3. Site some examples in your area for the students.

3. Show overhead 2 and discuss the characteristics of each alluvial type of deposit.

b. Glacial deposits: Large ice mass which moves by the force of gravity.

1. As glaciers moved southward, they moved soil and rock ahead of them.
2. As the glaciers melted, the mineral deposits were left behind.
3. These deposits became the parent material for soil in these areas.
4. Material left behind by glaciers is called glacial drift.

*NOTE: Some of these deposits might not be present in your part of the state.

*5. Site some examples of glacial deposits in Montana.

6. Note: An interesting library research project would be to have the students prepare a short paper on glacial action in Montana.

c. Loess deposits: Deposits of wind-blown silts.

1. Winds swept the silt and finer particles from the floodplain and then deposited them when the wind velocity subsided.
2. Most loess deposits occur in Kansas, Nebraska, Kentucky, Tennessee and Mississippi.
3. The soils created by loess deposits are very productive.

d. Organic deposits: Naturally occurring organic deposits which act like parent material.

1. Forms in swampy and marshy areas.
2. Plants begin to grow.
3. They die and the plant material remains in the shallow water.
4. Over the years, the plant material oxidizes creating an area of organic soil.

9. How does climate affect soil formation?

a. Temperature and rainfall are the critical factors.

1. Temperature:

a. Important in chemical and physical weathering of parent material.
b. Temperature fluctuations cause expansion and contraction.
c. High temperature speeds chemical reactions.

2. Rainfall:

a. Speeds chemical and physical weathering.
b. Increased rainfall means more sedimentation.
c. Moisture must be present for chemical weathering.

10. How does relief or topography affect weathering?

a. Relief: Elevations or inequalities of the land surface, considered collectively.

1. Affects soil drainage and erosion.
2. Soil on slopes tends to be shallow.
3. Nature of soil formed on slopes and uplands is usually:

    a. Well aerated soil
    b. Oxidized soils
    c. Bright colored B horizon
    d. Low in organic matter

11. The effect of vegetation on soil formation.

a. Two general categories of vegetation are forest and grasses.

1. Soils developed under grassland vegetation

    a. Tend to have thick, dark, organic matter rich A horizons.
    b. Have organic content and dark color caused by decomposition of grass roots.
    c. These soils are usually quite fertile.

2. Soil developed under forest vegetation may:

    a. Tend to have a thin A1 horizon.
    b. Tend to have a thick bleached B horizon.
    c. Usually have a thick O horizon.
    d. Have nutrient levels that are somewhat lower.

12. How does time affect soil formation?

a. Time determines the degree to which other factors express themselves.

b. Soils formed from granite develop very slowly.

c. Four general statements about soil formation and time.

1. Older soils have deeper soil profiles.
2. Older soils are usually more highly weathered.
3. Older soils contain thick A2 and B horizons.

4. Older soils have usually lost their plant nutrients due to leaching.

13. What is a soil profile and why is it formed?

a. A vertical section of the soil through all its horizons and extending into the parent material.

b. Show overhead 3 of a typical soil profile.

Application:

There are several possible activities that might be used to apply some of the knowledge learned in this lesson.

1. Break the class into small groups and prepare a report on how the soil was formed in the area in this lesson.

2. Select different soil formations in your area and have the students describe the unique characteristics of the formation.

3. Collect, identify and categorize the various rocks and minerals which are a part of the parent material of the soil in your area. This could be used for future soil studies.

References:

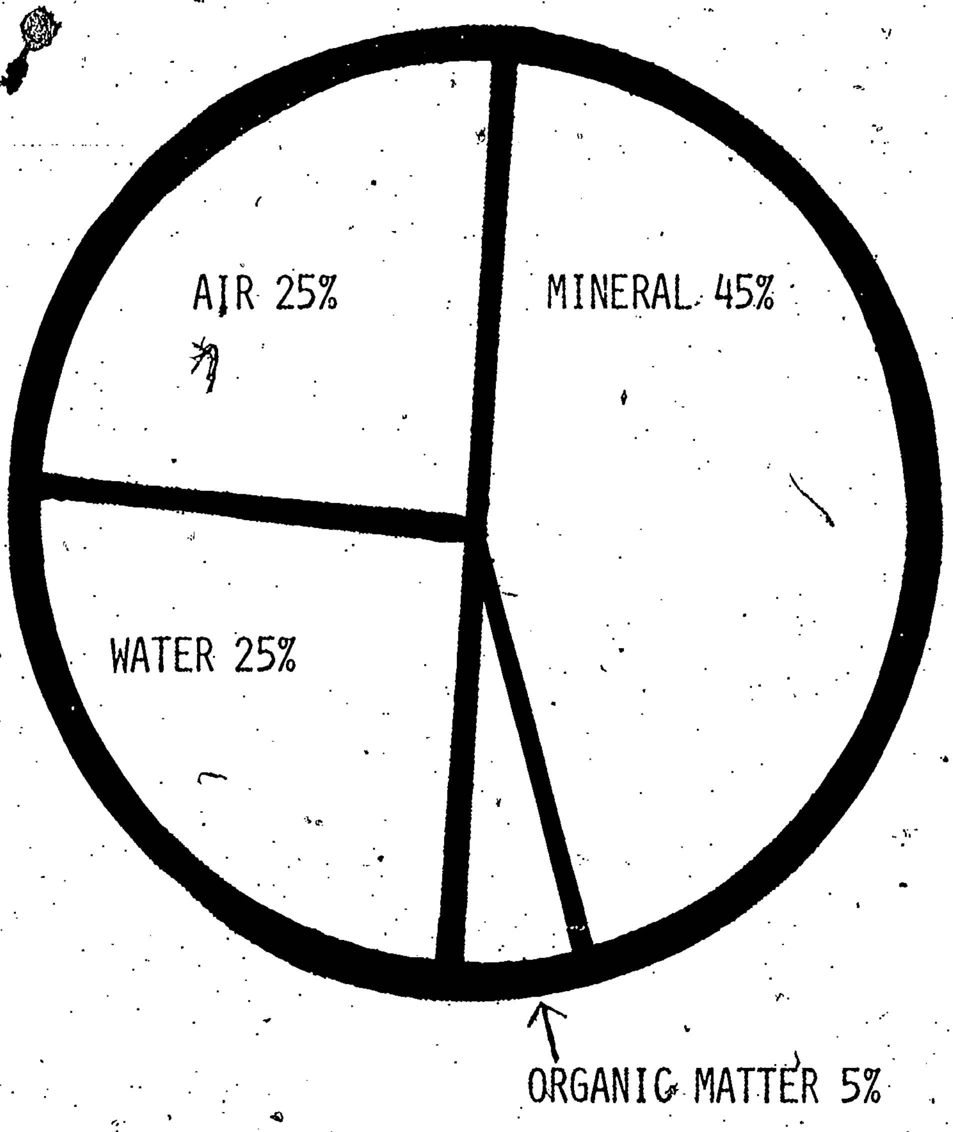
Bishop, Carter, Chapman, Bennet. Crop Science and Food Production, McGraw Hill, New York 1983.

Sopher & Baird. Soils & Soil Management, Reston Publishing Co., Inc., Reston, Virginia 1978.

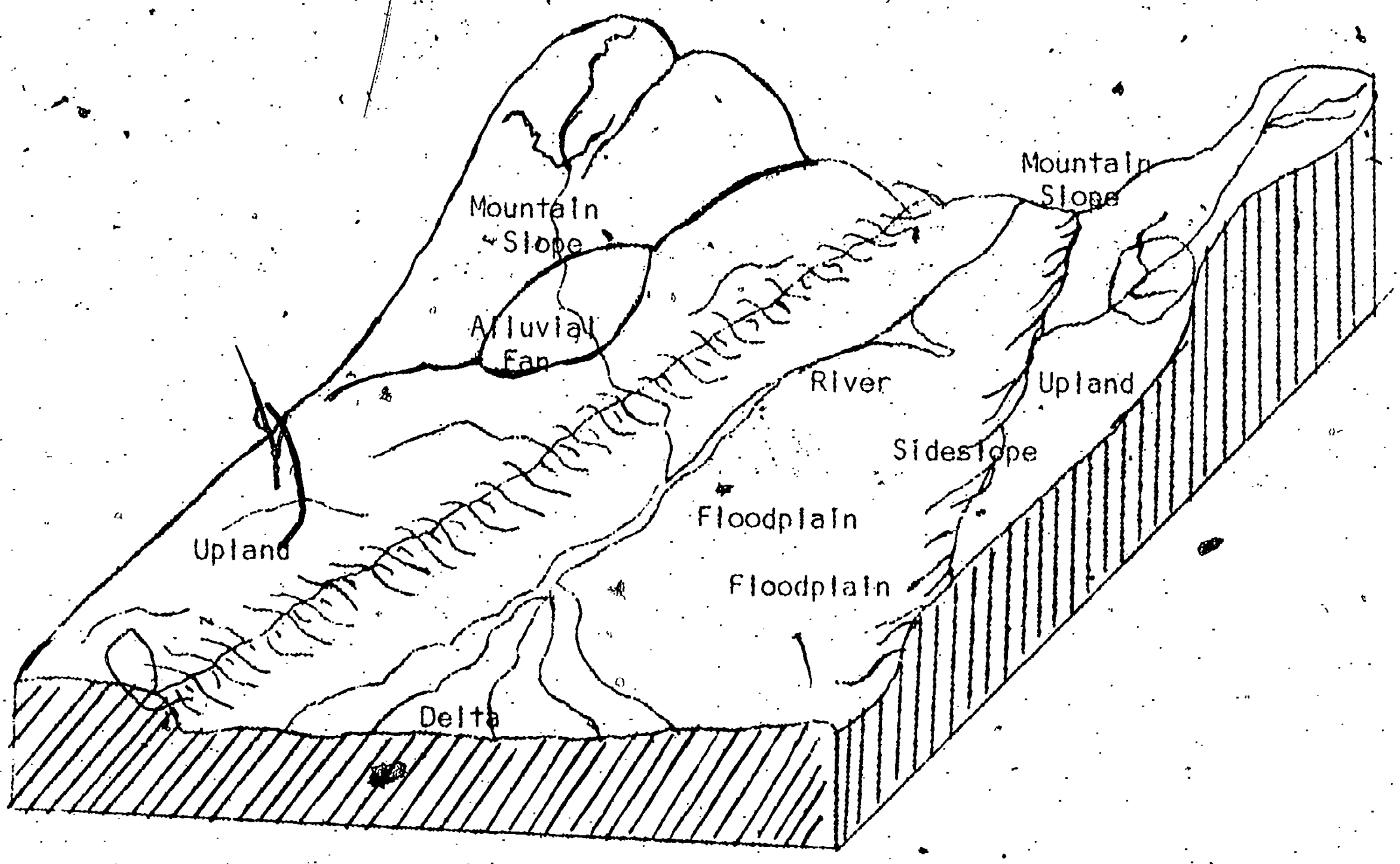
Knuti, Korpi, Hide, Profitable Soil Management, Prentice Hall Inc., Englewood Cliffs, NJ, 1962.

Various Film Strips.

REPRESENTATIVE COMPOSITION OF A MINERAL SOIL BY VOLUME



CHARACTERISTICS OF ALLUVIAL TYPE SOIL DEPOSITS



ALLUVIAL FAN:

1. GENERALLY AT THE FOOT OF A MOUNTAIN SLOPE.
2. GENERALLY THE SOILS ARE WELL DRAINED.
3. SOIL TYPES DEPEND ON SLOPES ABOVE FAN.

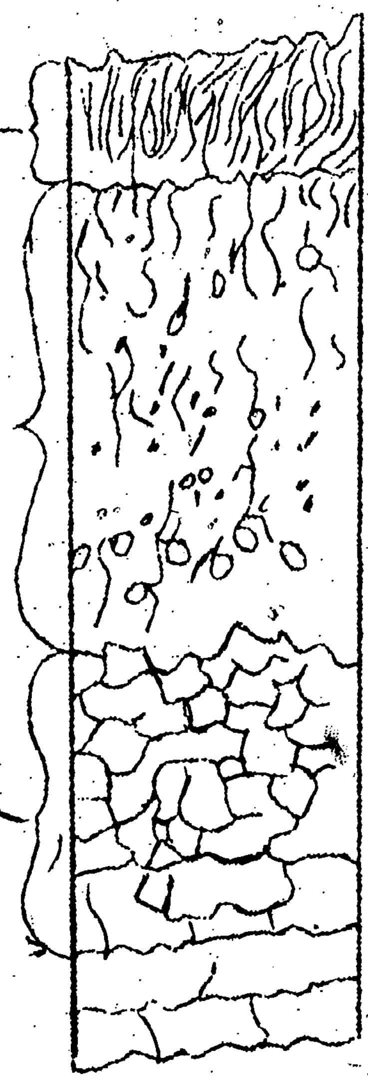
FLOODPLAIN:

1. USUALLY POORLY DRAINED.
2. SOIL TYPE DEPENDS ON SOURCE OF ERODED SEDIMENT
3. THEY MAY CONTAIN HIGH AMOUNTS OF ORGANIC MATTER
4. USUALLY HIGH IN NUTRIENTS.

DELTA:

1. USUALLY SWAMPY.
2. SUBJECT TO FREQUENT FLOODING.
3. THE SOIL IS USUALLY FINE WITH LARGE AMOUNTS OF CLAY.

SOIL PROFILE



MOST FINISHED LAYER
USUALLY DARKER IN COLOR
WHERE LIFE IS
USUALLY CONSIDERED
TO BE THE TOPSOIL

A HORIZON (TOPSOIL)

B HORIZON (SUBSOIL)

COMMONLY CALLED THE SUBSOIL
OFTEN FINER IN TEXTURE THAN
A HORIZON

C HORIZON

NOT YET TURNED INTO TRUE SOIL
CALLED THE PARENT MATERIAL

PARENT MATERIAL

BEDROCK

MAJOR CLASSES OF MINERALS

Broad Mineral Group	General Characteristics
FELDSPARS	
AMPHIBOLES and PYROXENES	
MICAS	
SILICA	
IRON OXIDES	
CARBONATES	

ROCKS FROM WHICH SOIL IS FORMED

Name of Rock	Class Igneous Sedimentary Metamorphic	Texture Course or Fine	Name of Principal Minerals	Physical Appearance Color	Hardness to Knife
Conglomerate					
Basalt					
Gneiss					
Granite					
Coral					
Limestone					
Marble					
Obsidian					
Pumice					
Quartzite					
Sandstone					
Schist					
Scoria					
Shale					
Slate					
Travertine					

UNIT: Basic Soils

Lesson: The Physical Properties of Soil

Need: A person need not be a soil scientist to describe the basic physical properties of soil. Everyone can appreciate the characteristics of soil by seeing it, feeling it, and smelling it. Color tells us about the organic content, feeling soil tells us something about particle size. Understanding the soil's physical characteristics will help everyone from the home gardener to the soil scientist conserve our greatest natural resource.

Objectives:

After the lesson has been taught and individual study and practice has been completed, the students will be able to:

1. Define the following terms that relate to the physical properties of soil.

   texture
   structure
   permeability
   soil separates

2. Describe and identify the three basic soil textures; a) sand, b) silt, and c) clay.

3. Distinguish between good soil structure and poor soil structure.

4. Determine the major soil textures using the "feel" test.

5. Identify and describe the major soil structures to include: a) platty, b) prismlike, and c) blocklike.

Interest Approach:

Have several samples of soil from the local area available. Have the students examine the soil. Discuss and list on the board the differences the students are able to see by looking at the soil samples. It would be appropriate to let one or two students use a feel test to determine if they think there is a difference. Be sure to point out that in this lesson they will be studying only those things that they can see.

Key questions, problems concerns	Teaching techniques and information
1. What are the physical properties of soil?	a. Physical properties add to the appearance and feel of a soil. They include color, texture, structure, consistency and permeability.

2. What is a soil separate?	a. A specific size of soil particle. b. Show overhead 1 to illustrate the different soil separates. c. Using a set of soil sifting screens, collect actual soil separates.
3. What is meant by a soil texture class?	a. Soil with similar amounts of sand, silt, and clay. b. Discuss the 4 broad soil texture classes. 1. Use overhead 2 to show the textural classes. 2. Have the students feel the texture of the major texture classes.
4. Practice identification of the common textural classes of soil.	a. Demonstrate the use of the textural triangle. (Use overhead 3) b. Distribute handout 1 describing the general characteristics of soil textural classes. c. Demonstrate the feel test and use of the soil triangle to determine texture.
5. What effect does soil texture have on soil management?	a. Pass out appropriate reference material. During supervised study, have students complete handout 2 before discussing the question.
6. What is soil structure?	a. The arrangement of soul particles into aggregates and the subsequent arrangement of these aggregates in the soil profile. b. Illustrate to the students by showing them one of the basic structural types.
7. What are the basic types of soil structures?	a. Use overhead 4 to show the various aggregates. b. Have actual examples to show the students.
8. Why is soil structure important?	a. Good structure: 1. Will increase permeability. 2. Will reduce runoff and erosion. 3. Will enhance root growth and penetration.

4. Will improve soil-air relationships.
5. Will enhance water movement in heavy soils.

9. What farming practices can be followed to improve soil structure?

a. Till soil when moisture conditions are right.

b. Maintain proper soil fertility.

c. Grow crops that produce organic matter.

d. Grow crops that enhance beneficial fungi.

e. Turn crop residues under.

10. Discuss the relationship between soil color and the physical properities of soil.

a. Use overhead 5 to discuss soil color.

11. What is soil permeability?

a. Movement of air and water through soil.

b. To have permeability, a soil must have pores which are continuous and large enough for air and water to pass through them.

c. Permeability depends on:

1. Porosity or pore space: represents soil volume which can be occupied by air and/or water.
2. Bulk density: weight per volume of an undisturbed soil.

12. What is the effect of soil permeability?

a. Coarse soils like sand usually have bulk density.

b. Coarse soils are quite permeable.

c. Poorly structured have lack of permeability.

d. Improvement of soil structure is the only economical means of changing permeability in large areas.

Application or Followup:

Provide each student with the form that is entitled: "Determination of Soil Textural Class". In part "A" fill in six known textural classes that you have available. When the students have completed part A, give them six unknown textural grades and have them complete part B.

Sieve and mechanical analysis procedures are provided if you wish to use them.

References:

Sopher & Baird, Soils & Soil Management, Reston Publishing, Reston Virginia, 1978.

Knuti, Korpi, Hide, Profitable Soil Management, Prentice-Hall, Englewood Cliffs, NJ, 1962.

