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USING SOIL AND OTHER PLANT GROWING MEDIA EFFECTIVELY.
HORTICULTURE-SERVICE OCCUPATIONS, MODULE NO. 5.
OHIO STATE UNIV., COLUMBUS, CENTER FOR VOC. EDUC.
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ONE OF A SERIES DESIGNED TO PREPARE HIGH SCHOOL STUDENTS FOR HORTICULTURE SERVICE OCCUPATIONS, THIS MODULE HAS AS ITS MAJOR OBJECTIVE TO DEVELOP THE APPRECIATIONS, UNDERSTANDINGS, AND ABILITIES NEEDED TO USE PLANT GROWING MEDIA IN GROWING HORTICULTURAL PLANTS. IT WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF DATA FROM STATE STUDIES. SUBJECT MATTER AREAS ARE (1) ORIGIN, COMPOSITION, AND IMPORTANCE OF SOIL, (2) SUITABILITY OF VARIOUS SOILS FOR PLANT GROWTH, (3) WATERING PRACTICES RELATED TO SOIL STRUCTURE, (4) RECOGNITION AND USE OF SOIL CONDITIONERS, (5) SOIL MULCH USE, (6) SOIL FERTILITY MAINTENANCE, (7) SOIL ORGANISMS, (8) SOIL EROSION CONTROL, AND (9) SOIL PREPARATION. SUGGESTIONS ARE INCLUDED FOR INTRODUCTION OF THE MODULE, SUBJECT MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL MATERIALS AND REFERENCES, AND EVALUATIVE CRITERIA. THE MODULE IS SCHEDULED FOR 35 HOURS OF CLASS INSTRUCTION, 70 HOURS OF LABORATORY AND 25 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS WITH A BACKGROUND IN HORTICULTURE MAY USE IT TO PLAN A UNIT FOR LESS ABLE HIGH SCHOOL STUDENTS WITH AN OCCUPATIONAL GOAL IN ORNAMENTAL HORTICULTURE. THIS DOCUMENT IS AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 619 - 000 631) FOR $7.25 FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212. (JM)

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USING SOIL & OTHER PLANT GROWING MEDIA EFFECTIVELY

One of Twelve Modules in the Course Preparing for Entry in

HORTICULTURE - SERVICE OCCUPATIONS

Module No. 5

The Center for Research and Leadership Development

in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

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United States Office of Education

August, 1965

MEMORANDUM

TO: The ERIC Clearinghouse on Vocational and Technical Education
The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

(Address) 980 Kinnear Road, Columbus, Ohio 43212

DATE: August 7, 1967

RE: (Author, Title, Publisher, Date) **Module No. 5, "Using Soil and Other Plant Growing Media Effectively," The Center for Vocational and Technical Education, August, 1965.**

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(3) Utilization of Material:
Appropriate School Setting High School
Type of Program High school class in horticulture--service occupations
Occupational Focus Service workers at nurseries, garden centers, greenhouses, etc.
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Material:
Teacher Competency Background in horticulture
Student Selection Criteria Designed for the less able high school student, goal in horticulture service occupations.
Time Allotment Estimated time listed in module. (P)

Supplemental Media --
Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

USING SOIL AND OTHER PLANT GROWING MEDIA EFFECTIVELY

CONTENTS

USING SOIL AND OTHER PLANT GROWING MEDIA EFFECTIVELY

Major Teaching Objective

To develop the necessary appreciations, understandings, and abilities required to use plant growing media effectively in growing horticultural plants.

Suggested Time Allotments

At School		
Class instruction	35 hours	
Laboratory experience	70 hours	
Total at school		105 hours
Occupational experience		25 hours
Total for module		130 hours

Suggestions for Introducing the Module

1. Plants and plant growing media are basic to horticulture. During this module the students will receive instruction in the following areas:

    a. Origin and importance of soil

    b. Evaluating soil quality

    c. Recognizing and using soil conditioning materials

    d. Preparing and using soil mixtures

    e. Using soil mulches

    f. Recognizing and controlling soil organisms

    g. Protecting and conserving the soil

    h. Maintaining and improving soil fertility

    i. Tilling and cultivating the soil

2. Students can benefit from a module in plant growing media in the following ways:

    a. Good plants result from favorable environmental conditions. Soil and other growing media constitute a vital part of the plant's environment. Therefore, if good plants are to be produced in the greenhouse, in the nursery, in the home or commercial landscape, or on the golf course, attention must be given to making the soil as suitable for plant growth as possible. The soil is to plants what a foundation is to a building.

b. All soils as they occur in nature are not particularly good for growing plants. In this module the students will learn how to recognize and improve poor soils, and how to recognize and maintain good soils.

c. Everyone should be concerned with our nation's soil and the way it is managed. Our standard of living, our economy, and our defense are very closely associated with good, fertile soil.

3. Approximately one hour per day will be devoted to classroom teaching; two hours per day will be devoted to laboratory type activities where the knowledge learned in the classroom can be further developed. Laboratory activities will include:

   a. Examining and comparing soils of several distinct types

   b. Determining soil composition and particle size

   c. Observing soil-water relations

   d. Examining, preparing, and using soil mixtures

   e. Examining, evaluating, and using soil mulching materials

   f. Observing and studying soil organisms

   g. Conducting fertility experiments

   h. Examining and applying fertilizer materials

   i. Taking soil samples

   j. Determining whether soil is in the proper condition to work

   k. Examining the affect of organic matter on soil structure

   l. Using watering and irrigation equipment

   m. Making compost or leaf mold

   n. Using erosion control measures

   o. Sterilizing the soil

p. Operating soil tillage equipment

4. In many cases it is difficult to get high school youth inspired to the point where they become excited about studying soils. Below are some suggestions which may help to get the module off to a good start.

   a. Set up various soil displays such as:

      1) A display of uniform-sized glass jars showing the great range of soil colors. An interesting effect can be made by making up an artificial soil profile using layers of the different colored soils.
      2) A sandy loam soil under a stereo microscope so that the students can see soil in a way in which they probably have never viewed it before.
      3) A block or piece unprocessed peat moss
      4) A soil profile
      5) Samples of the various soil classes
      6) Rock and mineral displays

      Direct the student's attention to the various displays. Ask questions which will arouse their curiosity and interest.

      Why is this soil red and this one is black? Why is this soil gray and this one is yellow? Which one is best? How can we tell which soil is best? Why does this soil have rocks in it and this one does not? Where does soil come from? What do rock and mineral displays have to do with soil?

   b. Show two plants of the same age and type, grown in a controlled experiment with the soil as a variable factor. The results should be striking if a very poor soil was used in one case and a very fertile soil of excellent structure was used in the second case.

   c. Show one of the following films as available from the U.S.D.A. (See Agriculture Handbook No. 14, U.S.D.A. for additional films.)

Food and Soil	(color)	11 minutes
Topsoil	(B/W)	11 minutes
Our Land-Its Many Faces	(color)	14 minutes

   d. Bring in a greenhouse operator or nurseryman to talk with the class about how important a good soil is to his business.

   e. Perform a soil test using a good soil testing kit.

f. Emphasize that our health, our standard of living, and even world peace are influenced by the soil. Hungry people are hard to reason with. Show the class pictures of undernourished and unhealthy peoples in various parts of the world. Such pictures might be obtained from newspapers, magazines, United Nations Health Organization, and various public health agencies. Stress the role of the soil in feeding and beautifying our world.

Competencies to be Developed

I. To understand the origin, composition, and importance of the soil as it applies to the production of horticultural crops

Teacher Preparation

Subject Matter Content

Understanding Soils

Some things can be made very quickly if the necessary materials are available.

1. Milkshakes
2. Bouquets
3. Telephone calls
4. Pizzas
5. Tire changes

Some things are made very slowly even when the necessary materials are available.

1. Healing of broken bones
2. Construction of a sky-scraper building
3. Putting a model ship in a bottle
4. Getting the first good harvest from an apple tree
5. Making a soil

Have you ever wondered just what soil is and where it comes from? Why soils are of different colors? Why some are "good" soils and others are not so good? Do you really care about these things?

If you are serious about your decision to prepare for a career in horticultural work, then perhaps we should begin to care about the soil, for after all don't plants grow in the soil? What will we do do for soil if it all washes away, since it takes nature such a long time to make more of this valuable resource?

With this as background, let us begin our study of soils.