Bishop, Chapman, Carter, Bennett, Crop Science and Food Production, McGraw Hill, New York, NY, 1983.

Carter, L.S., Experiments in Soil Science, California State Polytechnic College, San Luis Obispo, California.

SIZES OF SOIL SEPARATES

SOIL SEPARATE	DIAMETER LIMITS (MILLIMETERS)[2]	
VERY COURSE SAND	2.0 - 1.0	VERY GRITTY
COURSE SAND	1.0 - .5	VERY GRITTY
MEDIUM SAND	.5 - .25	VERY GRITTY
FINE SAND	.25 - .10	GRITTY
VERY FINE SAND	.10 - .05	SLIGHTLY GRITTY
SILT	.05 - .002	SMOOTH, VELVETY, BUTTERY
CLAY	LESS THAN .002	STICKY & PLASTIC

NOTE: A MILLIMETER = 0.03737 INCHES

THE FOUR BROAD SOIL TEXTURAL CLASSES

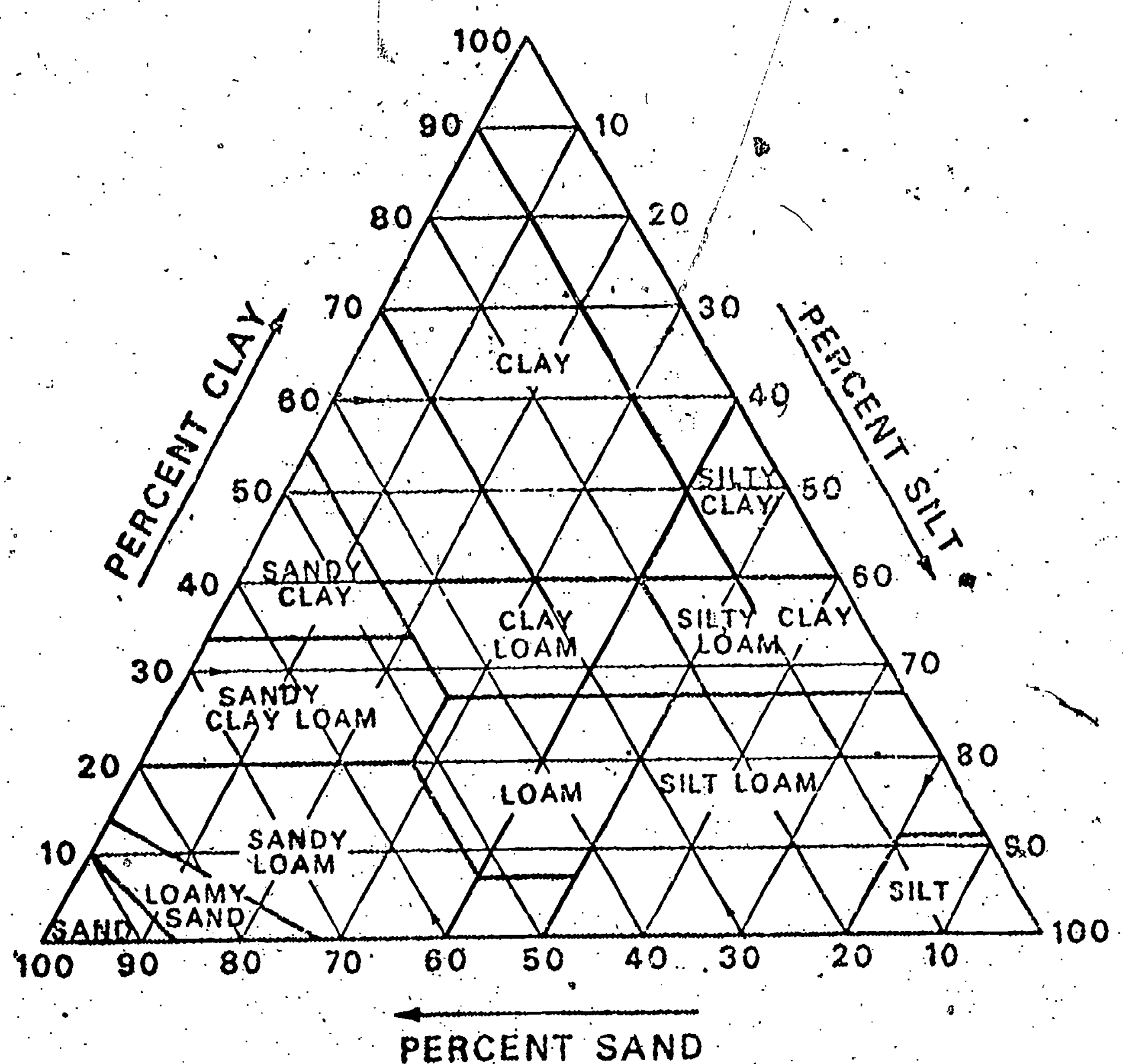
SAND: SOILS THAT CONTAIN MORE THAN 70% SAND.

SILT: SOILS THAT CONTAIN MORE THAN 80% SILT.

CLAY: SOILS THAT CONTAIN MORE THAN 40% CLAY.

LOAM: SOILS THAT CONTAIN AN INTERMEDIATE MIXTURE OF SAND, SILT AND CLAY.

GUIDE FOR TEXTURAL CLASSIFICATION

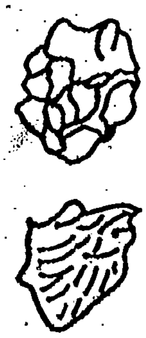


TYPES OF SOIL STRUCTURES

PRISMLIKE

PRISMLIKE

PLATTY



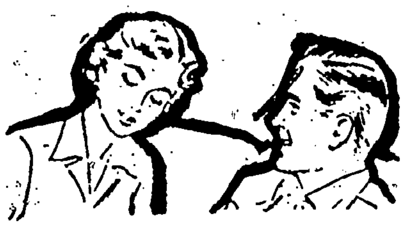
BLOCKY

GRANULAR

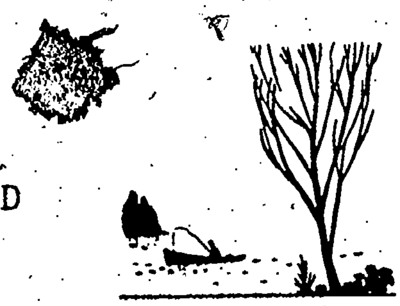
RELATIONSHIP BETWEEN SOIL AND COLOR

SOIL COLOR AND **HEAT** TEMPERATURE.

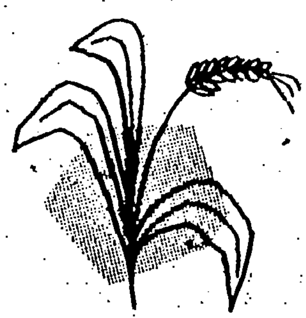
DARK SOILS ABSORB MORE HEAT
DARK SOILS WARM UP MORE QUICKLY IN THE SPRING
DARK SOILS TEND TO EXHIBIT HIGHER SOIL TEMPERATURE

SOIL COLOR AND  PARENT MATERIAL.

SOIL FORMED FROM MOFIC (BASIC) ROCK ARE USUALLY DARKER
SOIL FORMED FROM DELSIC (ACID) ROCK ARE USUALLY LIGHTER

SOIL COLOR AND  DRAINAGE.

WELL DRAINED SOILS ARE RED AND YELLOW DUE TO OXIDIZED IRON.
POORLY DRAINED SOILS HAVE BLUE AND GRAY COLORS.

SOIL COLOR AND  ORGANIC MATTER.

SOIL WITH HIGH ORGANIC MATTER CONTENT IS DARK.

SOIL TEXTURAL CLASS CHARACTERISTICS

SAND: Loose and single-grained with the individual grains readily visible; when squeezed a cast will form which will not fall apart when the hand is opened.

LOAMY SAND: Loose and single-grained with the individual grains visible; when squeezed a cast will form which will not fall apart when the hand is opened; the cast will break when handled.

SANDY LOAM: Loose and single-grained with the individual grains visible; often sufficient clay present to give the appearance of coatings on the grains; when squeezed a cast will form that can be handled very carefully without breaking.

LOAM: A relative uniform mixture of sand, silt, and clay that may feel gritty but usually does not have complete visibility of sand grains; a cast formed by squeezing can be handled freely without breaking.

SILT LOAM: Ranges from gritty to floury depending on size of the sand particles; usually visible sand grains appear coated when observed in the soil mass; a cast may be passed from hand to hand without breaking; soil will not ribbon and will give a broken appearance when pressed over the forefinger.

SILT: No visible sand grains; very smooth and floury feeling due to uniform particle sizes; may come close to forming a ribbon which barely sustains its own weight.

SANDY CLAY LOAM: Plastic soil; may have visible sand grains if pressed between thumb and forefinger; soil will form a ribbon which barely sustains its own weight.

CLAY LOAM: Heavy, fairly uniform, plastic mass; few visible sand grains; will form a ribbon which barely sustains its own weight.

SILT CLAY LOAM: Heavy, plastic uniform mass that has a rough appearance when rubbed over the forefinger; forms a ribbon which will barely sustain its own weight.

SANDY CLAY: Plastic soil that will form a ribbon capable of sustaining its own weight; will appear rough or broken when rubbed over the thumb and forefinger.

SILTY CLAY: Plastic soil that will form a ribbon capable of sustaining its own weight; will appear rough or broken when rubbed over the thumb and forefinger.

CLAY: Plastic to very plastic soil that will appear greasy or sticky when rubbed over the forefinger; capable of forming a long ribbon which will support its own weight.

SOIL TEXTURE AND SOIL MANAGEMENT

Texture	Type of Soil	Advantages	Disadvantages
SAND			
SILT			
CLAY			
LOAM			

DETERMINATION OF SOIL TEXTURAL CLASS

Part A. Known Samples

No.	Soil Textural Class	Primary and secondary characteristics
1		
2		
3		
4		
5		
6		

Part B. Unknown Samples

No.	Soil Textural Class	Primary and secondary characteristics
1		
2		
3		
4		
5		
6		

SIEVE ANALYSIS METHOD

Materials Needed:

- Soil samples - oven dry
- Distilled water
- 8% Calgon solution
- Set of Graduated sieves
- 400 ml. beaker
- Drying ovan

Procedure:

1. Weigh out 200 grams of oven-dry soil and place the material in a large beaker. Add 25 ml. of Calgon dispersing solution, add distilled water to bring the volume within about 1 inch of the top and stir frequently for about one-half hour.

2. Carefully pour the material in the beaker on a 270 sieve, rinse beaker and pour on sieve and flush the silt and clay through using a strong spray of tap water . . . Be very careful of the sieve.

3. Wash the sands into a small pan, rinse several times to get rid of the floating organic matter, carefully pour off excess water, transfer sands to a beaker and place in oven to dry.

4. At the next laboratory period, prepare a nest of sieves, pour all of the sands on the top sieve and gently rotate or shake the sieves for five minutes.

5. Weigh the fraction retained by each sieve. From these weights and the original weight of the sample calculate the percentage of each fraction in the sample. Discard sand and clean up glassware.

Sieve No.	Size mm	Separate	Weight gm	Percent
10	2.0	Gravel	______	______
18	1.0	very coarse sand	______	______
35	0.5	Coarse sand	______	______
60	0.25	Medium sand	______	______
140	0.10	Fine sand	______	______
270	0.05	Very fine sand	______	______
-270 less than	0.05	Silt plus clay	______	______

MECHANICAL ANALYSIS OF SOILS

Materials Needed:

- Various soil samples
- 1 fruit jar and lid for each sample
- 8% Calgon solution - Mix 6 tablespoons of Calgon per qt. of water
- Ruler - graduated in the metric system
- Measuring cup
- Tablespoon

Procedure:

1. Place approximately one-half cup of soil in a quart jar. Add five tablespoons of the 8% Calgon and three and one half cups of water. Cap and shake for five minutes. Place the jar on the desk and let stand for 24 hours.

2. At the end of 24 hours, measure the depth of settled soil. This represents the total depth of soil. Shake thoroughly for five minutes. Place the jar on the desk and let stand for 40 seconds. Now measure the depth of settled soil with a ruler. This is the sand layer.

3. At the end of 30 minutes measure the depth of settled soil and subtract the depth of sand from this depth to get the depth of the silt layer.

4. The remaining unsettled part represents the clay fraction.

5. Record your results for each of the soil samples.

Measurements:

You may convert the measurements into percentage figures using the following example:

		A	B
a.	Total depth of soil	23 mm	35 mm
b.	Depth of Sand Layer	9 mm	13 mm
c.	Depth of Silt Layer	10 mm	10 mm

% Sand equals $\frac{9 \text{ mm}}{23 \text{ mm}} \times 100\% = 39\%$ $\qquad \frac{12 \text{ mm}}{35 \text{ mm}} \times 100\% = 34.3\%$

% Silt equals $\frac{10 \text{ mm}}{23 \text{ mm}} \times 100\% = 43.5\%$ $\qquad \frac{10 \text{ mm}}{35 \text{ mm}} \times 100\% = 34.3\%$

% Clay equals 100% - (39% plus 43.5%) = 17.5%

100% - (34.3% plus 28.6%) = 37.1%

NOTE:
Refer to the soil triangle and determine the textural class of each soil.

UNIT: Basic Soils

Lesson: The Chemical Properties of Soil

Need:

Everyone is interested in having plenty of food to eat. The chemical properties of soil gives soil its ability to hold nutrients and create a desirable environment for the plant. Both conditions are necessary for a plant to produce. When studying chemical properties of soil, clay and organic material become extremely important. We will have to call on the students knowledge of positive and negative electrical charges to understand this lesson.

Objectives:

After the lesson has been taught and individual study and practice have been completed, the students should be able to:

1. Define the following terms that relate to the chemical properties of soil:

colloid	acidity
cation exchange	pH
ions	alkalinity

2. Describe how positive and negative electrical charges affect the soil and subsequent plant growth.

Interest Approach:

Have the students share what they know about positive and negative charges. Determine if they have any idea of how this phenomena relates to soil and the ability of soil to support plant growth.

Key questions, problems, concerns	Teaching techniques and information
1. What is a soil colloid?	a. A soil particle which is small enough to stay suspended in water. The particles are usually less than 0.002 mm in diameter. b. The colloid usually carries a negative electrical charge.
2. What are the different types of soil colloids?	a. Mineral 1. There are 1.1 clays (kaolinite) 2. 1.1 clay a. Show overhead 1. b. The negative charges come from broken chemical bonds along the edges of the particle.

c. Broken chemical bonds are caused by weathering.

3. 2.1 clay

a. Show overhead 2
b. The negative charges come from broken bonds and molecular arrangements within the aluminum layer.

b. Organic Colloids

1. Organic matter is of a colloidal nature when it decomposes.
2. They seldom have a distinct structure.
3. These colloids simply occur as coating around soil particles.

3. What is cation exchange? (Use overheads 3 & 4)

a. Because the colloids are negatively charged they are able to attract positively charged cations.

b. Remember there are water films around soil particles.

c. Cations can be attached to the soil particles and soil solution.

d. The cations come from fertilizers and the breakdown of minerals and organic matter.

e. The exchange takes place when one of the soil solution cations replaces one of the cations on a soil particle.

f. There is seldom an equilibrium because of leaching and plant uptake of cations is a continual process.

4. What is cation exchange capacity? (CEC)

a. The ability or capacity of a soil colloid to hold cations.

b. This capacity is dependent on the amount of charge on the soil colloid.

c. The amount of charge on the colloids is dependent on the types of colloids present.

d. Factors that affect CEC.

1. Number of colloids present (soil texture)
2. Type of colloids present (soil consistence)
3. Organic matter content

5. Why is CEC important in soil management?	a.	It indicates the nutrient holding capacity of a soil.
	b.	It determines how often and how much time must be applied.
	c.	Determines how crop nutrients other than time can be applied.
	d.	Help determine what form of nitrogen to apply to soil.
6. What is soil acidity?	a.	A soil with excessive amounts of H^+ ions in the soil solution.
		1. A common problem in the eastern part of United States.
7. What is soil alkalinity?	a.	An alkalin soil is one that has an excessive amount of OH ions in the soil solution.
		1. A common problem in many areas of the western half of the United States.
8. How do we describe acidity and alkalinity?	a.	Soil scientists speak of soil acidity and alkalinity as a soil reaction.
		1. Show overhead 5 of a pH scale. 2. Freshly distilled water is neutral. The H^+ ions and OH ions would result in a pH of 7. 3. Soils with a pH value of less than 7 are acidic. 4. Soils with a pH value greater than 7 are alkaline.
9. How are acid and alkaline soils formed?	a.	Acid soils
		1. Common in areas of high rainfall. 2. Soils in eastern half of the United States are predominantly acid. 3. In humid areas, soil moisture moves through the soil allowing the hydrogen ions of the water to replace other positive ions. Basic ions such as calcium tend to be washed out of the soil. 4. Soils in humid areas which were covered by forest are usually acid. 5. Loss of plant material from the soil tends to cause acid soil.
	b.	Alkaline soils
		1. Ususally occurs in dry areas. 2. Very little leaching takes place. 3. Soils which had a grass cover prior to cultivation are usually alkaline.

8. What is the affect of acidity and alkalinity on plant growth?

a. Acid soils

1. Plants generally favor a slightly acid soil.
2. The slight acid condition is more favorable to the activities of the soil organisms.

b. Alkaline soils

1. Will generally slow the growth of the crop.
2. If severe enough, the crop will be unable to draw moisture from the soil solution.
3. Review overhead 6 showing the crops and tolerance.

Application and Followup:

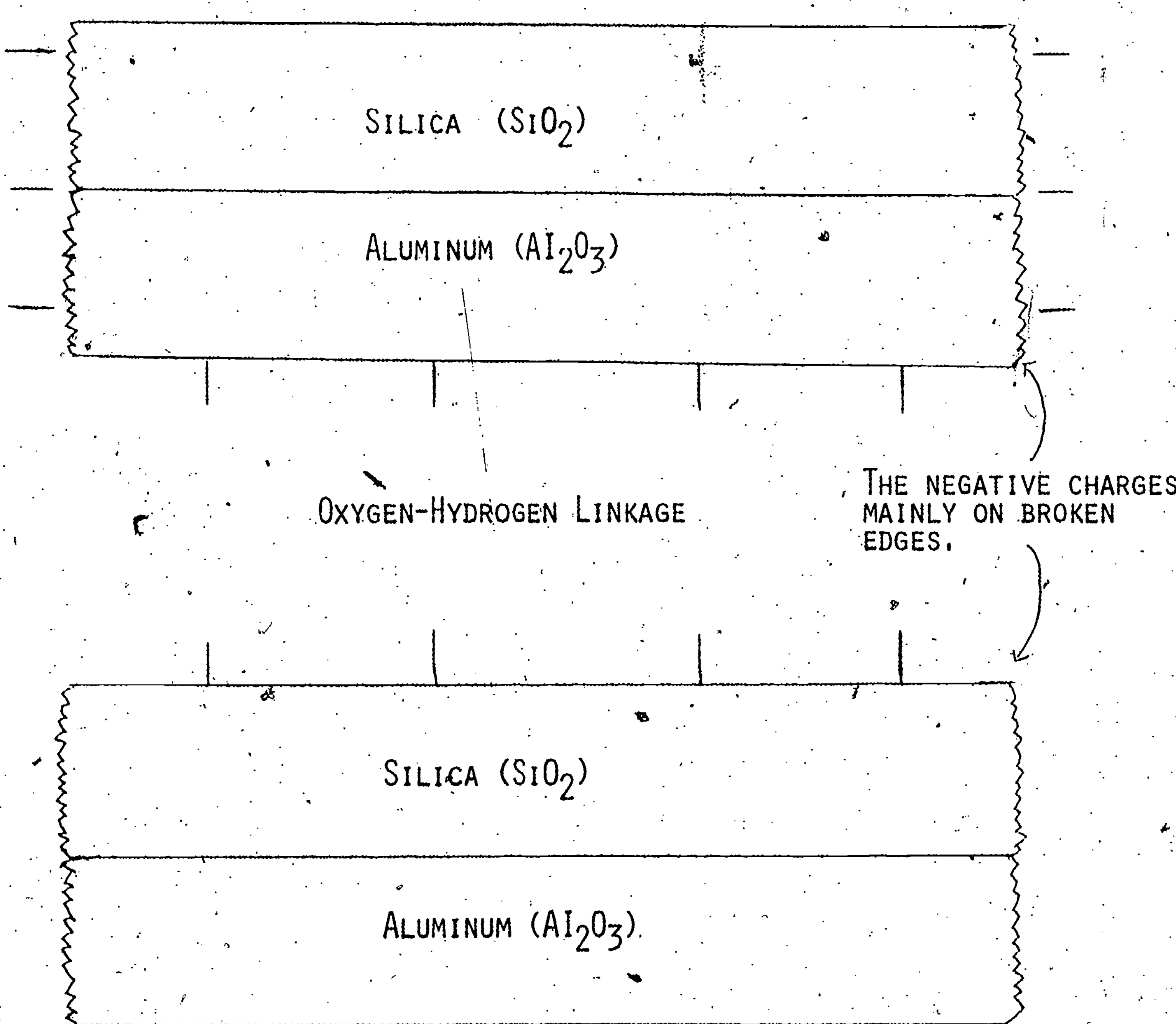
Assist the students in completing the exercise entitled, "Nature of Soil Colloids." Completion of this activity will require some advanced planning. Taken from page 201-203, Experiments in Soil Science.

References:

Sopher & Baird, Soils and Soil Mangement, Reston Publishing Co., Inc. Reston, Virginia, 1978.

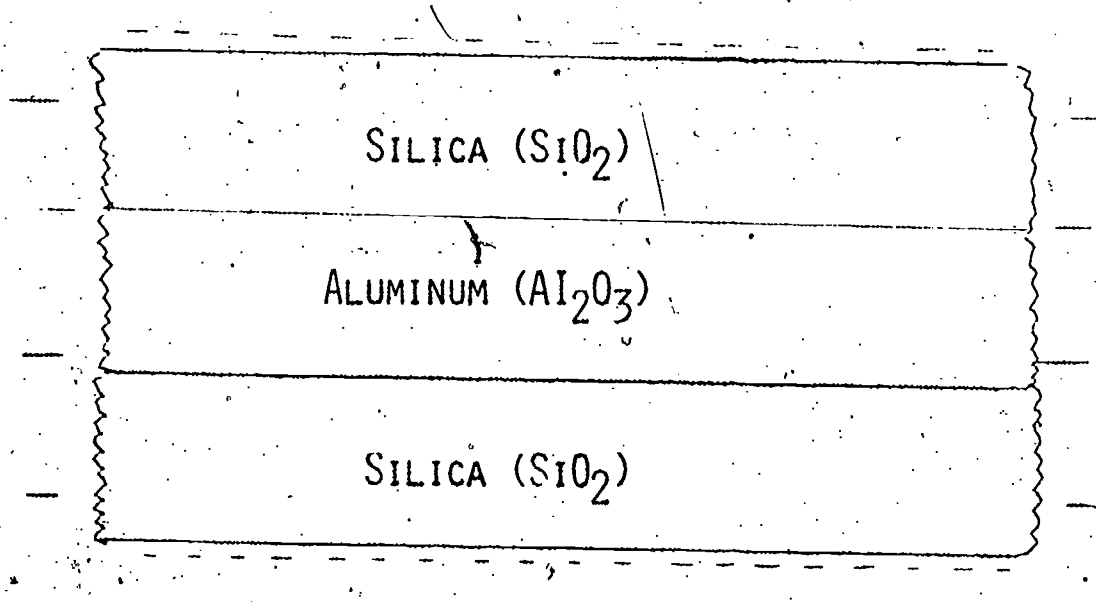
Carter, Logan S., Experiments in Soil Science, Instructional Material Program, California State Polytechnic College, San Luis Obispo, California.

1:1 CLAYS



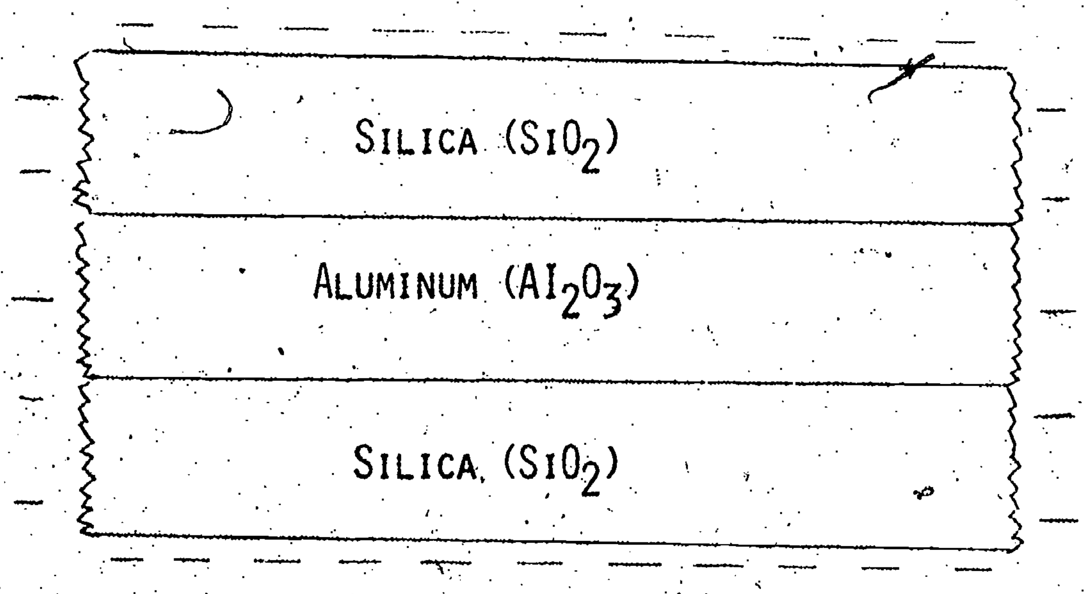
MAIN TYPES OF 1:1 CLAY: KAOLINITE AND HALLOYSITE

2:1 CLAYS



INTERLAYER SPACE

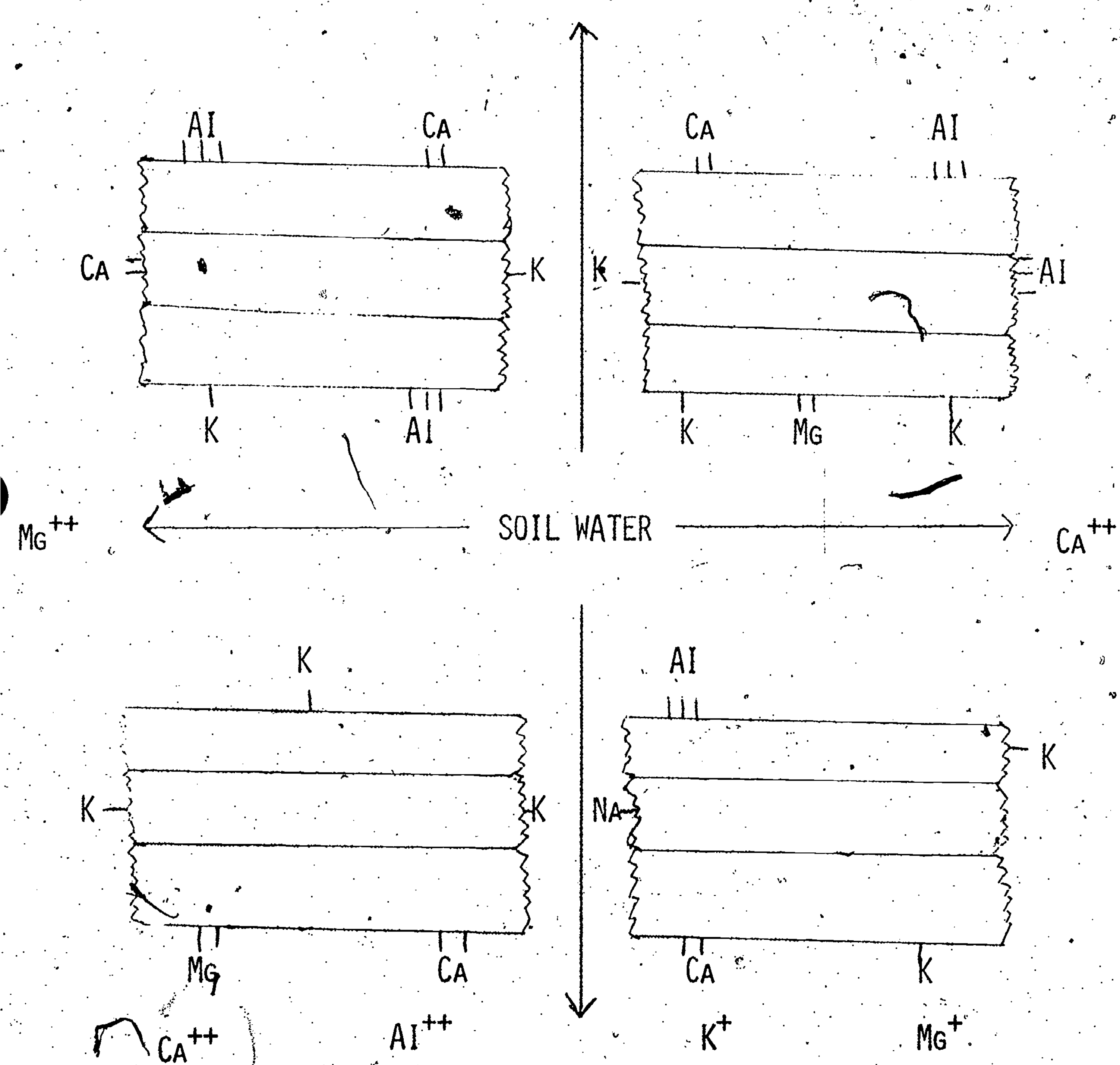
NEGATIVE CHARGES COME FROM BROKEN BONDS ALONG EDGES AND MOLECULAR ARRANGEMENTS WITHIN THE ALUMINUM LAYER.



NEGATIVE CHARGES COME FROM

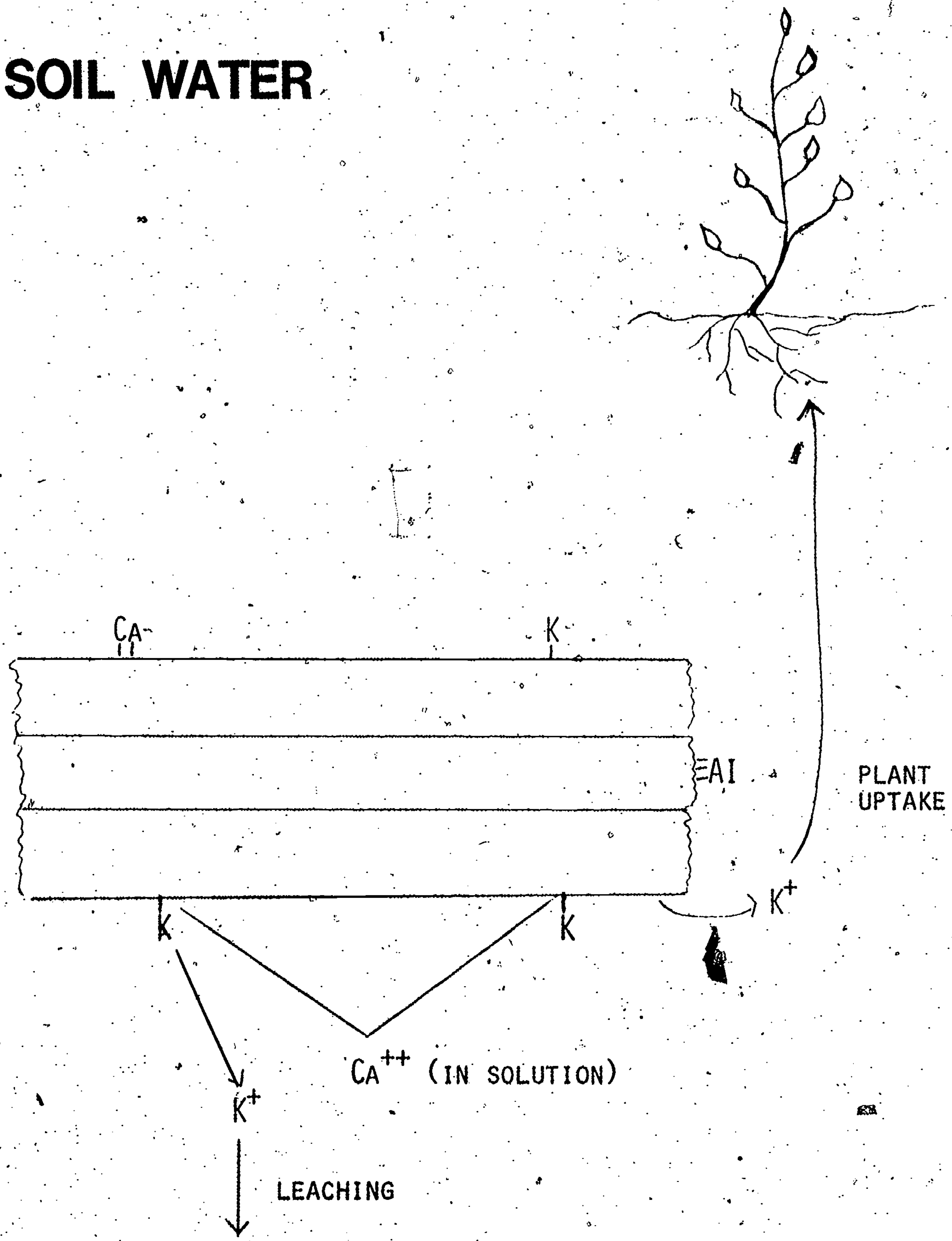
MAIN TYPES OF 2:1 CLAY: MONTMORILLONITE, ILLITE, VERMICULITE, VERMICULITE-CHOLORITE MATERIALS.

COLLOIDS CONTROL THE IONS IN SOIL WATER



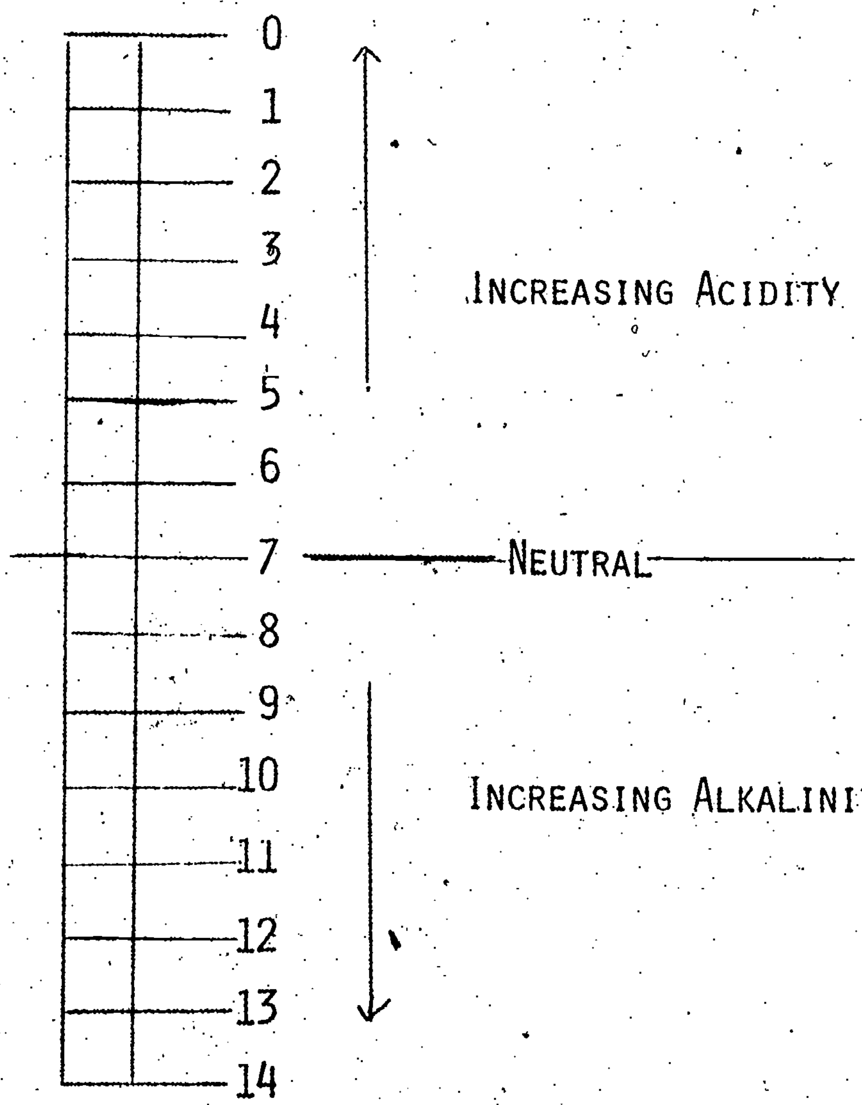
THE COLLOIDS CONTROL THE IONS IN SOIL WATER.