Some observations about soils:

1. Soil is found on the earth's surface.

2. Soil is made up of small rocks and other lightweight particles.

3. Soil is a product of nature.

4. Soil furnishes support to plants.

5. Soil occurs in a series of layers, the layers getting lighter in color as one moves downward from the surface.

6. Soil holds water.

7. Air bubbles can be observed as one waters the soil.

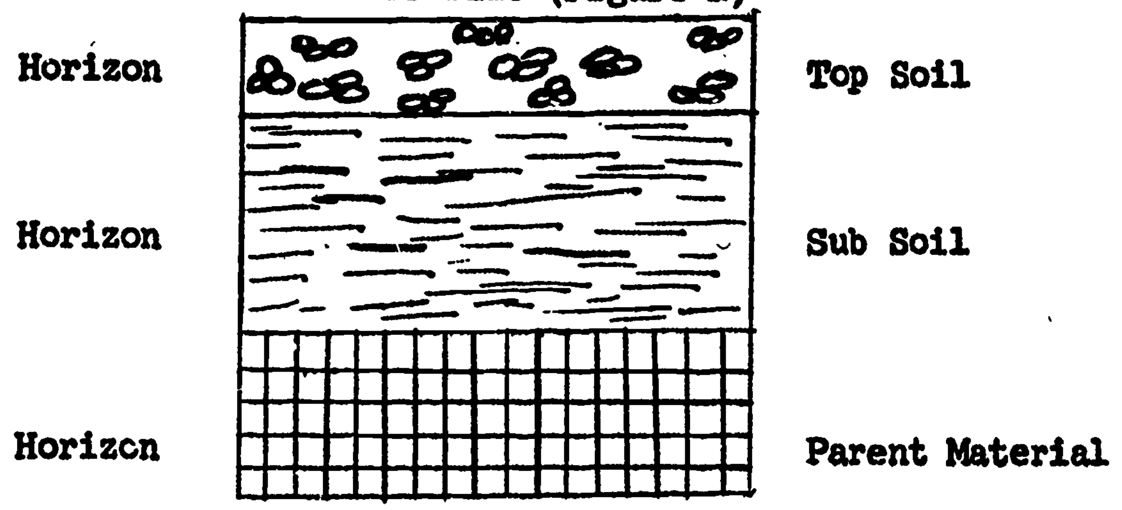
From these observations we can make this definition for soil:

Soil is a natural material occurring in a series of layers, and consisting of broken and weathered minerals and decaying organic matter. This material covers the earth in a thin layer, and when containing proper amounts of air and water, provides support and nutritional elements for plants.

or

Soil is the weathered, mineral or organic portion of the earth's surface.

A Soil Profile (Figure 1)



The top soil, sub soil, and parent material are referred to as soil horizons (layers). These horizons develop as a result of weathering.

Table 1
Descriptions of the Soil Layers

	Topsoil	Subsoil	Parent Material
Color	Dark	Lighter than top soil	Lighter than top soil
Texture	More porous than subsoil	Heavy due to many particles and often stones	Variable but often lighter than subsoil
Structure	Small particles "glued" together	Larger particles (blocky)	Variable or undeveloped
Depth	8 to 12 inches or deeper (depending upon extent of erosion, however)	36 inches	Variable

Rock Weathering

Rock weathering is the process by which rocks are broken down into soil size particles as a result of being exposed to the weather for many hundreds of years. Large rocks are broken down into smaller rocks by:

1. Heating and cooling which causes cracking
2. Water freezing and expanding in cracks in the rocks and thus causing breakage
3. Plant roots growing into rock cracks and thus causing additional cracking and breaking of the rocks
4. Small particles of rock and sand are driven by the water or wind against larger rocks, chipping pieces out of these rocks (this is like sandblasting buildings).

As the large rocks are broken down into smaller rocks, water and acids begin to work on the rock pieces causing them to crumble. It takes a long time for the water and acids to make the rocks crumble, however.

After the rock material has been broken and crumbled up, very small plants which can live in a very poor soil begin to grow in this pile of broken and crumbled rock material. This is now the beginning of a soil.

After a while these plants die, and as they decay they add a small amount of fertilizer-like material to the broken and crumbled pile of rocks. This makes the young soil material just a little richer than it was before. Soon more and more plants grow, die, and decay adding still more of the enriching material, known as organic matter, to the rocky material. The rocky material is getting richer all the time, and soon bigger and better plants are able to grow. As these bigger and better plants die and decay, they add still more organic matter to the developing soil material. As organic matter builds up, animal life invades the soil. These animals help to mix and aerate the soil, and upon death add to the store of organic matter. As this process continues for many, many years, a rich soil gradually develops.

Notice that it takes more than a broken and crumbled pile of rock material to make a soil. The rock material must be enriched with organic matter which increases fertility and allows air and water to be held in the soil material where it is available to plants. This takes many hundreds of years. Sometimes soil is developed in a particular place from underlying rock and vegetation and remains mostly undisturbed. In other cases, soil develops in one place and is transported to another place by wind, water or ice. River bottom soils are good examples of soils which have been transported into an area.

Some soils are richer than other soils because they were formed from rocks richer in minerals important to plant growth and because they contain more organic matter.

Table 2

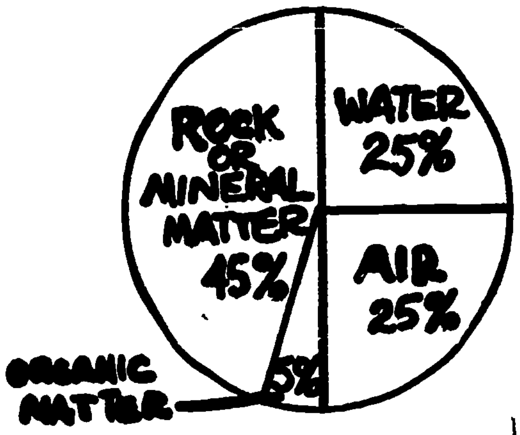
Naming soils according to the amount of organic matter present

Percent of organic matter	Name of soil
0 - 20%	Mineral soil
20 - 65%	Muck soil
Above 65%	Peat soil

Mineral soils are more important to us because there are more of them, but organic soils are very valuable because of their structure and fertility. Peat and muck soils are known as organic soils.

Figure 2

Showing Soil Parts as Slices of a Pie



A good soil provides plants with:

1. Fertilizer elements

2. Air for the roots

3. Enough, but not too much water

Soils have different colors because-----

1. Different amounts of air were present as the soil was formed.

   Drainage is very important in determining how much air will be in the soil. As water enters a soil the air is forced out because two things cannot occupy the same space at the same time. With much air present, red and yellow colors result. With a small amount of air present gray and blue colors result.

2. Differing amounts of organic matter are present.

   The amount of black pigment in humus (organic matter varies with the climate). The humus has the least color in areas where it is hot and moist and the most color in areas that are dry and cool.

3. The color and types of rocks from which the soil develops is different.

4. The color of the soil parts that are in most plentiful supply affects the final soil color.

One cannot judge soil quality on the basis of color alone. All dark, black soils are not necessarily "good" soils.

The Significance of the Soil

Often our valuable soil resources are taken for granted. To many, the soil represents an inexhaustible storehouse of plant nutrients which will continue to produce bountiful harvests, beautiful flowers, trees, and shrubs, and nice green grass year after year with little or no attention. To others, soil represents a material on which a road bed is to be placed, a run way poured, or a housing project situated. Many persons refer to the valuable resource soil, as dirt. The term dirt could probably be more appropriately thought of as something that is hurriedly swept under the rug before unexpected company enters the house or something that we empty out of the vacuum cleaner bag. Can we compare the type of material that is swept under a rug or emptied from a vacuum cleaner bag with a resource which helps us grow our food and beautify our world? Those who depend heavily upon the soil for their source of income think of the soil in different terms than those persons far removed from any direct contact with the soil. What do you think soil is worth?

Examination of Soils

Student Class and Laboratory Guide Sheet #1

Introduction

When we use such units as grams, pounds, inches, feet, yards, miles, etc. as descriptive items, we are using units which have the same meaning to everyone because of the standardization which exists today. Each pound is a weight identical to every other pound, each yard the same length as every other yard, etc. When the word soil is mentioned, however, does this convey the same meaning to everyone? That is, is soil a uniform body of material which is the same no matter where one goes? The answer to this question is obviously no, but if soils are not all alike what makes them different? What difference does it make if they are not all alike? The various factors which may be studied to compare and evaluate soils is the subject of this laboratory exercise.