SOIL WATER



CATION EXCHANGE TAKES PLACE BECAUSE OF LEACHING AND/OR NUTRIENT UPTAKE REMOVING IONS FROM THE SOIL SOLUTION.

PH SCALE


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
INCREASING ACIDITY
NEUTRAL
INCREASING ALKALINITY

pH RANGES FOR SOME COMMON CROPS

CROP	pH RANGE
ALFALFA	6.0 - 6.7
CORN	5.8 - 6.7
GRASSES	5.8 - 6.2
SMALL GRAINS	5.8 - 6.2
GENERAL GARDEN CROPS	5.8 - 6.2

UNIT: Basic Soils

Lesson: The Biotic Properties of Soil

Need: The soil is full of animal life that is constantly in motion, doing things that aid in crop production. The soil is literally alive with activity. To understand how the soil supports plant life, students must understand the role microorganisms play in the decay of organic material, causing of plant disease and converting nitrogen into a form that can be used by plants.

Objectives:

After the lesson has been taught and individual study and practice has been completed, the students will be able to:

1. Define the following terms that relate to the biotic properties of soil.

Macroanimal	Rotifers	Bacteria
Microanimal	Algae	
Nematodes	Fungi	
Protozoa	Actinomycetes	

2. Name and describe the benefits of organic matter in maintaining soil in a good condition.

3. Describe the benefits of organic and inorganic matter in the soil.

4. Distinguish between organic and inorganic matter in the soil.

Interest Approach:

Collect some nematodes ahead of the class and place them on a microscope slide. Let the students observe the eel-like organisms for a few moments Compare these organisms in size with the others that are common in the earthworms on hand at the same time. Why are earthworms so critical in maintaining a good soil condition?

Key questions, problems, concerns	Teaching techniques and information
1. General comments	a. A vast number of organisms live in in the soil. b. The greatest number belong to the plant kingdom. c. Most soil organisms are minute in size, but have great importance in the soil. d. Distribute handout A on "Important groups of animals commonly found in soil".

2. What is a soil macroanimal and how do they help improve soil conditions?

a. These are the larger animals found the soil.

1. Rodents
2. Insects
3. Millipedes
4. Sawbugs (woodlice)
5. Mites
6. Slugs and snails
7. Centipedes
8. Spiders
9. Earthworms

b. Commmon rodents include:

1. Ground squirrel
2. Pocket gopher
3. Woodchuck
4. Kangaroo rat
5. Prairie dog

c. As these animals burrow and dig in the soil they may help:

1. Pulverization
2. Granulation
3. Transfer of soil
4. Control insect populations
5. Aerate and drain land
6. Initiate the decomposition process

NOTE: Point out that these rodents can cause damage in large concentration.

3. What is the most important macroanimal in the soil?

a. The earthworm

1. They pass large amounts of soil through their bodies. (as much as 15 tons of dry earth per acre)
2. This process increases the availability of plant nutrients.
3. Increase the level of organic matter.
4. The holes or tunnels left by the worm improve aeration and drainage.
5. May increase size and stability of the soil aggregate.

4. What are the important soil microanimals?

a. There are three main groups: nematodes, protozoa and rotifers.

1. Nematodes (Threadworms, eelworms)

   a. Found in almost all soils
   b. Show overhead 1 of a nematode
   c. The organisms are round and spindle shaped

d. Almost wholly microscopic
e. Three groups of nematodes:

1. Those that live on decaying organic matter
2. Those that are predatory
3. Those that are parasitic

f. Groups "a" and "b" above are most numerous
g. Those in group "c" has the ability to penetrate plant tissue

2. Protozoa - Show overhead 2.

a. Simplest form of animal life
b. One-celled organism but larger than bacteria
c. Three groups of protozoa

1. Amoeba
2. Ciliates or infusoria
3. Flagellates

d. More than 250 species have been isolated
e. A number of serious animal and human diseases are due to protozoan infections

3. Rotifers - Show overhead 3.

a. Their numbers are greatest in swampy land.
b. Mostly microscopic in size
c. Their importance to soils is unknown.

5. What types of plant life are common to soil?

a. Five types: (1) roots of higher plants, (2) algae, (3) fungi, (4) actinomycetes and (5) bacteria

1. Roots

a. Roots of higher plants, (ie. wheat, alfalfa, etc.) supply large amounts of organic material
b. A good crop of oats will produce approximately 4,000 pounds of dry matter per acre in the parts of the plant that grow above ground.

c. The maintenance of a satisfactory supply of organic matter is possible only because of root residues.

2. Soil Algae: Chlorophyll bearing organisms that live near the surface of the soil.

   a. Algae contribute to organic content of soil.
   b. May be valuable in the storage of energy.
   c. They may fix some atmospheric nitrogen.

3. Soil fungi: Three main groups include yeasts, molds, and mushroom fungi. Show overhead 4.

   a. General characteristics of fungi:

      1. They are filamentous, microscopic, or semi-macroscopic.
      2. They aid in decomposition and digestion of the organic residues.
      3. They are found in all soil layers with greatest numbers in the surface layers.
      4. They aid soil fertility by keeping the decomposition process going.

4. Soil Actinomycetes: Filamentous, often profusely branched body. Show overhead 5.

   a. They occupy a position between the molds and bacteria
   b. Develop best in moist, well-aerated soil
   c. Quite active even during drought periods
   d. Especially numerous in high humus, low acid soil
   e. Important in dissolving soil organic matter and liberation of nutrients
   f. Important in releasing nitrogen from humus.

5. Soil bacteria: Single-cell organisms, one of the simpliest and smallest forms of life known. Show overhead 6.

   a. They multiply by elongating and dividing
   b. The greatest number of bacteria are in the surface horizons.
   c. Two general types of bacteria:

      1. Autotrophic: Take energy from the oxidation of mineral constituents.
      2. Heterotropic: Take energy directly from organic matter.

   d. They are a part of all organic transactions.
   e. They are important in enzymic transformation.
   f. Show overhead 7 and discuss the role of bacteria in the soil.

6. What are the general harmful effects of soil organisms?

   a. Rodents and moles may cause damage and irrigation ditches.

   b. Snails and slugs give the gardener problems.

   c. Eelworms can infest plant roots.

   d. May contribute to plant disease

   e. May temporarily compete for soil nutrients

7. How can a producer manage his/her soil to maintain organic matter?

   a. Use overhead 8 to discuss these practices.

Application and Followup:

Have the students conduct two lab experiments to illustrate the effect of the biotic action in the soil. The two exercises are taken from the publication, "Experiments in Soil Management". These experiments will require 6 to 7 weeks of advanced planning.

References:

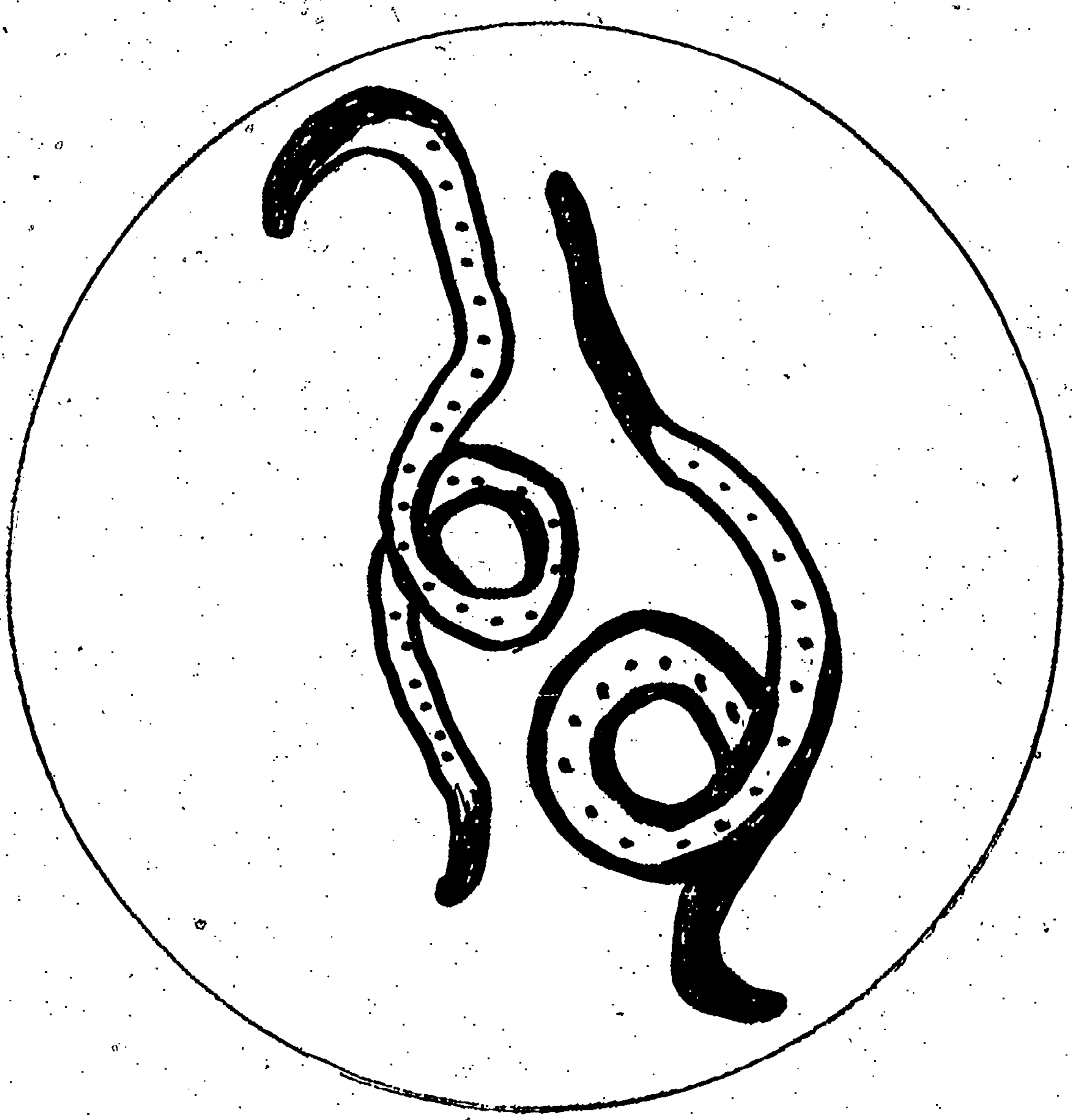
Bishop, Carter, Chapman, Bennett. Crop Science and Food Production, McGraw Hill, New York, NY 1983.

Sopher & Baird. Soils & Soil Management, Prentice Hall Inc., Englewood Cliffs, NJ 1962.

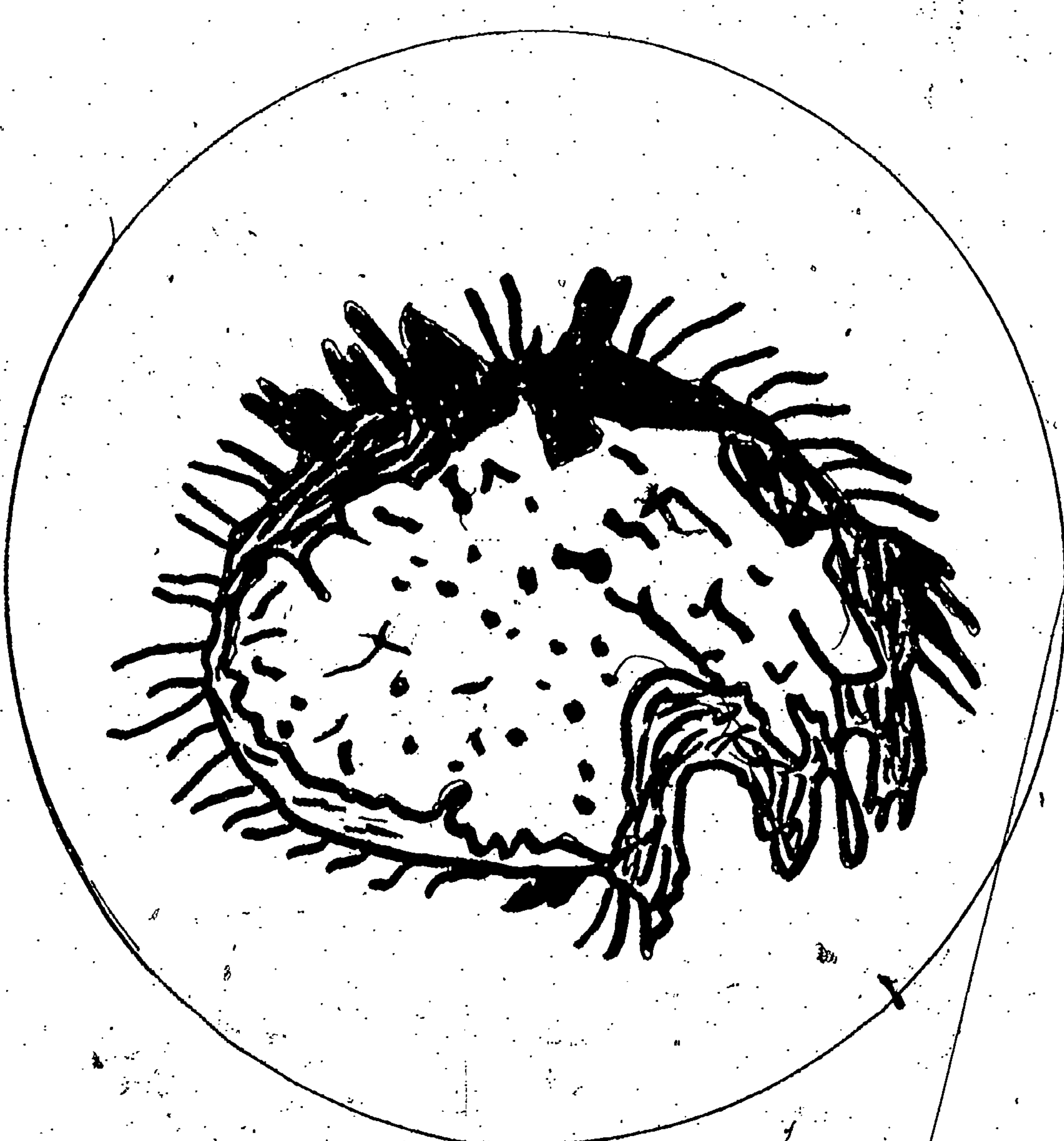
Knuti, Korpi, Hide, Profitable Soil Management, Prentice Hall Inc., Englewood Cliffs, NJ, 1962.

Carter, L.S., Experiments in Soil Science, Vocational Education Productions, California Polytechnic State University, San Luis Obispo, California.

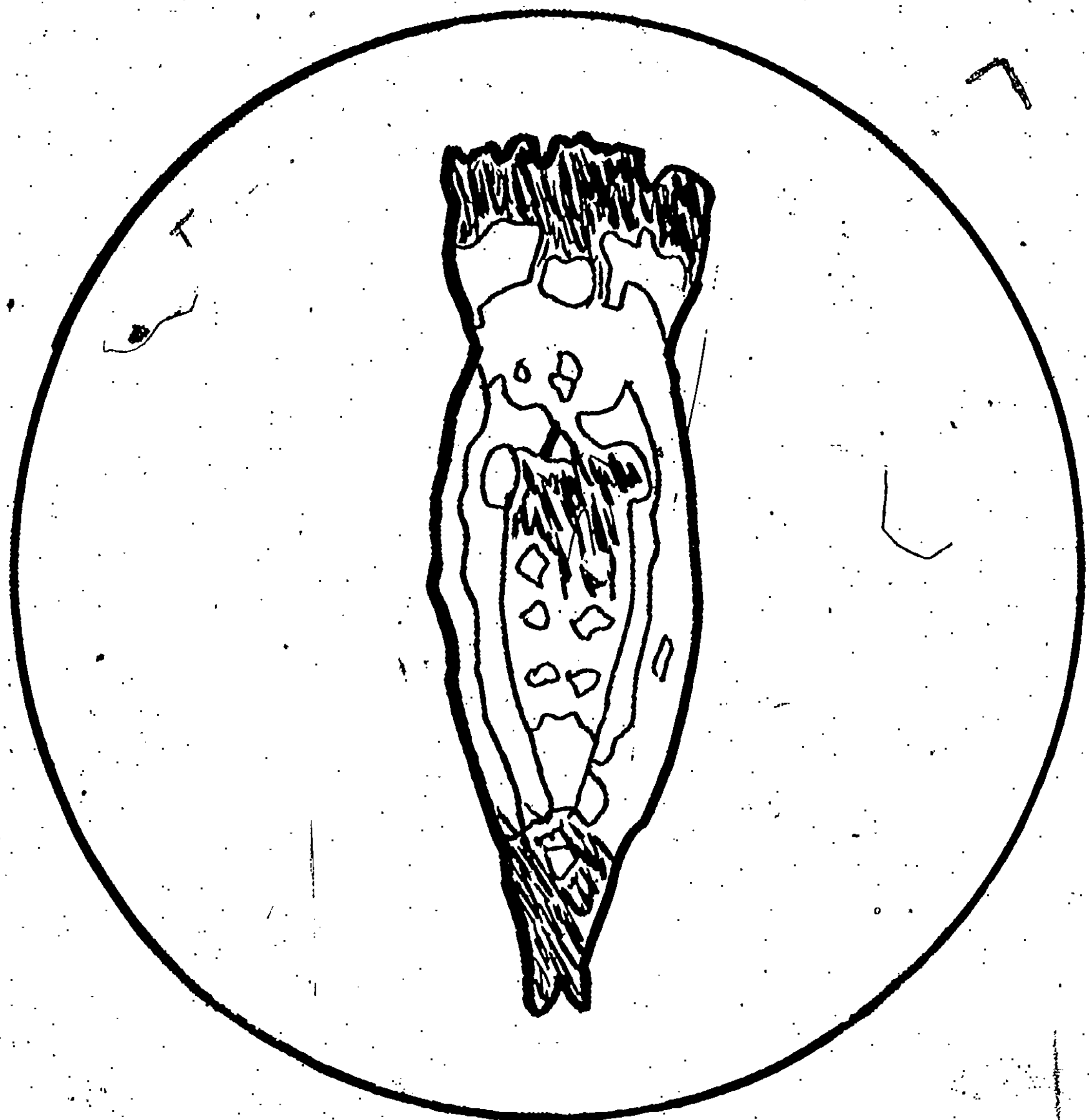
NEMATODE



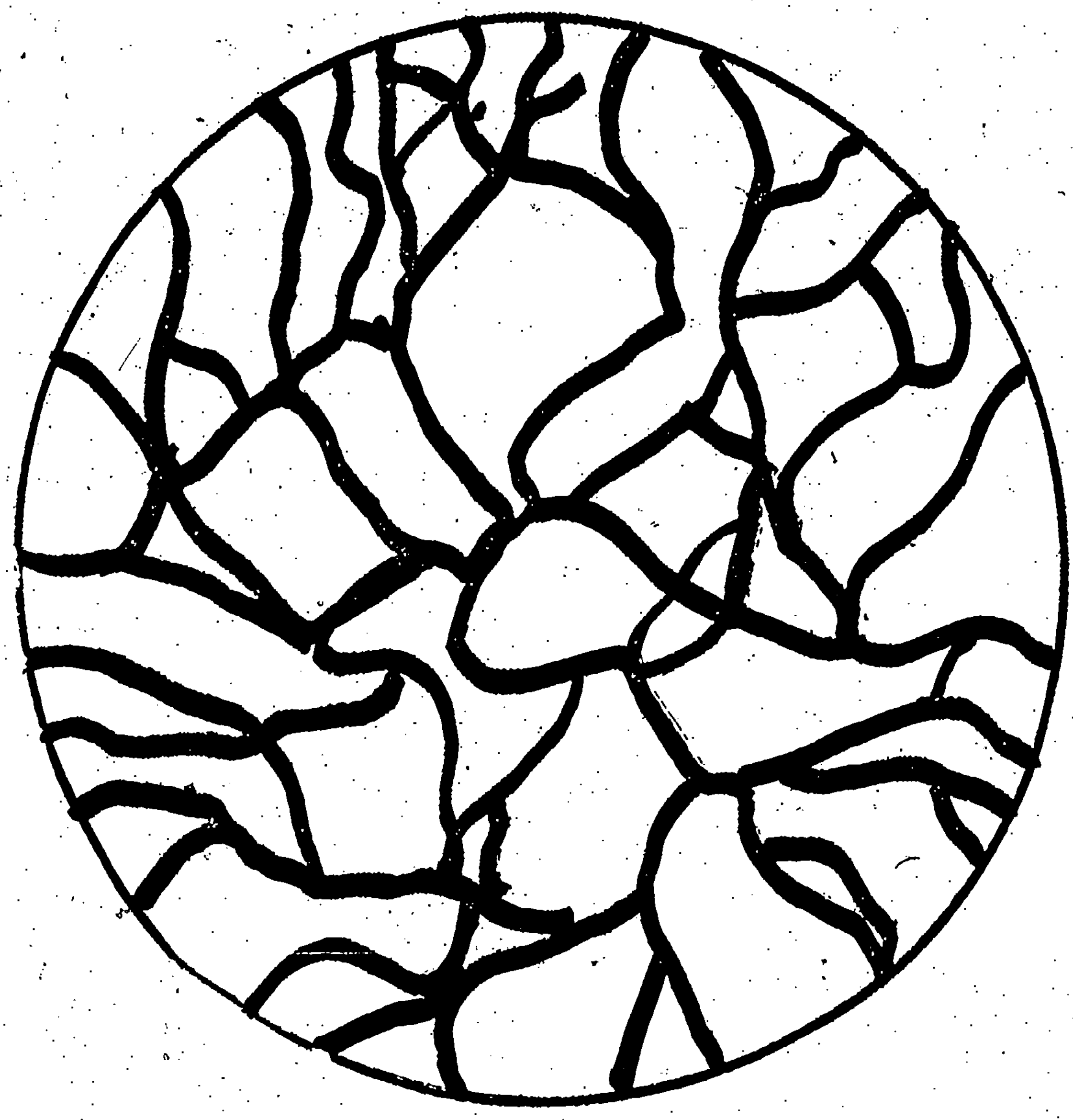
PROTOZOAN



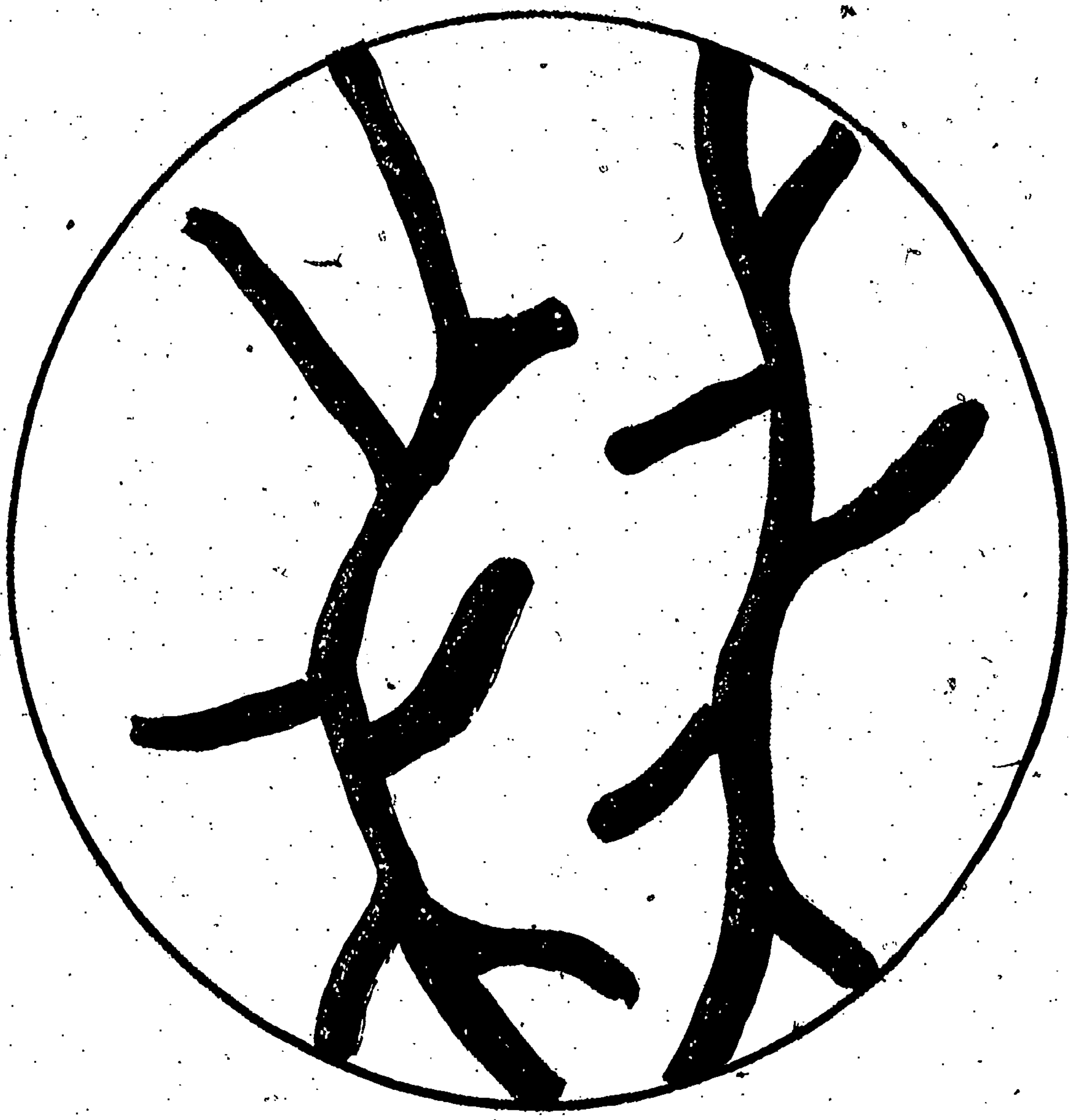
COMMON ROTIFIER



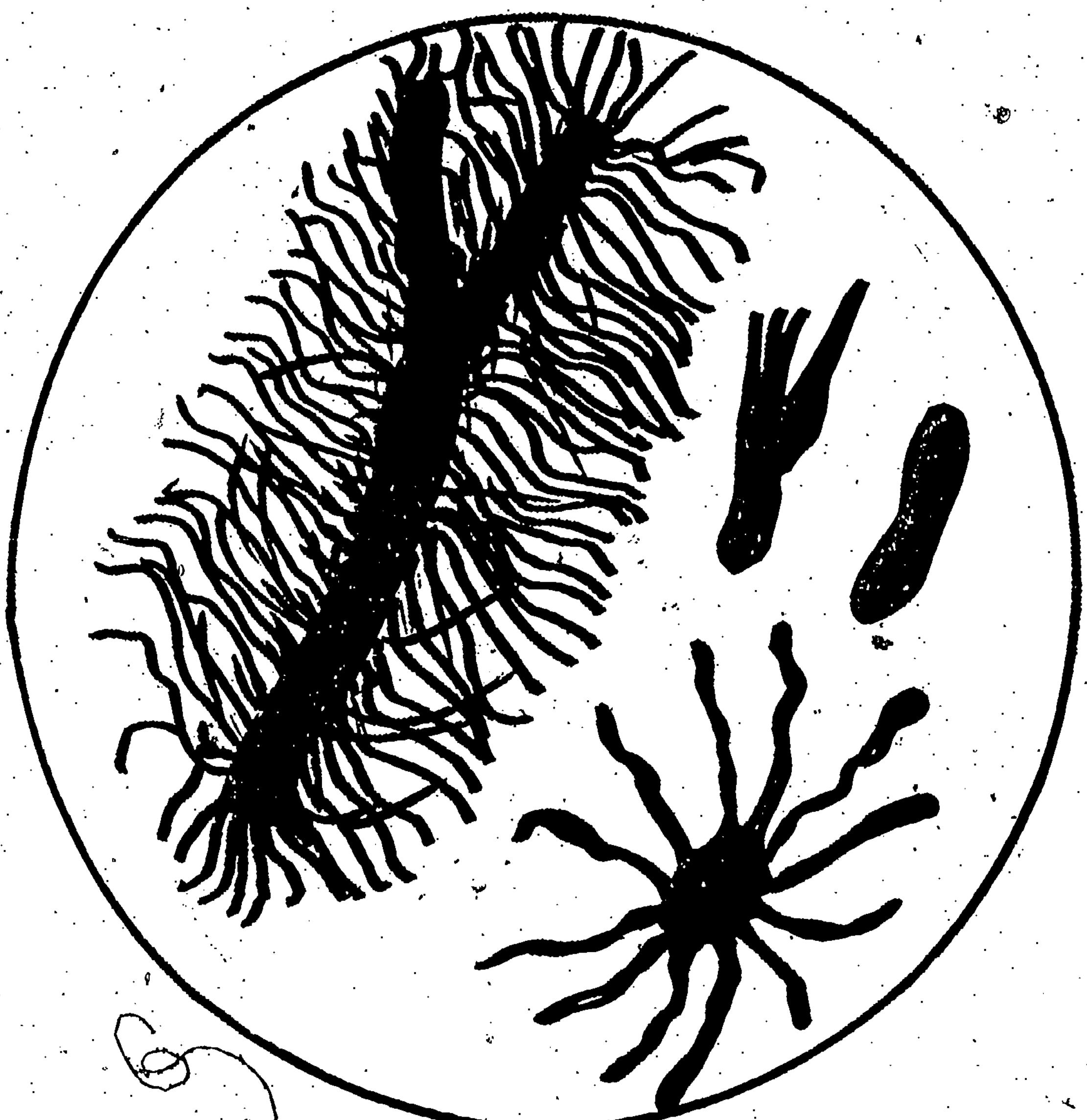
FUNGAL MYCELIUM



ACTINOMYCETES THREADS



VARIOUS TYPES OF BACTERIAL CELLS



PRIME FUNCTIONS OF SOIL ORGANISMS

NONSYMBIOTIC NITROGEN FIXATION: ORGANISMS IN THE SOIL THAT FIX NITROGEN IN SOIL FROM THE ATMOSPHERE.

SYMBIOTIC NITROGEN FIXATION: ORGANISMS THAT LIVE IN THE NODULES OF LEGUMES THAT FIX NITROGEN FROM THE ATMOSPHERE.

AMMONIFICATION: ORGANISMS THAT FREE AMMONIUM (NH_4^+) TO THE SOIL.

NITRIFICATION: ORGANISMS THAT CONVERT AMMONIUM (NH_4^+) TO NITRATE (NO_3).

PHOSPHORUS MINERALIZATION: ORGANISMS THAT CONVERT ORGANIC PHOSPHORUS TO ORTHOPHOSPHATES.

SULFUR CONVERSIONS: ORGANISMS THAT CONVERT SULFUR TO SULFATE (SO_4).

OTHER REACTIONS: ORGANISMS THAT RELEASE OTHER ELEMENTS DURING THE DECAY PROCESS.

MAINTAINING SOIL ORGANIC MATTER

1. KEEP GRASSES IN THE CROP ROTATION
2. RETURN ALL CROP RESIDUES TO THE SOIL
3. CULTIVATE NO MORE THAN NECESSARY
4. CONTROL EROSION
5. USE COVER CROPS WHEN POSSIBLE
6. RETURN ALL MANURES TO THE SOIL

IMPORTANT GROUPS OF ANIMALS COMMONLY FOUND IN THE SOIL

- Animals
  - Macro
    - Subsisting largely on plant materials
      - Small mammals - squirrels, gophers, woodchucks, mice, shrew
      - Insects - springtails, ants, grubs, beetles, etc.
      - Millipedes
      - Sowbugs (woodlice)
      - Mites
      - Slugs and snails
      - Earthworms
    - Largely Predatory
      - Miles
      - Insects - many ants, beetles, etc.
      - Mites, in some cases
      - Centipedes
      - Spiders
  - Micro
    - Predatory or parasitic or subsisting on plant residues
      - Nematodes
      - Protozoa
      - Rotifers
- Plants
  - Roots of higher plants
  - Algae
    - Green
    - Blue-green
    - Diatoms
  - Fungi
    - Mushroom fungi
    - Yeasts
    - Molds
  - Actinomyces of many kinds
  - Bacteria
    - Aerobic / Anaerobic and Autotropic / Heterotrophic

Taken from <u>The Nature and Properties of Soils</u> by Lyon, Buckman & Brady (1952)

Decomposition of Organic Matter

This exercise will help illustrate to your students that different factors affect decomposition of organic matter, the changes which occur during decomposition.

Materials Needed:

Soil
Residue, such as corn stalks, sawdust, grass, straw, leaves, etc.
Green manure, such as alfalfa hay or clover
Ammonium sulphate fertilizer
Treble superphosphate fertilizer
Two number 2½ size tin cans with holes in the bottom

Part One: This experiment shows the decomposing of organic materials in a miniature compost pile.

1. Cover the bottom of a number 2½ size with about ¼" of soil.

2. Add a layer of leaves and grass about an inch thick.

3. Sprinkle about ½ gram of ammonium sulphate and treble superphosphate, mixed in equal proportions, over the leaves and grass.

4. Dampen with water. Do not over-wet.

5. Repeat this layering until the can is full.

6. Weigh and record the weight, place the can on a saucer and set in an area where it will not be tampered with.

7. Weigh the can each week for six weeks and add enough water to maintain the original weight. (Keep the soil moist, but do not make it wet).

8. At the end of seven weeks, remove the contents of the can. Examine the material and record your results and observations.

Part Two: This experiment shows the variation in rate of decomposition of organic matter.

1. Chop or cut stalks of alfalfa hay into pieces one-half inch in length. Mix ten grams of this with 150 grams of soil.

2. Place the alfalfa and soil in a glass tumbler and moisten with water to field capacity.

3. Mark the tumbler with the treatment and the weight.

4. Repeat the above procedure, using straw.

5. Repeat the procedure, using corn stalks.

6. Make up a second set of tumblers with soil and organic matter as above, but, in addition, add one-half gram ammonium sulphate to each of the tumblers.

7. You should now have six tumblers set up as follows:

   a. Ten grams alfalfa in 150 grams soil.
   b. Ten grams straw in 150 grams soil.
   c. Ten grams corn stalks in 150 grams soil.
   d. Ten grams alfalfa in 150 grams soil with one-half gram ammonium sulphate.
   e. Ten grams straw in 150 grams of soil with one-half ammonium sulphate.
   f. Ten grams corn stalks in 150 grams of soil with one-half gram ammonium sulphate.

   All the samples should be moist but not wet.

8. Place these tumblers in the classroom for approximately six weeks, keeping them at optimum moisture.

9. At the end of six weeks, remove the contents of the tumblers, examine and compare them for completeness of decomposition. Note particularly the presence of ammonia.

10. Record your results.

UNIT: Basic Soils

Lesson: Plant-Soil-Water Relationships

Need: The soil is somewhat like a large sponge. It collects water during the wet periods of time and stores the water for the plants during the dry periods. Although it is a complex process, a general understanding of the process is important to help us know when to supply water to aid plant growth.

Objectives:

After the lesson has been taught and individual study and practice has been completed, the students should be able to:

1. Define the following terms that relate to the soil-water relationship.

gravitational water	field capacity
capillary water	wilting point
hygroscopic	adhesion
soil saturation	cohesion

2. To describe the differences among gravitational, capillary and hygroscopic water.

3. To describe the factors that will affect the soil's ability to hold water.

4. To describe the effects of water movement through the soil.

5. To identify some key farming practices that will make better use of soil moisture.

Interest Approach:

Illustrate the various soil moisture states (saturated, field capacity) by putting screened samples of a sandy and a clay soil in several wide-mouthed metal containers of similar size and adding different amounts of water to pairs of containers (one sand, one clay). You can determine how deeply the soil is wetted, and how much water drains out of soil, representing drainage after saturation.

Key questions, problems concerns	Teaching techniques and information
1. How does water enter the soil?	a. Water enters through pores (air spaces) by the action of gravity.
2. What three forms of water are found in the soil?	a. Gravitational water 1. Free water that moves through the soil because of gravity. 2. Usually moves so fast plants cannot use it.

3. May cause plants to wilt and die if it occupies necessary air space.

b. Capillary water

1. Water held loosely around soil particles.
2. Most of this water is available to the plant.
3. Water held by cohesion (attraction) between soil molecules.

c. Hygroscopic water

1. Forms very thin films around soil particle
2. Not usually available to plants
3. Held very tightly to the soil particle

d. Use overhead 1 to illustrate the three types of soil water.