Materials required

Binocular stereo microscope (For teacher demonstrations only)
Hand lenses or magnifying glasses
Glass squares
Various soil materials lettered A through F

a. A top soil taken from a sodded area
b. A heavy clay soil
c. Sand
d. A soil taken from a heavily eroded hillside

e. A muck soil
f. A peat soil

Paper cups

Directions

Each student should obtain a magnifying glass and glass slide from the supply room. Each lab team should obtain a small paper cup of each of the six soil materials available. After procuring the necessary materials, proceed to examine each soil sample in turn, filling in the date required in the data section of this exercise (page 12).

Save all of the soil materials provided you as they will be used for further analysis and comparison. Do this by putting your name on the containers and putting them on the designated shelf.

Requirements - To be completed by each student--Due next class period

1. Rank the soils in order of their organic matter content. (The highest first, the lowest last in all questions)
1.______ 2.______ 3.______ 4.______ 5.______ 6.______

2. Rank the soils in order of desirable structure.
1.______ 2.______ 3.______ 4.______ 5.______ 6.______

3. Rank the soils according to fertility.
1.______ 2.______ 3.______ 4.______ 5.______ 6.______

4. Rank the soils in order of your personal preference assuming you were going to purchase them.
1.______ 2.______ 3.______ 4.______ 5.______ 6.______

5. Rank the soils according to suitability for growing plants.
1.______ 2.______ 3.______ 4.______ 5.______ 6.______

6. Compare your rankings with those of others in the class. Were you in agreement or disagreement with the class members?

Questions

1. Is it possible that some soil particles might be too small to be seen with a magnifying glass?

2. Did you find any living organisms in the soils examined? Is this a typical situation? Explain.

3. How can you account for the different colors of soil?

4. What things do you feel are most important when choosing soil to grow plants in?

5. What are the four main parts of soil?
(a)____________________ (c) ____________________

(b)____________________ (d) ____________________

6. List some additional information that you would like to find out about soils.
(a) ____

(b) ____

(c) ____

(d) ____

(e) ____

Soils Examination Date Sheet

Soil Material	Color	Composition (What is it made of?)	Texture (How does it feel wet and dry?)	Particle Size (Large, small, microscopic)	Particle Arrangement (Individual particles, crumbs, clods)	Organic Matter Present? If so, what kind?
A						
B						
C						
D						
E						
F						

Suggested Teaching-Learning Activities

1. Use a bulletin board display with soil genesis as the theme.

2. Introduce the competency as suggested in the content.

3. Examine soils using the laboratory guide sheet.

4. Follow up the laboratory exercise in a conference type class.

    a. Introduce the competency and then call on class members for their observations about soils. These may be either as discovered during the laboratory exercise or from previous experience. List these observations on the chalk board (see the content for example of statements).

    b. Develop a working definition for soil. Place this on the chalk board.

    c. Discuss soil profile.

    d. Discuss rock weathering and soil formation. Set up a classroom display showing the process of soil genesis.

    Bed rock → Broken and crumbled bed rock → Subsoil → Top soil

    ↓ pioneer plants (under broken and crumbled bed rock)

    ↓ succession plants, animal life (under subsoil)

    ↓ climax plants (under top soil)

    Use terms which the students can understand. (See rock weathering in the content.)

    e. Answer the questions in the laboratory exercise. Do not go into depth at this point as more attention will be given to soil evaluation later.

5. Discuss the significance of the soil. (See the content for suggestions.)

6. Allow the students to view the different soil materials with the stereo microscope if possible. (This microscope should be used only under strict teacher supervision.)

7. Show the film Birth of a Top Soil for introductory purposes.

8. Set up a controlled experiment using tomato seedlings growing in each of the six soil materials. The class should make regular observations of the progress of the plants.

9. Suggested time for developing this competency

Classroom teaching	4 hours
Laboratory activity	6 hours
Total time	10 hours

Suggested Instructional Materials and References

Instructional Materials

1. One peck each of the following soils:

   a. A top soil taken from a sodded area

   b. A heavy clay soil

   c. A soil taken from a heavily eroded hillside

   d. A peat soil (peat moss will do)

   e. A muck soil

   f. Sand

2. Small paper cups for soil samples

3. Student hand lenses or magnifying glasses

4. A stereo microscope, if available

5. A set of soil specimen jars showing a complete range of soil colors

6. Sedimentary rock and mineral displays

7. Film, Birth of a Top Soil, 10 minutes, available from the Soil Conservation Service

References

1. Donahue. Our Soils and Their Management, Chapter 1.

2. Janick. Horticultural Science, pages 98-100.

3. Lyon and Buckman. The Nature and Properties of Soil, Chapter 1.

II. To develop the ability to determine the suitability of various soil materials for growing plants.

Teacher Preparation

Subject Matter Content

Some things are not so good

1. Castor oil for medicine
2. Fish won't bite
3. Dog barking all night when you want to sleep
4. Car won't start
5. Losing a football game
6. Some soils

Some things are good

1. Ice cream and cake
2. Hot rod cars
3. Girl friends
4. Boy friends
5. Vacations
6. Some soils

According to what has been said, some soils are "good" while others are not so good. What do we look for in a "good" soil? What is it about some soils that make them better than other soils? If a soil isn't "good," can we do anything to make it better? If a soil is "good" will it stay good indefinitely? Do you know the answer to these questions? If not, let us spend some time now finding out more about soils.

Soil is made of particles of different sizes and weights. (A demonstration may be used to illustrate this.)

Materials required

1. Six wide-mouth bottles--collecting bottles as used in the chemistry laboratory would work well.

2. One-half cup of sand, top soil, muck soil, peat moss, heavy clay, and a soil from a heavily eroded hillside.

3. Six corks or rubber stoppers.

Procedure

Fill the bottles about one-third full of each of the soils examined in Laboratory Exercise #1. Fill the bottles about three-fourths full of water and stopper with a cork or rubber stopper. Ask for six volunteers from the class. Assign one bottle to each volunteer, and ask each to vigorously invert and right each bottle five times, all beginning at the same time. Now place the bottles on the demonstration desk and fill in the information called for in the study guide listed on page 21.

Table 1

Characteristics of Mineral Particles

Name of Particle	Size	Shape	Composition	Visible With
Gravel	Very large	Irregular	Rock pieces	Naked eye
Sand	Large	Irregular	Unweathered minerals	Naked eye
Silt	Small	Irregular	Unweathered and weathered minerals	Microscope
Clay	Extremely small	Plate-like	Weathered minerals	Electron Microscope

Insofar as soils are composed of particles of different sizes, specific names are needed to indicate their texture and physical properties. Names are given to soils according to the amounts of sand, silt, and clay which they have in them. Basically there are three textural groups of soils. These groups are:

1. Sands

This group includes all soils made up of 70 percent or more of the sand sized particles by weight.

2. Loams

This group consists of soils having a mixture of sand, silt, and clay particles which have "light" and "heavy" properties in about the same amounts.

3. Clays

This group includes all soils made up of 40 percent of clay sized particles.

Table 2

Identifying Soil Particles by Touch

Soil Particle	Feel to the Thumb and Index Finger When Rubbed Dry	Feel to the Thumb and Index Finger When Rubbed Wet
Sand	Large, gritty particles	Large, gritty particles
Silt	Small, gritty particles	Small, gritty particles
Clay	Powdery or flour like	Slick or greasy

The students need to know that the relationship of weight to volume of a soil is an indication of composition and structure.

Soils have different weights
(The teacher may wish to show this by means of the following demonstration)

Materials required

1. One cup each of sand, top soil, muck soil, peat moss, heavy clay soil, and soil from a heavily eroded hillside
2. A 100 ml. beaker or other suitable small container of a standard size
3. Balance scales
4. Metric weights

Procedure

Weigh the container which is to be filled with soil. Fill the container heaping full with a soil material. Take a straight edge and scrape off the excess leaving the container level full. Do not pack the material down but fill it with material just as it comes from the stock container. Now weigh the container and the soil. Record the date and determine the weight of the soil. Repeat the procedure for the remaining soil materials.

The idea of particle orientation or arrangement can be shown by filling a pint jar about two-thirds full of marbles. Using a measuring glass, pour sand onto the marbles. Tap the jar on the table as additional sand is added to be sure that all the pores are filled. Stop when the sand completely covers the marbles. Check how much sand was used. (Taken from PA-341, USDA "Teaching Soil and Water Conservation," page 4.)

The students need to know about the value of pore space in the soil.

Pore Space Varies in Soils
(This may be shown by a demonstration.)

Materials required

1. A flat bottomed container capable of holding six four-inch clay pots

2. Six four-inch clay pots (azalea type)

3. Enough sand, top soil, muck soil, peat moss, heavy clay soil, and soil from a heavily eroded hillside to fill a four-inch clay pot one inch from the top

4. Enough water to fill the flat bottomed container to a level that will come two-thirds of the distance up the sides of the clay pots

Procedure

Place the six clay pots in the flat bottomed container. Carefully fill each pot to the same level with a different soil material. Now carefully add water until it comes to a point just below the rim of the pots. Determine the time for the soil surface of each pot to become entirely moistened. (Note: This may take up to two hours or more for some of the soil materials.)

Students working in the landscape need to know about the relationship between soil type, moisture content, and the time when a soil can be safely worked without damaging the structure.

Some Soils Tend to Puddle When Worked Wet
(A demonstration may be useful in securing this understanding.)

Materials required

1. Four two-square foot pieces of waxed paper

2. One four-inch pot each of sand, peat moss, top soil, and heavy clay soil

3. Several pages of newspaper

Procedure

Thoroughly soak the soil materials in each of the four-inch pots. Spread out the newspaper in a convenient, sunny location. Place the squares of wax paper on the newspaper and pour the contents of each of the pots on individual squares of wax paper. Stir and work the wet soils. Allow the soil materials to dry and then try to work them again. Compare the soils as to appearance, texture, and tendency to puddle.

Table 3

Characteristics of the Various Soil Classes

Characteristic	Sandy	Silty	Clayey
Looseness	Good	Fair	Poor
Air space	Good	Fair to good	Poor
Drainage	Good	Fair to good	Poor
Tendency to form clods	Poor	Fair	Good
Ease of working	Good	Fair to good	Poor
Moisture-holding cap.	Poor	Fair to good	Good
Fertility	Poor	Fair to good	Fair to good

Advantages and Disadvantages of the Various Agricultural Soils

Soil	Advantages	Disadvantages
Sandy	Easy to work	Low in fertility
	An early soil because it dries out rapidly in the spring	Low in organic matter
	Well drained soil	

Soil	Advantages	Disadvantages
Clay	Good moisture-holding capacity	Difficult to work
	Has fertility	Tends to be a wet soil
		Tends to puddle when worked wet and form clods when worked dry
		Tends to be low in organic matter
Loam	Tends to combine advantages of both sand and clay	

Definitions of terms are important in this competency.

1. Soil texture--refers to the size of mineral particles making up the soil
2. Soil structure--refers to the arrangement or grouping of the soil materials into aggregates
3. Platy structure--a soil structure in which the soil aggregates are arranged in relatively thin horizontal plates, leaflets, or lenses
4. Primsmatic structure--a soil structure described as having vertically oriented aggregates or pillars
5. Blocky structure--a soil structure where the soil aggregates are in the shape of irregular blocks with rather sharp edges
6. Granular structure--a soil structure where the soil aggregates are rounded and not over one-half inch in diameter
7. Soil aggregate--refers to a grouping of soil particles
8. Soil granule--a rounded porous mass of mineral particles of varying sizes held together with organic matter
9. Heavy soil--a soil that is difficult to work
10. Light soil--soil that is easy to work

11. Puddle a soil--working a soil when it is in a plastic condition, thereby greatly reducing the pore space. This makes it very difficult for air and water to enter the soil.

12. Tilth--refers to the physical condition of a soil in relation to plant growth

Determining the Suitability of Various Soil Materials for Growing Plants

Note: The teacher should prepare the following guide sheet for class distribution

Student Class and Laboratory Guide Sheet #2

Introduction

During earlier class periods, we learned that soils have different colors, different amounts of organic matter, and are made up of several different things. Now we are ready to learn about other ways in which soils are different from one another.

Class Demonstration on Soil Particle Size

Records

1 Soil Material	2 Time of placing bottle on desk	3 Time that the water began to clear	4 Time that the water was clear	5 Amount of time taken for water to clear
A				
B				
C				
D				
E				
F				

The demonstration showed that ____________________________

____

____

Information About Soil Particles

Name of Particle	Size	Shape	Made up of	Visible With
Gravel				
Sand				
Silt				
Clay				

The four kinds of soil particles are:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Name of Particle	Feel when dry	Feel when wet
Sand	____________	____________
Silt	____________	____________
Clay	____________	____________

Class Demonstration on Soil Weight

1 Soil Material	2 Weight of Container	3 Weight of Container and Soil	4 Weight of Soil	5 Volume of Soil
A				
B				
C				
D				
E				
F				

The demonstration shows that______________________________

____

____

Class Demonstration on Pore Space in Soils

Records

1 Soil Material	2 Time needed for water to reach the soil surface	Time needed for water to wet the entire surface
A		
B		
C		
D		
E		
F		

The demonstration shows that______________________________

____

____

Class Demonstration on the Effects of Working Soil When Wet

Records

Soil Material	Description of the soil after drying

Information About Sand, Silt and Clay

Item	Sand	Silt	Clay
Looseness			
Air space			
Drainage			
Tendency to form clods			
Ease of working			
Holding water			
Richness			

The ways in which I can use these lessons on the job are:

1. ______________________________

2. ______________________________

3. ______________________________

Suggested Teaching-Learning Activities

1. Introduce the competency as suggested in the content.

2. Hand out mimeographed "Student Class and Laboratory Guide Sheet."

3. Do suggested class demonstrations dealing with soil particle size.

4. Use the chalkboard and class discussion, complete the tables and discuss sandy, loamy, and clayey soils.

5. Bring in several different soil samples and allow the students to determine the soil texture by feeling the materials both wet and dry.

6. Conduct the demonstration dealing with the weight of soils. Point out that light weight soils tend to have high organic matter content or much pore space due to the way in which the particles are arranged in the soil. This is a valuable clue as to whether the soil has a good or poor structure.

7. Conduct the demonstration relating to pore space. Explain why pore space is so important in a soil. Point out the two kinds of pore space in soils. Explain how pore space can be increased in soils.

8. Conduct the class demonstration dealing with working soils when wet. Relate this demonstration to working the soil for flower beds, lawns, and shrubs under extremely wet conditions.

9. Discuss the characteristics of sandy, silty, and clayey soils.

10. Show the class how the clay soil in a flower pot shrinks away from the pot wall upon drying. This is not good because when water is applied it runs down along the pot wall and drains out rather than soaking into the soil.

11. Take the class on a field trip around the school area. Have the students evaluate and describe the various soils as encountered.

12. Work a small corner of the land laboratory when the soil is too wet and observe the results.

13. Have students bring in soil from the home site to evaluate and describe as to its physical properties.

14. Discuss the effects of soil tillage equipment on soil structure. Overwork a soil area with the rototiller and examine the area after a heavy rain.

15. Discuss methods for improving soil structure.

16. Examine plants that are being grown in each of the various soil materials.

17. Suggested time for developing this competency

Classroom teaching	6 hours
Laboratory activity	12 hours
Total time	18 hours

Suggested Instructional Materials and References

Instructional Materials

1. Soil materials as used in Competency I area

2. Labeled samples showing the various soil classes (i.e., sand, loam, clay)

3. Six wide mouthed bottles and stoppers

4. Six 100 ml. beakers or other small standard size containers

5. Balance scales and weights

6. One flat bottomed container

7. Six four-inch clay pots (azalea type)

8. Roll of waxed paper

References

1. Donahue. Our Soils and Their Management, Chapter 1.

2. Janick. Horticultural Science, pp. 99-103.

3. Lyon and Buckman. The Nature and Properties of Soils, Chapter 3.

4. U.S.D.A. Teaching Soil and Water Conservation, pp. 4 and 7.

III. To understand how plant watering practices are related to soil structure.

Teacher Preparation

Subject Matter Content

Suggested Introduction to the Competency.

Some things can go for days without water.	Some things need water all the time.	Some things need just the right amount of water.
Camels Cactus	Fish Water lilies	Most horticultural plants

The moisture in the soil represents an important part of the plant environment. It is common knowledge that many plants tend to wilt when lacking in water. If water is not supplied to the plants soon after the wilting point is reached, they often die. Water is used by the plant in many ways. The needed water is taken from the soil by the roots. If plants are to remain healthy and grow well, water must be made constantly available to the plants. The type of soil in which the plants grow has a definite influence upon the frequency of watering.

Soil water is very important.