3. How is the force with which water is held determined?

a. A bar. One bar equals one-third bar pressure applied by a water column 1 c in area and 1000 c in height.

1. From zero to about one-third bar pressure all gravitational water drains
2. From one-third bar to fifteen bars, capillary water drains
3. From fifteen bars upward we have hygroscopic water.

4. Discuss the important moisture constraints.

a. Soil saturation: When the soil contains all the water it can hold without standing on the soil.

b. Field capacity: Moisture content of soil gravity removed all the water it can.

c. Wilting point: That amount of soil moisture at which plants cannot obtain enough water to keep from wilting.

d. Hygroscopic percentage: The moisture content of the soil when it is about air dry.

e. Oven dryness: When soil moisture has been removed by heating the soil at 105°C for at least 12 hours.

f. Use overhead 2A, B to discuss the relationship of soil moisture to plant available moisture.

5. How is soil moisture calculated?

a. Use overhead 3 to illustrate moisture calculations.

b. It would be a good exercise to have the weight, dry and determine the moisture in some soil samples.

6. What soil factors affect water holding capacity?

a. Soil texture

1. The more clay there is in the soil, the more water it will hold.
2. Discuss why. What principle applies?

b. Soil consistence

1. The type of clay affects water holding capacity.

c. Soil structure

1. Has no direct effect on the soil's ability to hold water.
2. Does make soil more permeable
3. May increase soils effective water holding capacity

d. Organic matter

1. Improves soil structure and aggregation
2. Increases moisture holding capacity

7. How do the various types of soil water move in the soil?

a. Gravitational water

1. Have students define again
2. Responsible for nutrient leaching and soil erosion
3. Nutrients must be added when plants need them when the soil has a low water-holding capacity.
4. When irrigating, apply water to avoid leaching and erosion.

b. Capillary water

1. Have student define again
2. Moves to points of highest tension
3. Use overhead 4 to explain how roots produce tension.

	4. When plant root cannot produce enough tension to take moisture the wilting point is reached.
8. How does soil moisture rise by capillary action?	a. Illustrate and explain using a series of test tubes as shown on lab sheet.
9. How can producers reduce water losses?	a. Use overhead 5 to discuss.
10. What cultural practices can be used to make better use of soil moisture?	a. Plant crops at the proper time to utilize seasonal rainfall.
	b. Plant varieties (cultivars) adapted to meet available water conditions.
	c. Use proper plant-spacing.
	d. Avoid compaction causing plow pans.
	e. Arrange crops to take advantage of varying soil moisture holding capacities.

Application or Followup:

The purpose of these exercises is to help the students determine the different types of soil moisture. The moisture content of mineral soils can be determined by heating the soil in an oven at 105°C until it has reached a constant weight. This process will usually take 24 hours. The loss in weight is considered to be water. Use the attached exercise sheet. The exercise is taken from "Experiments in Soil Science".

References:

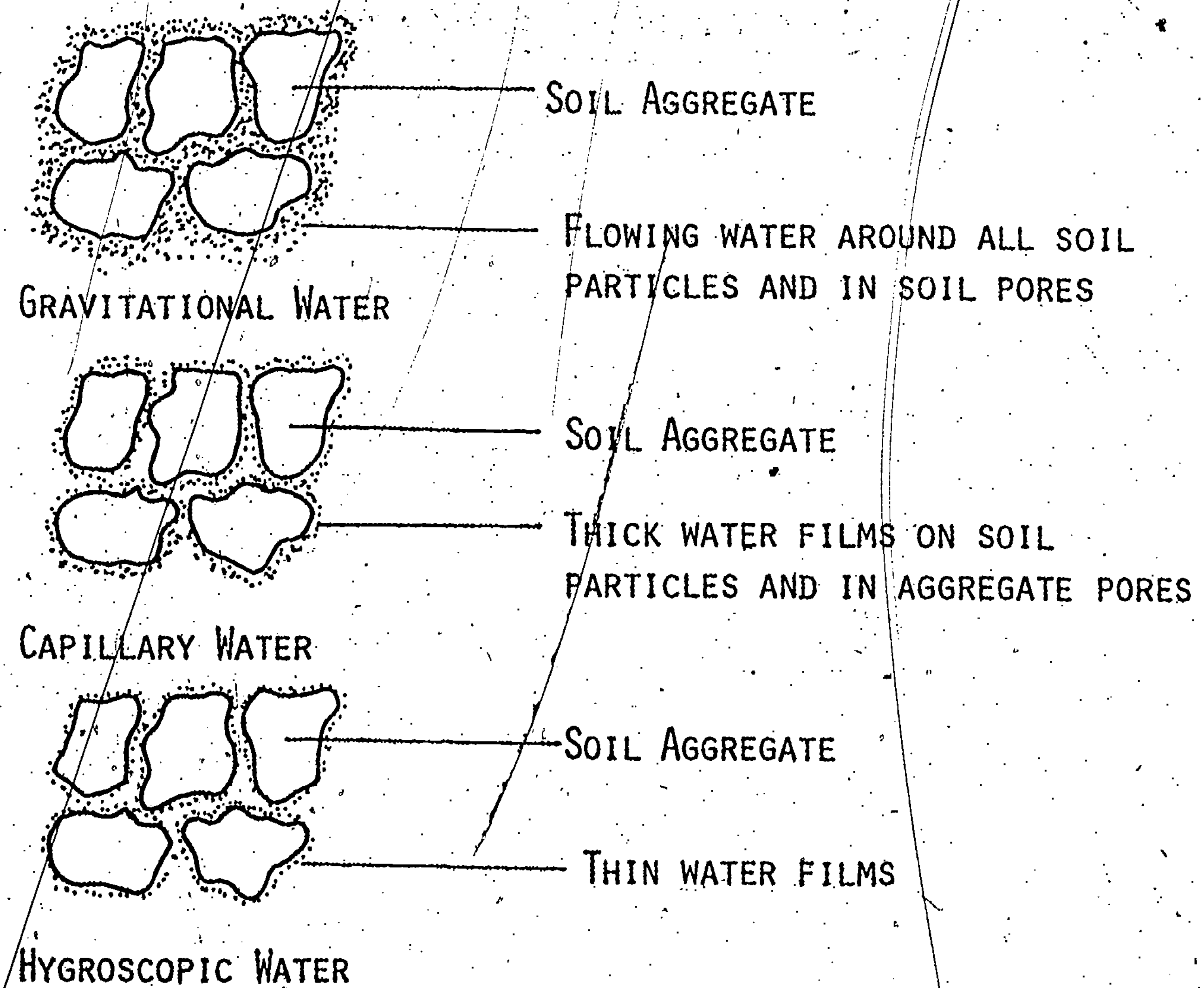
Bishop, Carter, Chapman, Bennett. Crop Science and Food Production, McGraw Hill, New York, 1983.

Sopher & Baird. Soils and Soil Management, Reston Publishing Co., Inc., Reston, Virginia, 1978.

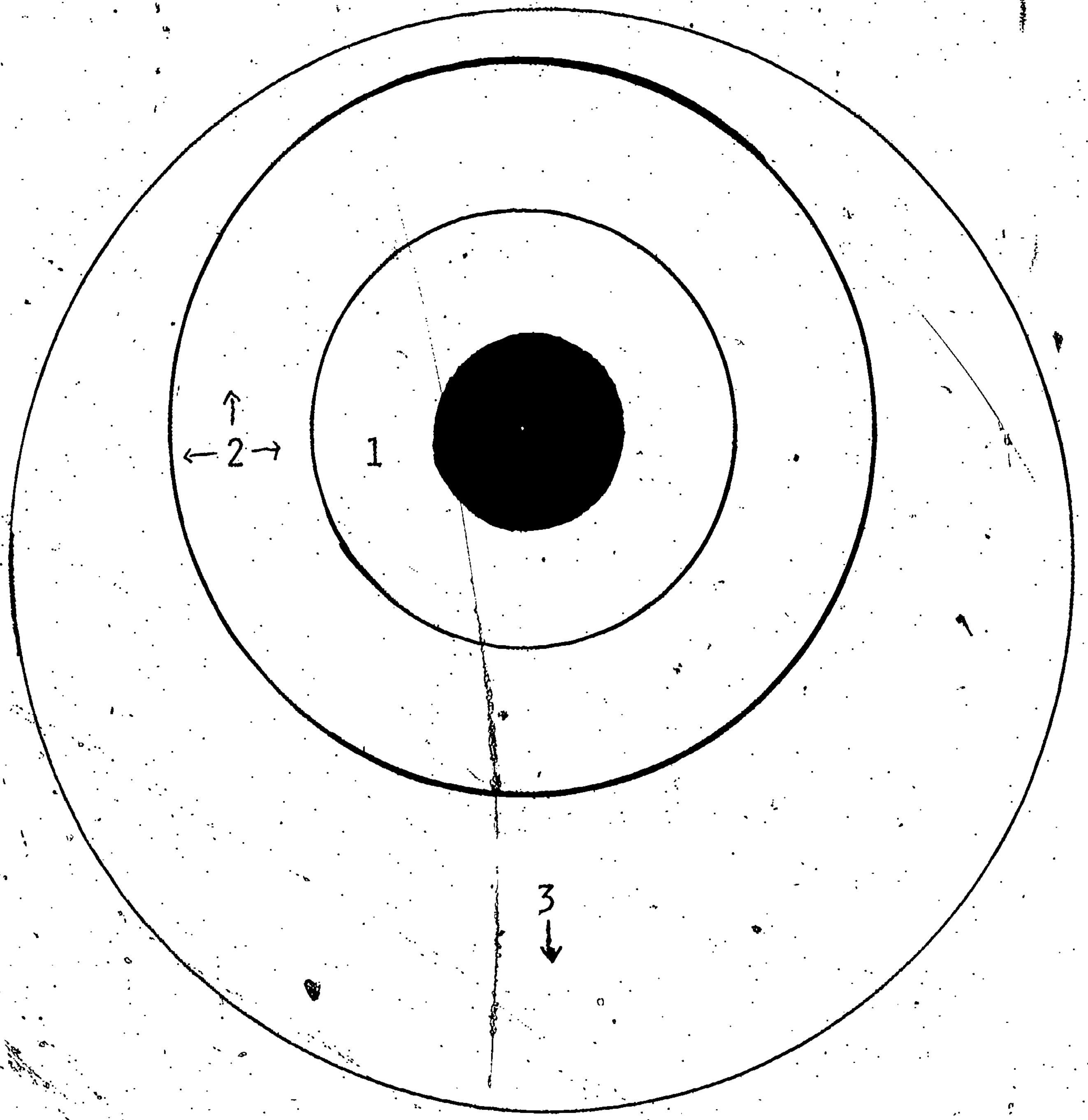
Knuti, Korpi, Hide, Profitable Soil Management, Prentice Hall Inc., Englewood Cliffs, NJ, 1962.

Carter, L.S., Experiments in Soil Science, Vocational Education Productions, California Polytechnic State University, San Luis Obispo, California.

FORMS OF SOIL WATER



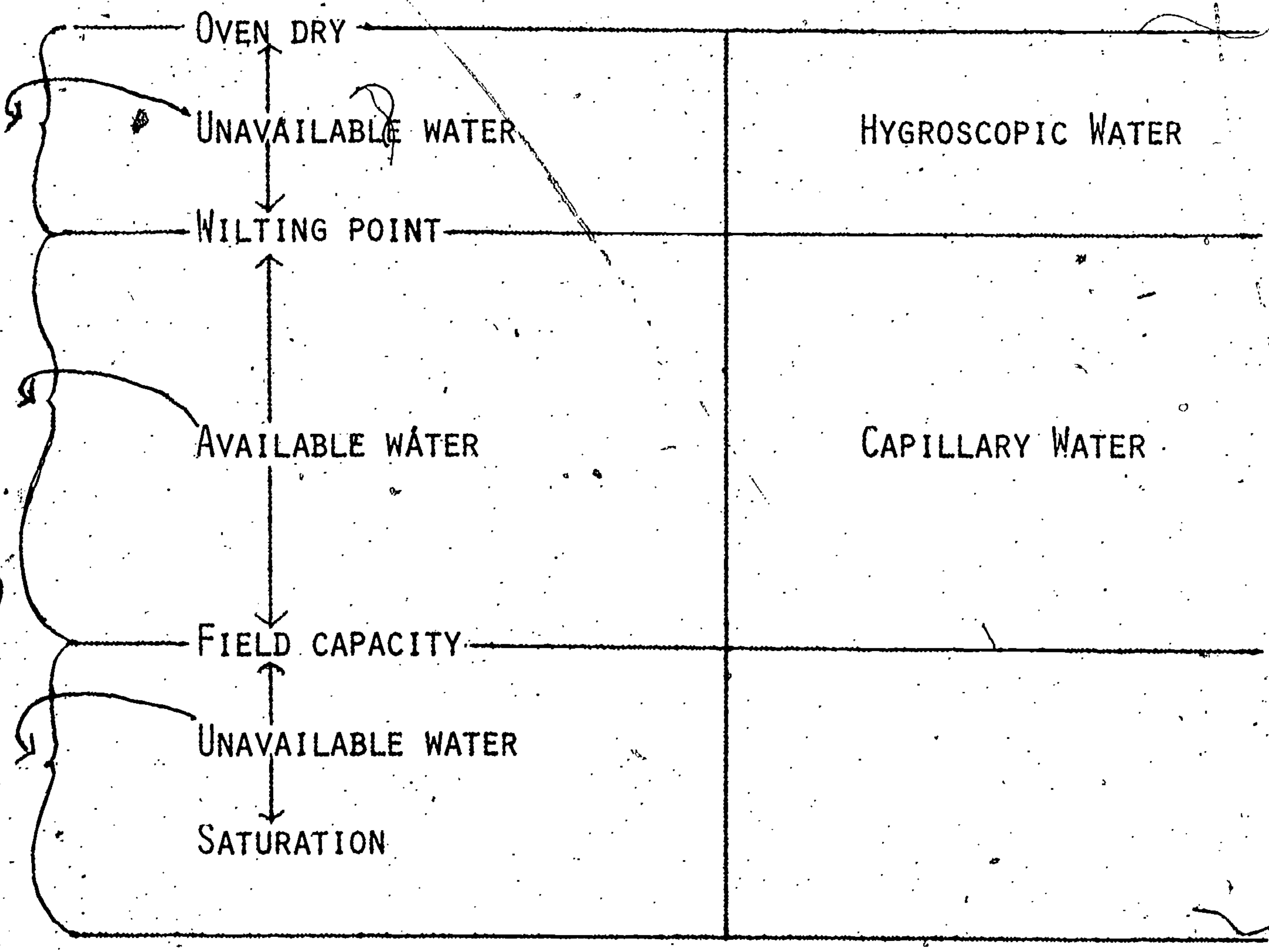
HYGROSCOPIC, CAPILLARY, AND GRAVITATIONAL WATER



1. HYGROSCOPIC WATER IS HELD SO STRONGLY TO A SOIL PARTICLE BY ADHESION THAT IT IS NOT AVAILABLE TO THE PLANT
2. CAPILLARY WATER IS HELD IN THE SOIL BY COHESIVE FORCES GREATER THAN GRAVITY, AND MOVES EITHER UPWARD OR SIDEWAYS FROM WET PLACES TO DRIER PLACES.
3. GRAVITATIONAL WATER MOVES DOWN THROUGH THE SOIL TO THE WATER TABLE.

Taken from "Profitable Soil Management" by Knuti, Korpi, Hide (1962)

SOIL MOISTURE AVAILABLE TO PLANTS

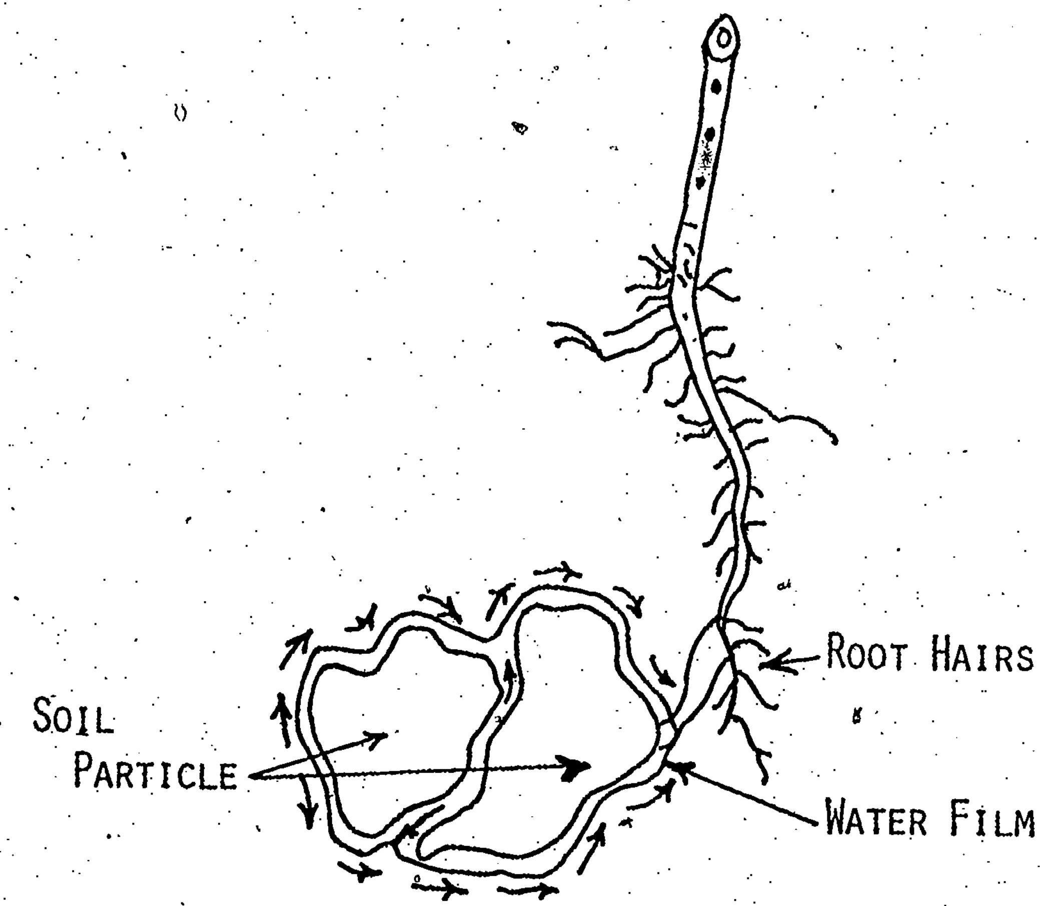


CALCULATING SOIL MOISTURE

$$\frac{\text{Weight of Soil Moisture}}{\text{Dry Soil Weight}} \times 100$$

$$\frac{100 \text{ grams}}{400 \text{ grams}} \times 100 = 25 \text{ percent}$$

THE MOVEMENT OF CAPILLARY WATER

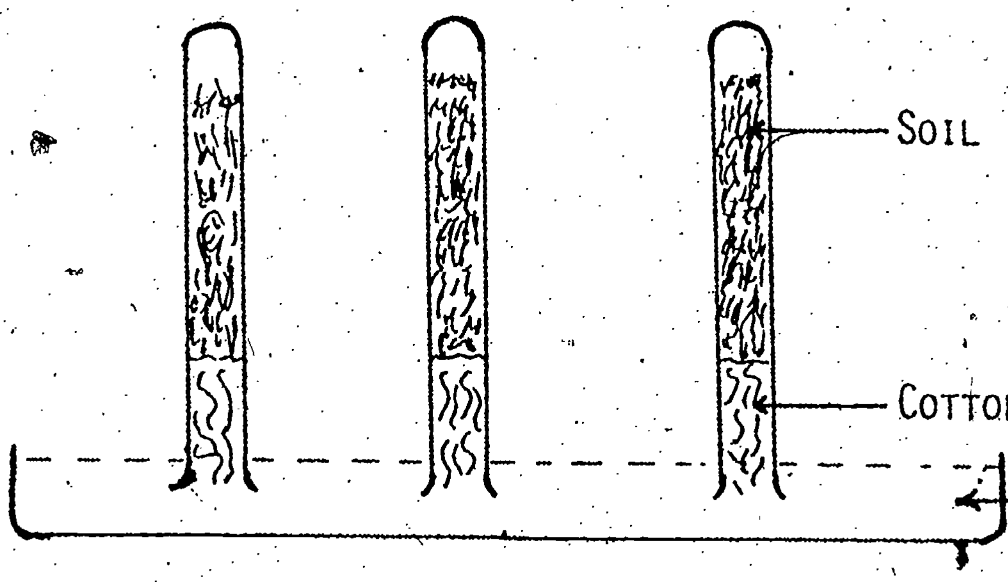


AS THE ROOT HAIRS OF THE PLANT REMOVE THE CAPILLARY WATER FROM ONE POINT, WATER MOVES AS INDICATED BY THE ARROWS.