1. Large amounts of water lost by plants in transpiration must be replaced.

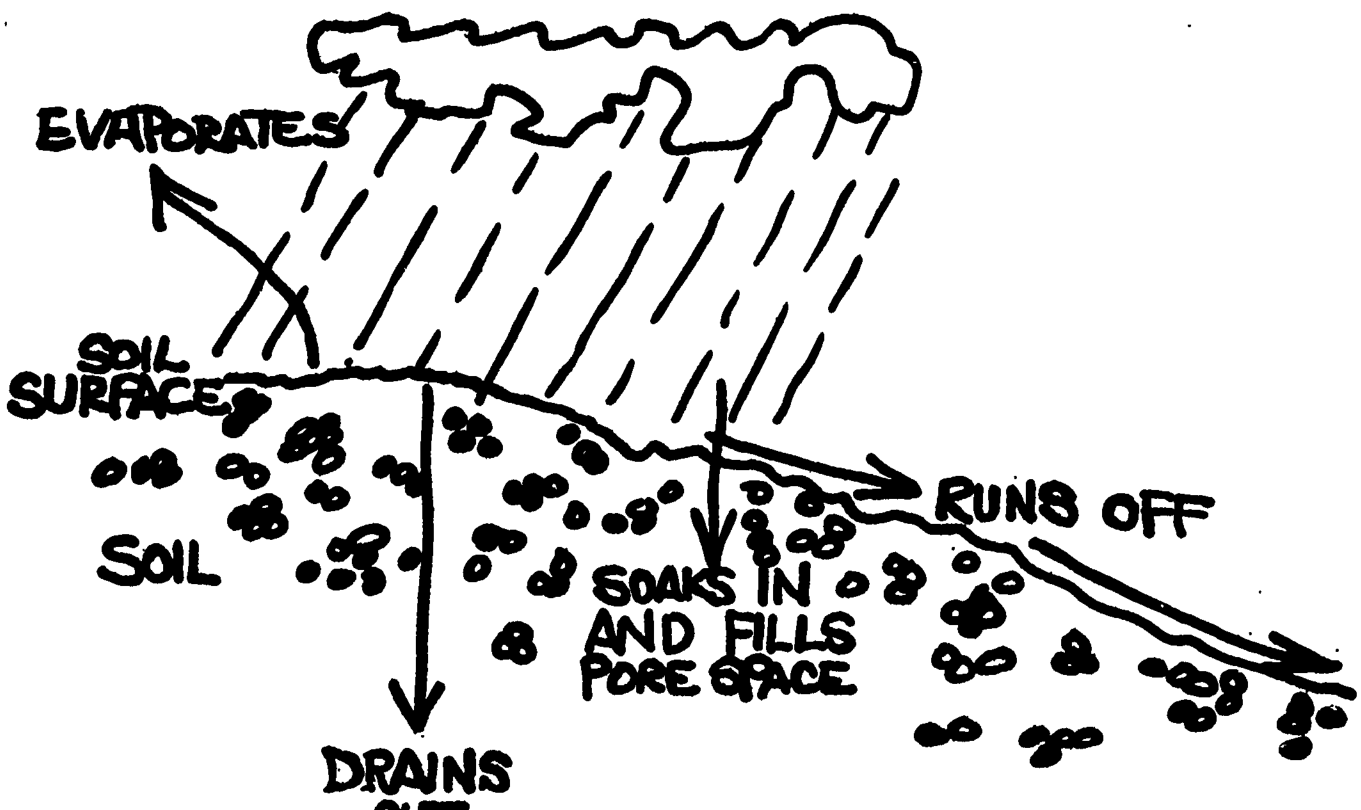
2. Water acts as a solvent for dissolved minerals.

3. Water affects soil aeration.

4. Water affects soil temperature.

What happens to rain which falls to the earth's surface?

Figure 1



Water absorption is very important to the growth of plants. (A demonstration may be desirable to show water absorption.)

Materials required

1. A plastic sponge, moistened
2. Sheets of blotter paper, moistened
3. A plastic squeeze bottle
4. A supply of water

The sponge

The sponge represents soil in excellent condition for water intake. It is porous, and like porous soil, absorbs water rapidly and provides good drainage. Large pores allow air to get into the sponge. Small pores hold water against the pull of gravity. This is called capillary water. Most of the capillary water in the soil is available for farm crops, lawns, shrubs, flowers, trees, and other growing plants.

The blotter paper

The blotter paper represents a heavy, tight soil in poor condition for water intake. Its pores are small and they absorb water very slowly. Drainage is extremely slow. Very little air gets into the pores. Just as the small pores in the blotter hold much water, so do the pores in a heavy, tight soil hold a fairly large amount. But all this water is not available for crops because much of it is held too tightly. A clayey, poorly aggregated clay soil, like the blotter paper, stays wet for long periods.

The plastic squeeze bottle

The plastic squeeze bottle provides a means of applying water to the sponge and blotter paper. The plastic bottle provides the rain.

Procedure

1. Hold the sponge in one hand and the squeeze bottle in the other. Slope the broad side of the sponge so that you can see the water run off. Tilt the bottle and squeeze it. Notice how fast the sponge absorbs the water. Can you apply water from the bottle fast enough to cause run off? Continue applying water until some begins to drop from the bottom of the sponge.

2. Now place the moist blotter paper on top of the sponge. Squeeze the excess water from the sponge before starting

this test. Now apply the water from the squeeze bottle and watch how little penetrates the blotter into the sponge. Note how much water runs off.

3. Now place the blotter paper on the bottom of the sponge. The sponge and blotter must be tilted slightly to allow for runoff or lateral seepage. After you start applying the water, note how long it takes for water to penetrate the sponge and seep out over the blotter. Note that there is no runoff over the sponge surface. Also note that no water is seeping through the blotter. (This material was taken from Miscellaneous Publication No. 925, Agricultural Research Service, U.S. Department of Agriculture, pages 1,2,3, and 5.)

How can these demonstrations be related to the soil?

1. The sponge represents a porous soil.

2. The soil surface was not disturbed by the beating and packing action of the raindrops.

3. In a porous soil, most of the water from a gentle rainfall is absorbed. There is no runoff and no erosion.

4. Water absorbed by the soil is sufficient for vegetation for several days.

5. As the soil dries out (squeezing the sponge) a greater reservoir for water absorption develops in the soil.

The blotter represented a soil crust which formed when tillage operations break up soil aggregates. As the aggregates are broken down, the fine particles clogged the pores at the soil surface. Raindrops puddled and packed the surface. Upon drying, a crust is formed and the open, loose, porous soil lies beneath the crust. Under such conditions, runoff increases and infiltration decreases.

Rain water is absorbed and rapidly passes downward through a porous soil. When the upper surface of the subsoil has a slope, much of the water flowing over its surface seeps out of the hillsides in springs and quickly contributes to stream flow.

Why do soils differ in the capacity to hold or "soak up" water?

Soils Have Different Water Holding Capacity
(The following demonstration may be helpful.)

Materials required

1. Four coffee cans
2. Four 18-inch squares of cloth
3. Some heavy string
4. A balance scales and metric weights
5. A container of water
6. Enough of each of the following soil materials to fill a coffee can:
    a. A fertile top soil taken from a sodded area
    b. Soil taken from a heavily eroded area (the sample should be hard and cloddy)
    c. Sand
    d. Peat moss

Procedure

Allow the soil materials to completely air dry. Empty the four samples on the cloth squares, pull the corners together and tie with a heavy string. Weigh each sample and record the weight. Saturate each sample by holding it in the water long enough to thoroughly soak it. Remove the soil samples from the water and allow them to drain off the free water for a few minutes. Re-weigh each sample and record the weights. Determine the difference in weight.

Another demonstration to show that soils have different water holding capacities follows.

Materials required

1. Two kerosene lamp chimneys
2. Enough cheesecloth to cover the chimneys and be tied securely
3. One quart each of the following soil materials:
    a. A fertile top soil taken from a sodded area

b. A soil taken from a heavily eroded area

c. Sand

d. Peat moss

4. Two pint jars

Procedure

Tie the cheesecloth squares over the tops of the two lamp chimneys. Turn the chimneys upside down and fill them about two-thirds full with two of the soil materials which are equally dry. Place the tops of the chimneys in the two pint jars. Pour a pint of water into each chimney. Note how long it takes the water to begin to drip into the jars, how much water comes from each soil, and how long the water continues to drip. The procedure can be repeated for the other two soil materials or all four materials can be handled at one time if additional lamp chimneys can be obtained. (These two demonstrations were taken from PA-341, U.S.D.A., "Teaching Soil and Water Conservation", page 11.)

Summarizing the demonstrations

1. When organic matter is used up, soil packs together. Thus a cloddy soil has fewer air spaces, its particles do not cling together in granules, and the lack of organic matter means that it weighs more than an equal volume of crumbly soil from a well managed plot.

2. A crumbly soil can take in water faster than a cloddy one, and it can hold more water. The thoroughly decomposed soil, organic matter (humus) in a crumbly soil, can hold lots of water. Organic matter acts as a sponge in holding water. In addition to the water held by the organic matter itself, is the water held in the pores between the soil particles and between the soil granules. Hundreds of very fine soil particles are glued together by the organic matter to form granules or crumbs.

3. The increased water-holding capacity of soils high in organic matter under natural conditions makes a big difference in the intake of water. This is extremely important during droughty seasons.

Water Affects Soil Temperature
(This demonstration may be helpful.)

Materials required

1. Two wide-bottomed pans at least three inches deep and of the same size

2. One peck of a good top soil

3. Two thermometers

4. A heat lamp and support

5. One quart of water

Procedure

Place one-half peck of soil in each of the two containers. Pour one quart of water over one of the soils. Insert a thermometer in each soil. Place the pans of soil under a heat lamp and note the differences in heating of the soils.

If soils do not warm up early in the spring, what effect does this have on the timeliness of working the soil and the rate of plant growth?

How plants are supplied with water:

1. By root extension

   The roots may grow rapidly enough to make contact with moist soil at all times. This will allow water absorption by the roots to take place furnishing the plant with adequate water.

2. By capillary action

   Water can move in the soil independent of gravity. It may move sideways or upwards. This process results in water being brought near to absorbing root surfaces.

Capillary Water Moves in the Soil
(This demonstration may be helpful in demonstrating this.)

Materials required

1. Four plastic or glass tubes at least 12 inches long
2. Top soil
3. Sand
4. Muck soil
5. Clay soil
6. Small squares of cheesecloth
7. String
8. Four ring stands or supports for tubes
9. Four burrette clamps
10. Four small wide-mouth jars

Procedure

Tie a small square of the cloth over one end of each tube. Fill the four tubes with the various soil materials. Support the tubes using ring stands and burrette clamps. Fill each of the small wide-mouthed jars (baby food jars will do) three-fourths full of water. Immerse the cloth covered bottoms of the four tubes well into the jars of water. Observe the progress of the water in the various tubes.

Moisture moves through the soil in all directions even against gravity by capillary movement. This movement is caused by the attraction water molecules have for each other as well as the attraction between water molecules and soil particles. Water molecules cling together and form droplets in the air or on a greasy surface where there is nothing to interfere. When a drop of water falls on soil particles, it spreads out in a thin film over the soil particles because of the interaction occuring between the soil particles and the water molecules. Water that moves through soil in this way is known as capillary water.

How far and how fast capillary water will move in a soil depends on the size of the soil particles and the condition of the soil. If the spaces around the soil particles are large, the attraction between the water molecules and the soil particles will not be enough to overcome the weight of the water and it will not rise too much. The movement that does take place, however, will be rapid because there is little friction. This is true in sandy soils.

In fine-textured soils, the particles are closer together and the attraction between soil and water is greater. Water may be expected to rise more slowly, but higher in soils of fine texture.

Under field conditions, moisture moves from wetter soil to drier soil. The difference is not always great; therefore, capillary water moves slowly and not far. Even so, moisture moves a short distance to the roots of growing plants to make it an important plant-soil relationship.

Much soil moisture can be lost when capillary water moves to the surface and evaporates. (The interpretation of this demonstration was taken from "Teaching Soil and Water Conservation," U.S.D.A. Publication, PA-341.)

A Plant Can Get Too Much Water
(The following demonstration may be helpful.)

Materials required

1. Two five-week old bean plants of the same variety grown under identical conditions

2. A pneumatic trough, battery jar, or similar container

Procedure

Immerse the pot in which one of the bean plants is growing, in water. Place the two bean plants in a sunny environment. Add water as required to keep the control plant in a turgid, healthy condition, and the soil and root system of the second plant immersed. Observe the state of health of the two plants for a period of three weeks, then carefully wash the soil from the root systems of the two plants. Compare these two root systems.

All living cells carry on respiration. Roots are made of living cells. In order for respiration to occur, oxygen must be present. Oxygen is normally found in the air occupying the pore space of soils having good aeration. As water fills the pore space of these soils, however, the air is forced out (no two things can occupy the same space at the same time) and consequently, the supply of oxygen in the soil is lost. This means that root cells die and the root system decays away.

Excessive water in the soil → Decreased aeration → Decreased respiration → Root cells die →

root system decays → water and mineral intake ceases → top growth of the plant dies → a dead plant →

loss of money or beauty

Some implications of understanding of soil-water relationships for the horticulture service worker.

1. Many soils cannot be tilled or cultivated when wet except at the expense of desirable soil structure. This is more true for heavy clay-like soils than for sandy soils.

2. Plants can be easily overwatered or underwatered. Sandy soils require more frequent waterings than heavy clay soils, especially during periods of prolonged sunny days.

3. If soils do not have desirable moisture holding capacities, they should be modified to make them more desirable. (See the next competency)

4. It is more critical to overwater plants growing in heavy soils during periods of prolonged cloudy weather than it is to overwater plants growing in light soils, during this type of weather conditions. Soil type and the amount of sunlight affect plant-watering practices.

5. Loose, porous soils having a good structure soak up and hold more water than hard compact soils. This has an important influence on plant-watering practices.

6. Overwatering causes decreased aeration and subsequent root decay and death of the plant.

7. Underwatering causes wilting, dehydration, and subsequent death of the plant.

The teacher should mimeograph the following guide sheet for class distribution.

Plant Watering Practices as Related to Soil Structure

Student Class and Laboratory Guide Sheet #3

Introduction:

The water in the soil is very important to plant growth. Plants require a certain amount of water to live. It is possible that plants may be either underwatered or over-watered. During the next few periods, we will learn about how the kind of soil in which plants are grown affects the way in which the plants are watered.

Class Demonstration on Water Absorption

1. Did any water run off the porous sponge as water was sprinkled on it? Why or why not?______________________

____

2. How long did it take for the water to drop from the bottom of the sponge?______________________________

____

3. How can the soil in flower beds, gardens, or lawn construction areas become crusted?_____________________

____

4. Why is soil crusting bad?___________________________

____

Class Demonstration on Water Absorption

Soil Sample	Weight dry	Weight wet	Difference in weight
Top soil	________	________	________
Eroded soil	________	________	________
Sand	________	________	________
Peat moss	________	________	________

This demonstration showed that ______________________

____

____

Class Demonstration on Water Holding Capacity of Soil

Soil Sample	Time required for water to drip into the jars	Time required for water to stop dripping
Top Soil		
Eroded Soil		
Sand		
Peat Moss		

This demonstration showed that ______________________________

____

____

Organic matter is important in the soil because it:

1. ____
2. ____
3. ____
4. ____
5. ____

Class Demonstration on the Effect of Moisture on Soil Temperature

Soil Sample	Temperature after five minutes	Temperature after ten minutes
Top Soil (dry)		
Top Soil (wet)		

This demonstration showed that ______________________________

____

____

Plants are supplied with water by:

1. ____
2. ____

Class Demonstration on the Capillary Movement of Water in the Soil

	Time Required to Move			
Soil Sample	1 inch	2 inches	6 inches	Top
Top Soil				
Sand				
Muck Soil				
Clay Soil				

Water moves upward fastest in ______________________

Water moves more slowly upward in ______________________

This demonstration showed that ______________________

____

____

Class Demonstration Pertaining to the Correct Amount of Water for Plant Growth

Why is too much water bad for plants?

1. ____

2. ____

3. ____

Ways that I can use these lessons on the job.

1. ____

2. ____

3. ____

Suggested Teaching-Learning Activities

1. Introduce the competency (see content).

2. Give students mimeographed "Student Class and Laboratory Guide Sheet."

3. Discuss the importance of water to plants.

4. Carry out the class demonstrations, discuss their implications, applications, and appropriate teaching points.

5. Take the class on a field trip to map the wet areas of the school grounds. Determine if the wetness is due to topography or soil type.

6. Have the students water extremely dry peat moss. Ask them to relate their experiences and observations to the class.

7. Have the students transplant some tomato seedlings in market paks of sand, peat, and perlite, and clay soils. Water thoroughly initially by subsurface irrigation. Set the plants in a sunny growing environment and do not water again for a week. Watch what happens in each case.