HOW PRODUCERS CAN CONTROL SOIL MOISTURE LOSSES

TYPE OF MOISTURE LOSS	HOW THE LOSS CAN BE CONTROLLED
1. RUNOFF	TERRACE THE LAND, STRIP CROP, ADD GRASSES TO THE ROTATION, INCREASE INFILTRATION BY IMPROVING SOIL STRUCTURE
2. EVAPORATION	
SOIL SURFACE	SPACE PLANTS TO GIVE A COMPLETE SOIL COVER
PLANT SURFACES	NOTHING CAN BE DONE
3. TRANSPIRATION	REMOVE WEEDS AND GRASSES FROM GROWING CROPS
4. PERCOLATION	INCREASE SOIL MOISTURE-HOLDING CAPACITY ON SMALL AREAS, ADD ORGANIC MATTER FROM CROP RESIDUES

COLLECT 3 SOIL SAMPLES OF TOPSOIL FROM WIDELY SCATTERED LOCATIONS IN THE COMMUNITY. SCREEN, DRY AND PLACE THE SOIL IN THREE TEST TUBES. PLUG THE ENDS WITH COTTON. LOWER THE TEST TUBES EVENLY IN THE WATER AND WATCH THE MOVEMENT OF THE WATER UP INTO THE SOIL. THEN ANSWER THE QUESTIONS BELOW.



1. WHY DOES THE WATER MOVE UP INTO THE SOIL SAMPLES?

2. WHY DOES THE WATER MOVE HIGHER IN ONE TEST TUBE THAN IN ANOTHER?

3. WHICH SOIL HOLDS THE MOST WATER? WHY?

4. WHAT DO YOUR OBSERVATIONS MEAN IN TERMS OF CROP PRODUCTION?

DETERMINATION OF TYPES OF MOISTURE IN SOILS

Materials:

1. Soil samples
2. Empty cans and lids
3. Gram scale
4. Oven

Procedure: Start with soils at field capacity.

Part 1 - Capillary Moisture

1. Weigh empty cans and lids
2. Add soil and weigh cans and lids
3. Place lids under cans and set cans on table to air dry
4. Weigh cans each laboratory period until weight becomes constant. The difference between the starting weight and the air-dry weight is calculated as the percent capillary water.

Part 2 - Hygroscopic Moisture

1. Place air dry samples in oven with lids below cans and dry at 105 degrees to 110 degrees C. (above the boiling point of water)
2. Next laboratory period, place lids on cans, cool and weigh.
3. Calculate loss of water by oven drying. This is hygroscopic moisture.

Part 3 - Total Moisture

1. The percentage of capillary and hygroscopic moisture will be equal to the total moisture content of the soil at the time of sampling.

UNIT: Basic Soils

Lesson: Soil Classification

Need:

It would be impossible to account for all of the different soil types unless there was some type of classification system. The system allows us to talk about soils in such a way that everyone can understand what the other person is talking about. Understanding a few of the basic concepts of soil classification will enable each of us to classify soil according to its major properties.

Objectives:

After the lesson has been taught and individual study and practice has been completed, the students should be able to:

1. List the 6 levels of the soil classification system.
2. Define and describe a soil survey.
3. Demonstrate their ability to estimate slope.
4. Recognize the common symbols used on soil maps.
5. Describe what farming practices to use with the eight capability classes.

Interest Approach:

Identify some land formations in your immediate area that the students will recognize. A series of color slides of the area will certainly make the introduction and motivation easier. Discuss the features the students can observe from the slides such as slope, erosion, vegetation, etc. Lead the discussion as to the importance of soil classification and how it is used to conserve soil.

Key questions, problems, concerns	Teaching techniques and information
1. Why do we need to understand the classification system?	a. To make sure we are not misusing the soil.
	b. To help us decide on the right soil management practice.
	c. To better understand soil surveys.

2. How are soils classified?	a. There are 6 levels of classification: 1. Orders 2. Suborders 3. Great Groups 4. Subgroups 5. Families 6. Series
	b. Use overhead 1 to discuss the important features of each classification.
3. What is a soil survey?	a. The systematic examination, description, classification and mapping of soils in an area.
	b. Usually soil surveys are divided on the basis of soil series, slope and erosion.
4. Discuss Survey Slope Classes.	a. Show overhead 2 of "Soil Survey Slope Classes".
	b. Make an estimate of slope by using a 100" board, a yardstick and a carpenter's level. The vertical distance in inches is equal to the slope of the ground in percent.
5. Why is slope so important when determining land use?	a. Affects oils permeability
	b. Determines crop and machinery selection
	c. Determines soil & water conservation measures
6. What are the soil erosion classes?	a. Use overhead 3 to discuss "Soil Survey erosion classes".
7. Using an area soil map, have the students tell what some of the symbols mean.	a. Distribute a group of soil maps.
	b. Usually an aerial photograph
	c. Features on the map such as: 1. Cities 2. Roads 3. Houses 4. Streams 5. Churches 6. Other landscape features such as mines, factories and cemetaries

8. What kind of information is included in a soil survey report?	a. Supplementary materials 1. Descriptions of all soils 2. Guides for their use and management b. An inventory for land managers, appraisers, researchers, farm planners, developers and soil engineers
9. Discuss the definition and purpose of a land capability class? (SCS system)	a. Similar soil series grouped according to slope and erosion. b. To classify larger areas of land according to its potential for certain uses. c. Using the handout 1, discuss the eight capability classes.

Application and Followup:

Arrange with a scientist from the SCS to serve as a guide on a planned field trip. After the field trip, have the students prepare a report on the sites that were visited.

References:

Sopher & Baird. Soils and Soil Management, Reston Publishing Co., Inc., Reston, Virginia, 1978.

SOIL CLASSIFICATION SYSTEM

CLASSIFICATION	NO.	BASIS OF CLASSIFICATION	WHO WILL MAKE THE MOST USE OF THE PARTICULAR CLASSIFICATION?
ORDERS	10	BASED ON THE PROCESSES BY WHICH THE SOIL IS FORMED.	THOSE INTERESTED IN WORLD PLANNING.
SUBORDERS	47	BASED ON THE CHARACTERISTICS OF WETNESS AND TEMPERATURE.	THOSE INTERESTED IN WORLDWIDE PLANNING.
GREAT GROUPS	185	BASED ON SOIL HORIZONS AND THEIR ARRANGEMENTS, TEMPERATURE REGIMES AND SIMILAR BASE SATURATIONS.	GEOGRAPHERS
SUBGROUPS	970	BASED ON REFINEMENT OF THE GREAT GROUPS.	GEOGRAPHERS
FAMILY	4500	BASED ON PROPERTIES THAT AFFECT SOIL USE, USUALLY AGRICULTURAL AND/OR ENGINEERING.	BROADSCALE AGRICULTURAL PLANNERS
SERIES	10,500	BASED ON THE FIVE FACTORS OF SOIL FORMATION.	INDIVIDUAL FARM PLANNERS AND THOSE USING THE INFORMATION FOR ENGINEERING. USE OVERHEAD 4 TO DISCUSS PROPERTIES THAT DETERMINE A SOIL SERIES.

SOIL SURVEY SLOPE CLASSES

SLOPE CLASS	PERCENT SLOPE*
A	0-2
B	2-6
C	6-10
D	10-15
E	15-25
F	25-+

*THE PERCENT SLOPE IS DEFINED AS THE NUMBER OF FEET OF RISE OR FALL IN 100 FEET. IT MAY BE CALCULATED AS FOLLOWS:

$$\text{PERCENT SLOPE} = \frac{\text{FEET FALL}}{\text{HORIZONTAL DISTANCE}} \times 100$$

NOTE: TAKEN FROM SOIL AND SOIL MANAGEMENT BY SOPHER & BAIRD, 1978.

SOIL SURVEY EROSION CLASSES

EROSION CLASS	OFFICIAL DEFINITIONS	WORKING DEFINITIONS
0	Topsoil washed in	15 in. topsoil
1	1/4 topsoil removed	10-15 in. topsoil
2	1/4-3/4 topsoil removed	3-10 in. topsoil
3	3/4 topsoil removed	3 in. topsoil
4	Gullied land	Gullied land

PROPERTIES THAT DETERMINE A SOIL SERIES

1. HORIZON ORDER AND SEQUENCE
2. HORIZON DEVELOPMENT OR THICKNESS
3. TEXTURE OF EACH HORIZON
4. ORGANIC MATTER CONTENT
5. SOIL pH OF EACH HORIZON
6. PARENT MATERIALS
7. DEPTH TO HARD ROCK
8. PAN HORIZONS PRESENT
9. SOIL COLOR
10. SOIL STRUCTURE
11. TYPE OF CLAY PRESENT
12. ANY OTHER FACTOR THAT WOULD MAKE THE SOIL DIFFERENT

D

LAND CAPABILITY CLASSES

Class	Percent Slope	Slope Class	Description
I	0-2	A	Nearly level land with few limitations; row crops may be grown every year.
II	2-6	B	Gently sloping land with 1/4 to 3/4 of the topsoil removed; row crops every other year.
III	6-10	C	Moderately sloping land with 1/4 to 3/4 of the topsoil removed; row crops one out of every three years.
IV	10-15	D	Sloping land with 1/4 to 3/4 of the topsoil removed; row crops one out of every four years.
V	-----	-----	Land not suitable for agriculture because of some special hazard such as flooding or drought (could become Class I if the problem were removed.)
VI	15-25	E	Very sloping land subject to severe erosion; only suitable for trees and light grazing.
VII	25	F	Mountain slopes not suitable for cropland; may be used for forestry and recreation.
VIII	-----	-----	Mountain peaks and coastal marshes; not suited for agricultural production; may be quite valuable for recreation.

UNIT: Basic Soils

Lesson: Saline Seep

Need:

Saline seep is a major problem in Montana. We are losing productive land at the rate of about 10% per year. It is not entirely a farmer problem because it is not caused entirely by producers. Road construction and other activities can speed the formation of a saline seep condition.

Objectives:

After the lesson has been taught and individual study and practice has been completed, the students should be able to:

1. Define the following terms that relate to saline seep and its formation.

Saline soil	Recharge area	Soil amendment
Sodic soil	Osmatic Movement	Threshold level

Interest Approach:

Show some pictures or slides of a saline seep area. If you live in an area where saline seep is a problem, refer to some local situations. Use the Montana Map to discuss the extent of the problem. (Map from bulletin).

Key questions, problems, concerns		Teaching techniques and Information
1. What is saline seep and where is it generally found?	a.	An area where an excess amount of salt has accummulated throughout the upper surface of the soil.
	b.	In acid or semi-acid regions where rainfall is insufficient to leak out of the salt.
2. How critical is the problem in Montana?	a.	In 1974, Montana had 140,000 acres of saline seep.
	b.	The saline seep has been growing at about 10% per year.
	c.	Currently, Montana has in excess of 200,000 dryland acres affected by saline seep.
	d.	The problem is most acute in Eastern and Central Montana.

3. How did salts accumulate in the first place?	a. There was a natural weathering of rock material.
	b. Salts including ions of magnesium, calcium, carbonate and bicarbonate of sulfate accumulates.
	c. When water evaporates from the surface of the soil or is used up by the crop, the salt is left behind.
	d. Review the terms associated with saline seep.
4. How does a saline condition affect crop production?	a. Osmatic salt damage 1. Salt concentration is increased through evaporation. 2. The high salt concentration causes the plant to exert more pressure to obtain water. 3. The plant reaches a point where it can no longer obtain water. 4. The plant will then wilt and die. 5. Use a slice of fresh potato in salt water to illustrate the above effect. 6. Use the overhead 1 to illustrate the effect on different crops.
5. What visable signs are evident when a saline problem exists?	a. Bare spots or uneven growth in the field.
	b. Plants have a bluish-green cast.
	c. Leaf-tip burning 1. Especially true in woody plants under sprinkler irrigations.
6. Discuss terms related to saline seep.	a. Use overhead 2 and 3.
7. How did the potential saline condition develop?	a. Use overlay to discuss the accumulation of salts.
	b. Weathering of rock will produce salt as a by-product.
	c. Salts include ions of magnesium, calcium, carbonate, bicarbonate, and sulfate.

d. When the water evaporates from a soil surface or is used by a crop, salts are left behind.

e. Fossil salts are another source of salt.

f. Rainwater carries some salt.

8. What usually causes the accummulation of salt?

a. Water movement causes salt to accummulate. Evaporation, groundwater, landforms and local geology determine where the salt will accumulate.

b. Soluble salts are readily dissolved in water.

c. Evaporation leaves the salt in the soil.

d. When more water enters the soil than can be used or held, leaching prevents salt accummulation.

e. Salts commonly accummulate in poorly drained areas. Discuss why.

f. If saline seep is a problem in your area, have the students identify potential danger spots.

9. What are some of the most obvious signs of saline seep?

a. Field-clues

1. Presence of a permanent or seasonal high water table in a semi-acid to acid climate.
2. Poorly drained potholes in glacial landscapes.
3. Excessive soluble salts on the soil surface.

b. Crop clues

1. Poor or spotty stand establishment in cereal grains.
2. Bluish-green color in herbaceous crops.
3. Leaf-tip burn and die-off of older leaves in cereal grains.

10. How can we help correct saline and sodic conditions?

a. Saline soils

1. Leach out salt where drainage is adequate.

2. Provide adequate drainage.

a. Maintaining a water table below 4' in sandy soil and 6' to 7' in clayey soil.

3. Use proper irrigation practice.

a. Do not over apply water.
b. Use proper ditch system.
c. Distribute water evenly.

4. Under dryland conditions.

a. Plant salt-tolerant crops or forages.
b. Deep rooted legumes remove large quantities of water from the soil. (Alfalfa is good).

b. Sodic soils

1. Chemical treatment

a. Adding soil amendments which replace excess calcium.
b. Same amendments supply calcium directly, others replace sodium or soil clays. (ex: gypsum).
c. Organic amendments, manure and crop residues improve the physical nature of soil. Cereal grain residue is particularly effective.

2. Mechanical treatment

a. Tillage to depth of 18" or more.
b. The deep tillage fractures the compact claypan.
c. Discuss why it must be below the ordinary plow depth.

11. How can a producer prevent saline seep?

a. Be able to identify the early warning signs of seep development. (Give each student a handout with these warning signs.)

b. Identify potential recharge areas.

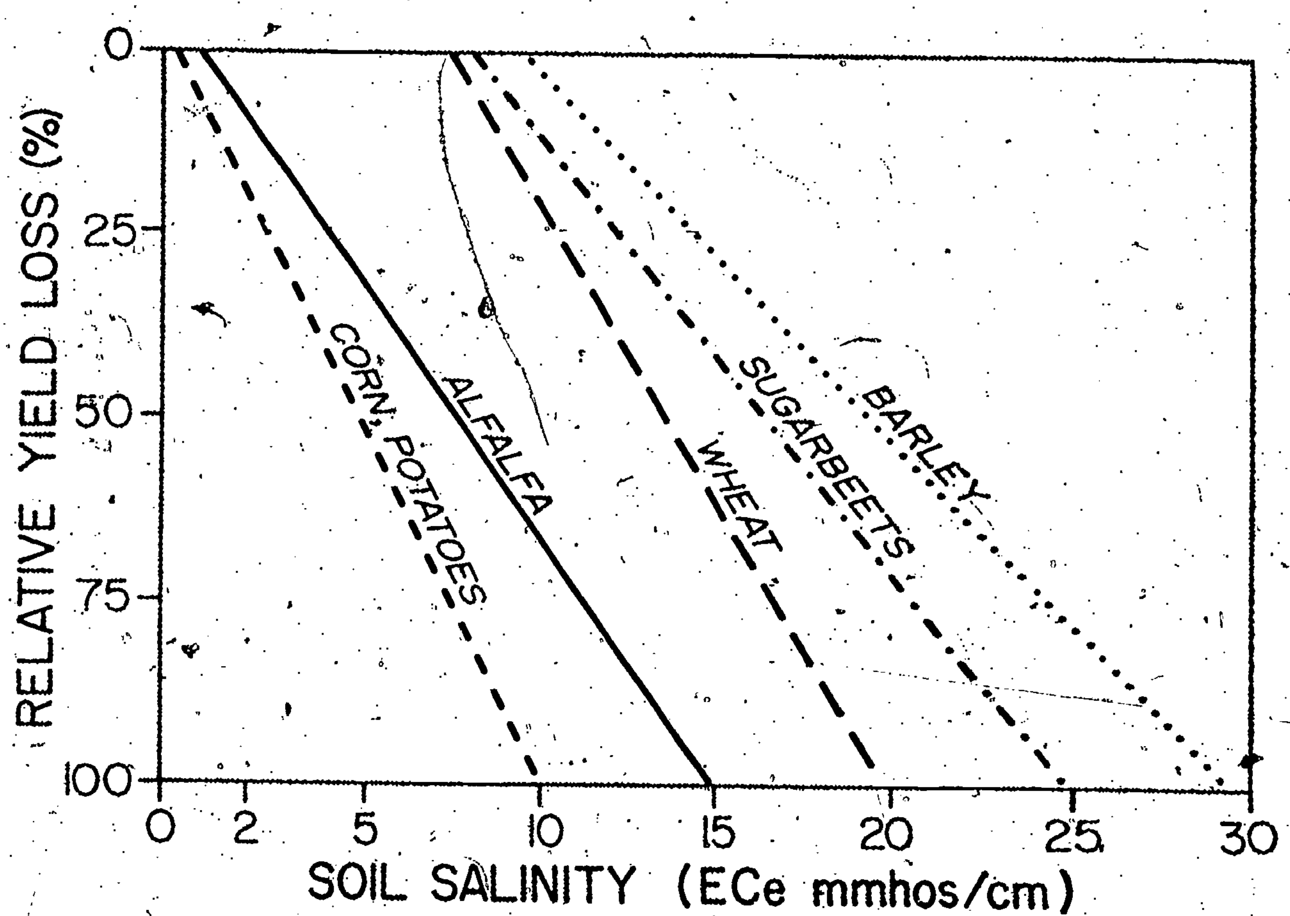
c. Use a cropping system that will use up water in the recharge area.