8. Suggested time for developing this competency

Classroom teaching	5 hours
Laboratory activity	10 hours
Total time	15 hours

<u>Suggested Instructional Materials and References</u>

Instructional Materials

1. Sponge
2. Blotter paper
3. Plastic sprinkler bottle
4. Two kerosene lamp chimneys
5. Cheese cloth
6. Balance scales and metric weights
7. Four coffee cans
8. Four small glass jars (baby food jars will do)
9. String
10. Two wide-bottomed pans

11. Two thermometers
12. Four ringstands
13. Four burrette clamps
14. Four 12- to 18-inch glass or plastic tubes
15. Two 5-week old bean plants
16. Pneumatic trough

References

1. Janick. Horticultural Science, pp. 102-103.
2. Lyon and Buckman. The Nature and Properties of Soils, Chapters 7 and 8.
3. U.S.D.A. Publication PA-341. "Teaching Soil and Water Conservation," pp. 5 and 10.
4. U.S.D.A. Miscellaneous Publication No. 925. "Water Intake by Soil," pp. 1-7.

IV. To be able to recognize and effectively use soil conditioners

Teacher Preparation

Subject Matter Content

Some things by themselves are not so good.

1. Bread without butter
2. Cake without icing
3. Hamburgers without mustard
4. Cars without gas
5. Houses without furniture
6. Some soils

Display four tomato plants which have been grown in sand alone, heavy clay alone, top soil and soil mixture consisting of one-third sand or perlite, one-third loam soil, and one-third peat moss. Ask questions which stimulate interest.

1. Why did some plants grow better than others?

2. Which kind of plants would you like to grow?

3. What does one have to do to raise good plants?

Introduction

From preceding laboratory periods, it has been determined that soils differ in color, composition, structure, organic matter content, moisture holding capacity, etc. Many soils used alone prove unsatisfactory for good crop production. Other soils can be used alone and produce excellent crops. They continue to do so as long as good soil management practices are used. On a large scale, it takes considerable time and money to appreciably modify large areas of poorer soils for agricultural production. In many cases the soils are so unsuited to large scale crop production, that it is not economically practical to modify them for agricultural production. In the greenhouse, however, since we are dealing with much smaller quantities of soil, it is possible to "tailor make" the soil as required for growing particular types of plants. How this is done is the subject of this particular series of lessons.

Many soils used alone or unmodified prove unsatisfactory for good crop production. This may be due to poor structure, low moisture-holding capacity, excessive moisture-holding capacity, poor aeration, low fertility, or high soluble salts. In order to improve soils for growing good plants, various conditioning materials are used. Several of these materials are described below.

Sand

Sand consists of small rock grains ranging from 1/5,000 of an inch to 3/40 of an inch in diameter. The grains result from the breaking down of various rocks, its mineral composition depending upon the type of rock. Quartz sand is used for propagating plants, while plastering grade sand is satisfactory for rooting purposes. Sand is also used to "lighten" soils. This increases the aeration and improves the drainage of the soil.

Peat Moss

Peat moss consists of the remains of water, marsh, bog or swamp plants which have been preserved under water in a partly decomposed state. Peat moss which is light brown or yellowish brown in color is made up of the remains of moss, reeds, or sedges, and is quite acid in reaction. The brown to black, partly fibrous peats are woody, lumpy or granular and range from very acid to alkaline.

Surface layers and layers of peat moss which have been considerably weathered such that the plant remains are difficult to identify are known as muck soils. These soils generally have between 20 to 65 percent organic matter content whereas peats and peat mosses have above 65 percent organic matter content.

Sphagnum Moss

Commercial sphagnum moss is the dried out remains of certain acid bog plants. The material is mostly free of harmful organisms such as weed seeds and agents capable of causing plant disease. It is light in weight and has a very high moisture-holding capacity, being able to hold 10 to 20 times its weight in water. The material is generally shredded before use. It contains only a very small amount of plant nutrients.

Vermiculite

This material is a mica type mineral which expands considerably when heated. It is very light in weight, weighing about six to ten pounds per cubic foot. It is neutral in reaction, insoluble in water and able to absorb large quantities of water (from three to four gallons per cubic foot of material). The crude vermiculite ore consists of thousands of thin, separate layers which have small amounts of water trapped between them. The ore is run through furnaces at temperatures near 2,000 degrees Fahrenheit. The water between the layers turns to steam, popping the layers apart forming small, porous sponge-like kernels. Due to the extreme temperatures of the processing, the material is sterilized.

Perlite

This material is gray-white in color and is of volcanic origin, being mined from lava flows. The crude ore is crushed and screened in heated furnaces where the small amount of moisture in the particles changes to steam, exploding the particles to small sponge-like kernels. The material is light in weight weighing only six to eight pounds per cubic foot. The product is sterile due to the high temperature at which it is processed.

Leaf Mold

Maple, oak, sycamore, and elm leaves are leaves suited to making leaf mold. Leaf mold is prepared by alternating layers of leaves with thin layers of soil to which small amounts of a nitrogen fertilizer have been added. The mixture should be well-watered to maintain decomposition action, and the compost heap should be protected from the leaching action of heavy rains. The material is not sterile and should be sterilized before use.

Shredded bark, sawdust, wood shavings

These by-products of lumber mills can be used in soil mixes serving much the same purposes as peat moss except that their rate of decomposition is slower. (Adapted from Plant Propagation by Hartman and Kester, pages 24-26.)

Relative cost of soil conditioning materials from the most expensive to the least expensive

1. Peat moss
2. Perlite
3. Vermiculite
4. Sand
5. Leaf mold--generally home-made
6. Sawdust--generally free

Soil mixtures

1. Loam soils by themselves are generally unsatisfactory for growing plants for various reasons.
    a. Often "heavy"
    b. Often poorly aerated
    c. Often have a low moisture-holding capacity

d. Often tend to become sticky after watering

e. Often tend to shrink upon drying

2. Advantages of incorporating organic matter and soil "lightening" materials with loam soils include:

   a. Better aeration

   b. Greater ease of working

   c. Better drainage

   d. Better moisture-holding capacity

   e. Lighter in weight (easier to carry and cheaper to transport)

Some typical soil mixtures

1. For potting rooted cuttings and young seedlings (Parts by weight or volume in each case)

   1 or 2 parts sand
   1 part loam soil
   1 part peat moss (or leaf mold)

2. For general container-grown nursery stocks

   1 part sand
   2 parts loam soil
   1 part peat moss or leaf mold
   $\frac{1}{2}$ part dried or well-rotted manure

3. For plants which do best under acid soil conditions

   2 parts sand
   2 parts loam soil
   2 parts peat moss
   1 part leaf mold
   $\frac{1}{2}$ part dried or well-rotted manure

4. The University of California (U.C.) mix

   50 percent sand
   50 percent peat moss
   Fertilizer additives (a or b)

a. If the mix is to be stored for an indefinite period before using. This furnishes a moderate supply of available nitrogen, but the plants will soon require supplemental feeding. To each cubic yard of the mix add:

4 oz. potassium nitrate
4 oz. potassium sulfate
$2\frac{1}{2}$ lb. single superphosphate
$7\frac{1}{2}$ lb. dolomite lime
$2\frac{1}{4}$ lb. calcium carbonate lime

b. If the mix is to be planted within one week of preparation. This furnishes available nitrogen as well as moderate nitrogen reserve. For each cubic yard of the mix add:

$2\frac{1}{2}$ lb. horn and hoof or blood meal (13% nitrogen)
4 oz. potassium nitrate
4 oz. potassium sulfate
$2\frac{1}{2}$ lb. single superphosphate
$7\frac{1}{2}$ lb. dolomite lime
$2\frac{1}{2}$ lb. calcium carbonate lime

5. In making the U.C. mix for

a. Bedding plants and nursery container grown stocks use

75 percent sand
25 percent peat moss

b. Potted plants use

50 percent sand
50 percent peat moss

This mixture, including the fertilizer, can be safely sterilized by steam or chemicals without resulting in the subsequent harmful effects to the plants that often occurs when other soil mixes are sterilized.

The teacher should check with the state university as to mixtures which are being recommended for use according to locally available materials and needs. (The above material is adapted from publication by: Hudson T. Hartmann and Dale E. Kester, PLANT PROPAGATION: PRINCIPLES AND PRACTICES, (C) 1959. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, N.J.)

The ideal soil mix has these characteristics.