Application and Followup:

Have the students do a research report on the development and control of saline seep in Montana. Select the best reports and have them given to the entire class.

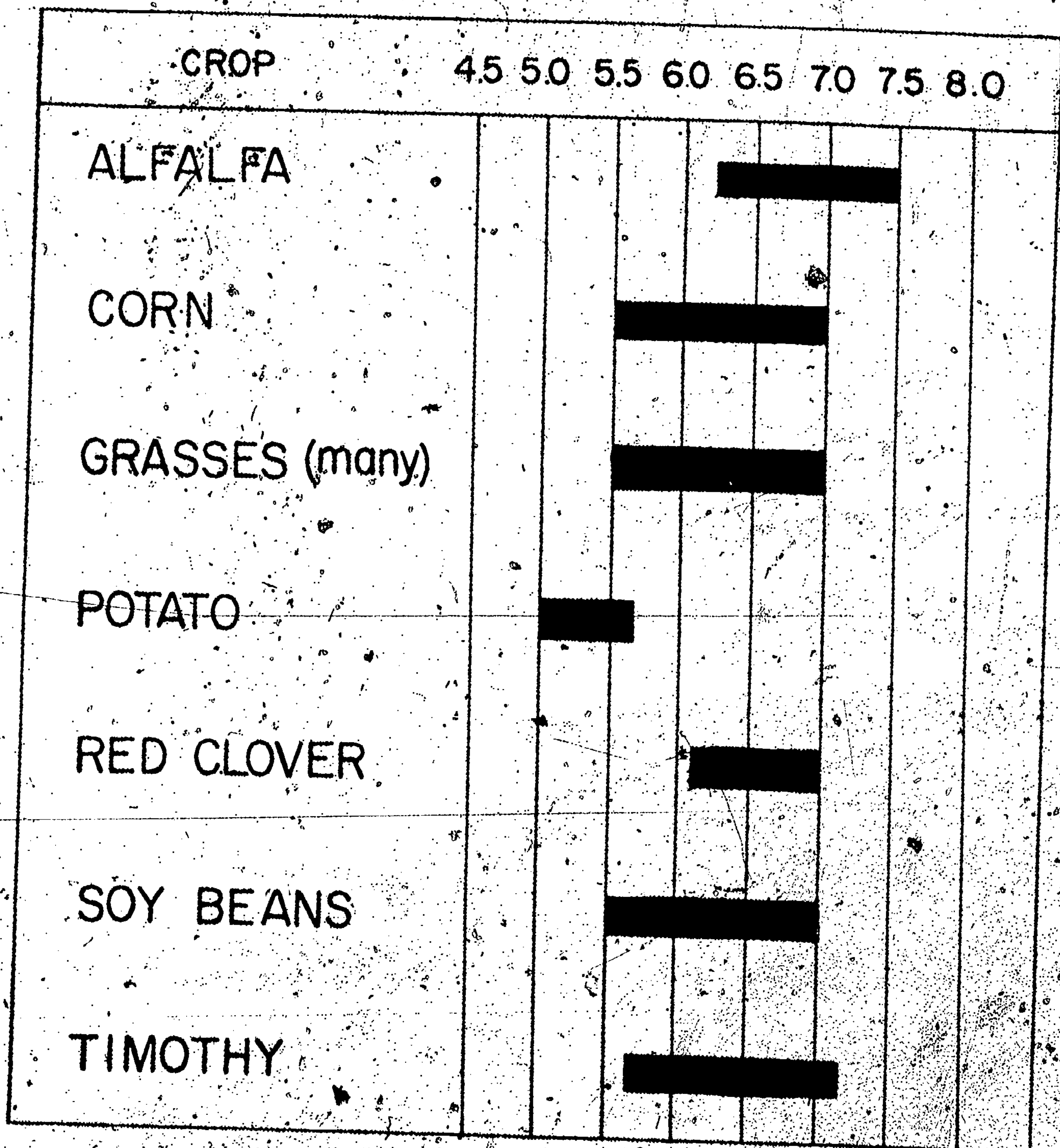
References:

Schafer, W. M., Saline and Sodic Soils in Montana, Cooperative Extension Service, Montana State University, Bozeman, 1972.

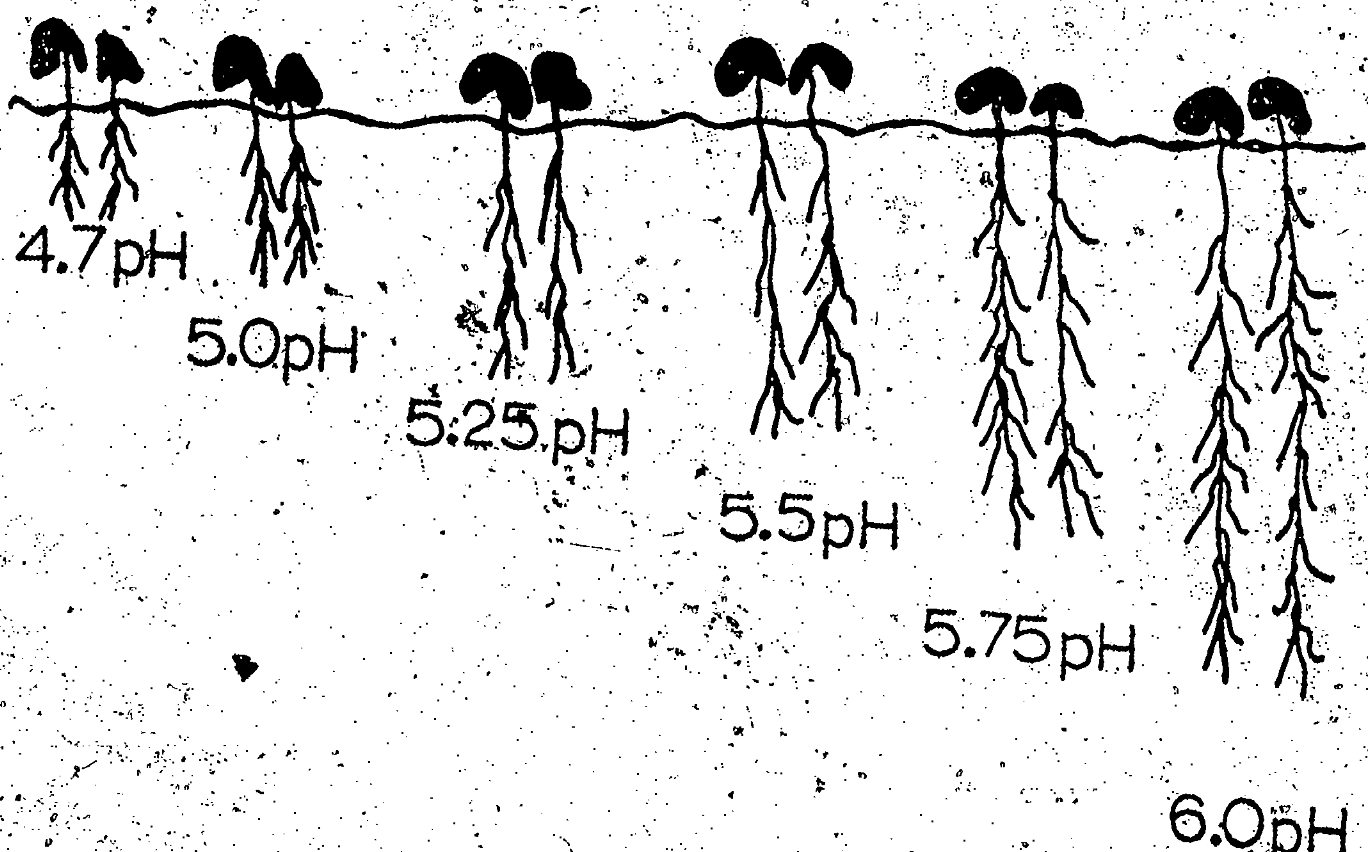


CROP YIELD REDUCTION AT INCREASING LEVELS OF SOIL SALINITY. EC_E IS THE ELECTRICAL CONDUCTIVITY OF AN EXTRACT OF WATER-SATURATED SOIL.

pH REQUIREMENTS OF CROPS



LOW pH LIMITS ROOT GROWTH



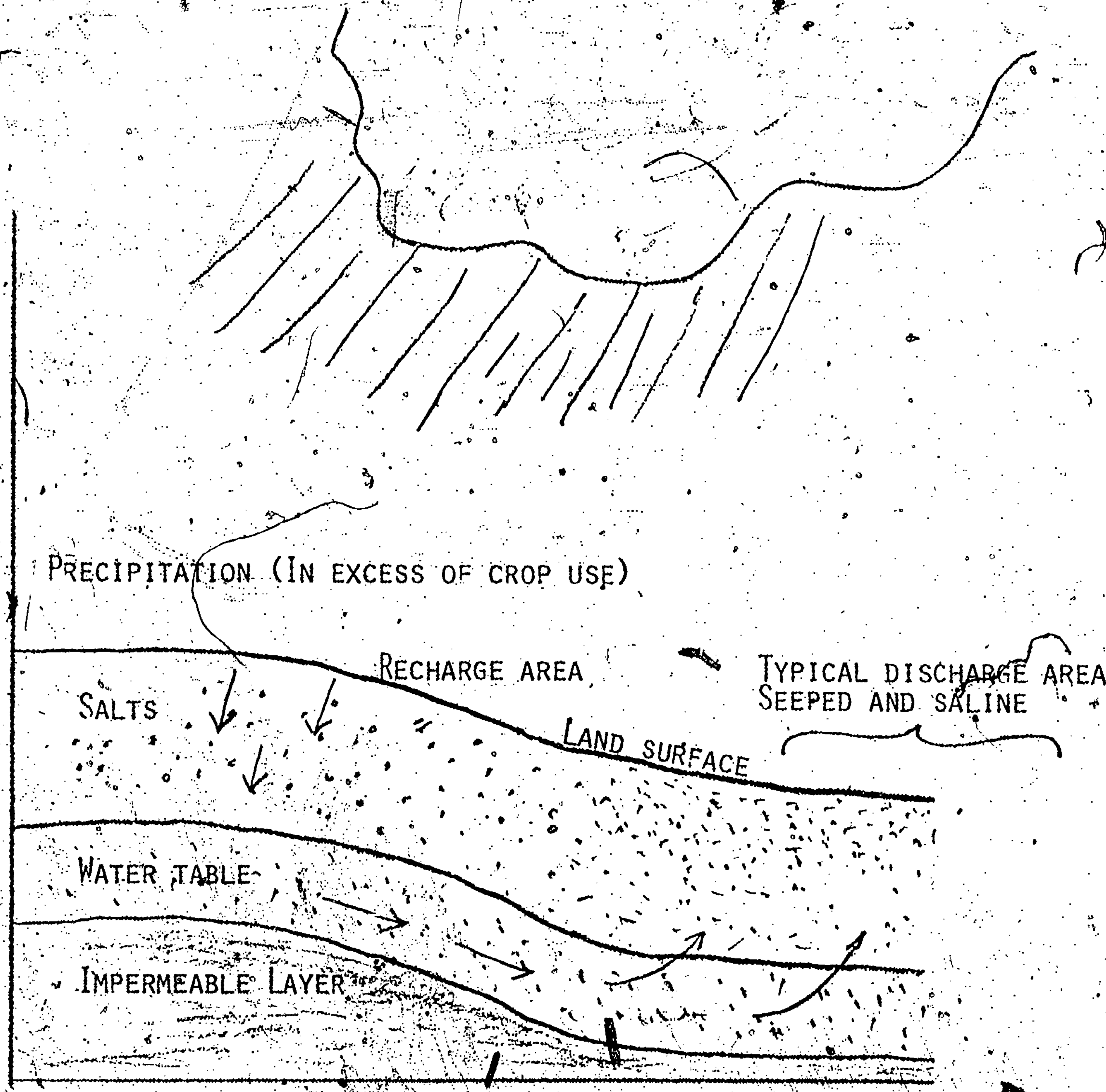
TERMS

SALINE SOILS: THESE SOILS CONTAIN EXCESS SOLUBLE SALTS THAT MAKE IT DIFFICULT FOR THE PLANT TO TAKE UP NUTRIENTS AND WATER.

SODIC SOILS: SOILS THAT CONTAIN "EXCHANGEABLE" SODIUM. THE SODIUM IS HELD ON THE CLAY PARTICLE. SUCH A CONDITION REDUCES PERMEABILITY.

SALINE-SODIC SOILS: THE SOILS HAVE BOTH EXCESS SOLUBLE SALTS AND EXCESS EXCHANGEABLE SODIUM.

THRESHOLD LEVEL: A POINT WHERE YIELD IS DECREASED BY INCREASING LEVELS OF SALT.


PRECIPITATION (IN EXCESS OF CROP USE)
RECHARGE AREA
TYPICAL DISCHARGE AREA
SEEPED AND SALINE
SALTS
LAND SURFACE
WATER TABLE
IMPERMEABLE LAYER

FIELD CLUES TO DETERMINE WHETHER A SALINITY OR SODICITY PROBLEM EXISTS

1. The presence of a permanent or seasonal high water table in a semi-arid to arid climate.

2. Poorly drained potholes in glacial landscapes.

3. Excess soluble salts will often crystallize on the surface of fallow fields.

4. Patterns of growth in cropped fields will often foretell a salinity problem.

5. Under salt stress, herbaceous crops appear bluish-green in color.

6. Leaf tip burn and die-off of older leaves in cereal grains can result from salinity or drought stress.

UNIT: Basic Soil

Lesson: Collecting A Soil Sample

Need:

Fertilizer is very expensive so it is important to know what nutrients the soil needs before we decide on how much fertilizer and what kind of fertilizer to buy. In many cases too much fertilizer or the wrong kind of fertilizer will do more harm than good. Thus, production costs are higher and production itself is lowered.

Objectives:

After the lesson has been taught and individual study and practice has been completed, the students should be able to:

1. Collect and prepare a soil sample for testing according to the guidelines established by the MSU Soil Testing Laboratory.

Interest Approach:

Have all of the tools that are needed for taking a soil sample on hand for the students to look at. Prepare a drawing or overlay of a field and have the students suggest how they would go about taking a soil sample. Be sure to include some unusual features.

Key questions, problems, concerns		Teaching techniques and information
1. Why is a soil test so important to a producer?	a.	To determine the kind and quantity of nutrients available to plants.
	b.	To determine the kind and amount of nutrients needed to build the level of productivity of a soil.
	c.	To aid in determining long-range production costs.
	d.	To uncover warning signs that may help avoid future problems.
2. Obtaining forms and soil sample bags.	a.	Special soil sample bags are available from the county extension office along with special application forms.
	b.	Prepare an overlay of the soil testing form and discuss the contents with the class.

3. Go through the procedure for taking a soil sample.

a. Provide each student with a job sheet on taking soil samples.

Application and Followup:

Make arrangements for the students to take one or more soil samples either from their own farm or another farm in the area. When the results come back, you should discuss the reports in class.

References:

__________, Topics in Soil and Water Resource Management, Soil Testing. Cooperative Extension Service, Montana State University, Bozeman, MT.

Unit: Basic Soils
Operation Sheet: Collecting a Soil Sample

Steps		Procedure		Key Points
1. Select your equipment.	a.	Sampling tube is best (A spade or auger can be used): Clean plastic bucket; sampling mailing bag.	a.	Mailing bags are available from the county extension agent.
2. Examine the field to be sampled.	a.	Determine the uniformity of the field.	a.	Sample each uniform area separately.
	b.	Divide the area to be tested so you have the same color, texture, drainage, part cropping history and fertilizer treatment.	b.	Develop a pattern for sampling - don't randomly pick locations.
	c.	Leave out low spots.		
	d.	Avoid fertilizer bands or fertilizer spillage.		
	e.	Prepare a field map of the area to be tested (Use overhead 1).		
3. Collect the sample.	a.	Take sample from surface to plow depth in cultivated fields.	a.	A subsoil sample form 6" to 12" will help characterize the soil.
	b.	Take sample to 6" depth in uncultivated fields.	b.	Put 1/4 to 1/2# of mixed soil in each mailing container..
	c.	Collect 20-25 small subsamples to mix.	c.	Use some postage and speed the analysis by air-drying samples.
4. Number your samples.	a.	Take 3 or more samples from each separate area.	a.	To avoid confusion match number or sample.
	b.	Number soil sample container to maintain its identity.		

Steps	Procedure	Key Points
5. Fill out soil information sheet.	a. Fill out or complete as accurately as possible.	
	b. Send white copy to soil testing lab with sample.	
	c. Give yellow copy to the county agent.	
	d. Keep the pink copy for your records.	

FIELD MAP FOR TAKING A SOIL SAMPLE