1. Uniformity
2. Freedom from disease
3. Low soluble salts
4. Good drainage
5. Good moisture retention
6. No shrinkage
7. Ease of preparation and storage
8. Complete availability
9. Light in weight

Equipment used in preparing soil mixtures includes:

1. Soil screens (may be a powered rotary screen)
2. Scoop shovel
3. Wheel barrow
4. Soil shredder (either gasoline or electric powered)
5. Cement mixer
6. Water hose

Steps in preparing soil mixtures

1. Screen the soil to make it uniform and to eliminate large particles.
2. Moisten slightly extremely dry materials (especially peat).
3. Mix smaller quantities by putting the ingredients in a pile in layers, and turn the pile with a shovel until uniformity is attained.
4. Use a power driven cement mixer or shredder for large scale mixing operations.

5. Prepare the mixture at least one day in advance of use so that the moisture will tend to become equalized throughout the mixture. The soil mixture should be slightly moist at the time of use so that it does not crumble. Be sure that the mixture is not so wet that it forms a ball when squeezed in the hand at the time of use.

The teacher should mimeograph the following student guide sheet and distribute it to the class.

Using Soil Conditioners
Student Class and Laboratory Activity Guide Sheet #4

Introduction

From other classes, it has been learned that soils are different in color, make-up, structure, organic matter content, and the amount of water which they can hold. Many soils used alone as they come from nature are not real good for raising plants. We can make soils better for growing plants by mixing other things with them. What these other things are and the ways in which we mix them to make soils better is the subject of the next few hours' activities.

Directions

On the various tables in the classroom you will find many trays of materials used to make soils better for growing plants. Each tray has a label giving its name and some information about it. You are to visit each sample material and:

1. Write down the name of the material.

2. Learn to spell the name of the material.

3. Describe the material as to where it comes from, its origin, its color, and other important things about it.

4. Tell what the material is used for.

Name of Material	Comes From	Color	Make-up	Important things about material	Use

Watch the teacher prepare soil mixtures and answer these questions about soil mixtures.

1. Why are loam soils alone not real good for growing plants?

   a.____

   b.____

   c.____

   d.____

2. Should materials be wet, dry, or slightly moist before mixing? Why?

3. How are soil materials best mixed when large quantities are needed?

4. How are soil materials best mixed when rather small quantities are needed?

____

____

____

5. How soon before use should the materials be mixed?

____

____

____

6. How much moisture should be in the mixture at the time of use?

____

____

____

7. Describe an ideal soil mixture.

____

____

____

8. List some of the common soil mixtures used for growing plants.

a. ____

b. ____

c. ____

d. ____

Prepare a soil mixture as assigned by the teacher. Place a card on the mixture telling how much of each material you used. Compare your mixture with unmixed soils and those prepared by your classmates. Grow a plant in both the mixture which you made and an unmixed soil.

Keep a record of your experience in preparing soil mixtures.

Date	Type of mixture made	Amount of mixture made	Type of equipment used	Type of plant(s) for which the mixture was made

Suggested Teaching-Learning Activities

1. Display the various soil conditioning materials and prepare description cards using appropriate vocabulary for each sample giving:

   a. The name of the material

   b. Origin of the material (where it comes from)

   c. Its composition (its make-up)

   d. Important characteristics such as weight, moisture (water) holding capacity, expense, etc., and its use

2. Demonstrate how to prepare soil mixes using a small flower pot, the scoop shovel, the soil shredder, and the cement mixer. It may be well to coach a team of students to do the actual work while the teacher explains the process.

   Note: Use the flower pot for making very small quantities of potting soil. This will be a good way to approach the concept of parts--a part can be a flower pot full of material, a flat of material, a wheelbarrow load, etc.). This may be confusing to the students so stress just what is a "part" or portion.

3. Give individual and small group instruction on the use of the soil shredder. Emphasize nomenclature, feeding soil into the machine, trouble shooting, maintenance, and safety.

4. Prepare a set of cards listing various soil mixtures. Give a card to each student, and have the students prepare the soil mixture called for. Allow the students time to examine the various prepared mixtures and compare these with the unmixed soils. The students should be provided with seeds or seedlings so that they might compare plant growth of plants grown in mixed and unmixed soils.

5. Determine quantitatively the moisture-holding capacity of peat moss, sphagnum moss, or vermiculite.

6. Provide each student with considerable opportunity to prepare soil mixtures for use in the greenhouse or nursery area.

7. Suggested time for developing this competency

Classroom teaching	3 hours
Laboratory activity	4 hours
Total time	7 hours

Suggested Instructional Materials and References

Instructional Materials

1. Soil conditioning materials:

   a. Sand

   b. Peat moss

   c. Sphagnum moss

   d. Perlite

   e. Leaf mold

   f. Sawdust

2. Soil screens

3. Scoop shovel
4. Wheelbarrow
5. Soil shredder
6. Cement mixer (if available)
7. Water hose
8. Growing containers
9. Cards (5" x 7")
10. Balance scales and weights

References

1. Hartman and Kester, Plant Propagation, pages 23-30.
2. The Ball Red Book, pages 63-64.
3. The U.C. Soil Mix Booklet - University of California.
4. Mimeographed Student Class and Laboratory Activity Guide Sheet #4.

V. To develop the ability to use soil mulches effectively.

Teacher Preparation

Subject Matter Content

Oftentimes we do certain things to protect ourselves and our property from the elements.

Examples of this are as follows:

1. Wearing a coat to keep from getting cold
2. Using a raincoat to keep from getting wet
3. Oiling metal to prevent rusting
4. Painting wood to prevent decay
5. Mulching to keep the soil from drying out

There are many places in the landscape where mulches can and should be used. Rose and flower beds, trees and shrubbery, and newly seeded lawn areas are good examples of areas where mulches are used.

The landscape or greenhouse worker needs to know how to use mulching materials. What kinds of materials are used as mulches? Which kinds of materials make the best mulches? What are mulches used for? How deep should mulches be applied? When should mulches be applied?

A mulch is any material applied to the surface of a soil primarily to conserve moisture, maintain a uniform temperature, and to help control weeds.

A class demonstration to show the value of mulches in conserving soil moisture

Materials required

1. Two pneumatic troughs or other shallow, wide containers

2. Two quarts of a top soil

3. A mulching material such as peat moss, straw, peanut hulls, etc.

4. A balance scales and metric weights

5. Measuring cup

Procedure

Weigh both containers and record the weights. Pour one quart of soil into each container and level off the surface. Pour one measuring cup of water on the soil surface of each container. Weigh each container of moistened soil and record the weights. To one of the soil surfaces add two inches of the selected mulch material. Now place both containers in a sunny location for 24 hours. After 24 hours carefully remove the mulching material and reweigh each container. Record the weights and determine whether the mulch was effective in reducing moisture loss.

Similar demonstrations could show the relative efficiency of different kinds of mulching materials. One could also determine if mulches were effective in maintaining a uniform temperature by a similar demonstration.

Effects of mulches when incorporated into the soil

1. Dilutes the soil and usually increases root growth

2. Promotes soil granulation

3. Improves and stabilizes soil structure (surface mulch)

4. Effects soil pH slightly

5. Adds some fertilizer materials

6. Leads to nitrogen deficiency in cases where carbonaceous materials such as straw, corn cobs, or fresh sawdust are added

7. Serves as food to micro-organisms

8. Introduces weed seeds in the soil in some cases

Two basic kinds of mulches

1. Inorganic or processed

2. Organic

The teacher should mimeograph the following guide and distribute it to the class.

Inorganic or Processed Mulch Material

1. Aluminum Foil - Used to some extent in vegetable planting. Research work shows that growth of plants is increased markedly.

2. Asphalt - A light spray on straw is used commonly by landscape contractors to hold soil in place on steep banks. The asphalt is used to prevent the straw from being blown or washed away.

3. Asphalt Paper - May be used but hard to keep in place. Can become unsightly.

4. Crushed Stone-Gravel Chips-Pebbles - This is a common mulch in areas where organic mulch is scarce. Good in plantings for effect. May be colored to blend in with the features of the home, patio or landscape.

5. Black Polyethylene - Becoming a popular mulch especially in areas which are not part of the foundation planting. This mulch is used in commercial vegetable plantings.

Organic Mulch Material

1. Buckwheat Hulls - This material is fine textured and may blow around in windy places. It is long lived and has a good neutral color so it is good in landscape plantings.

2. Cocoa-bean Hulls - This material is often available in garden centers or farm supply stores. It is a by-product of the chocolate or candy companies. It tends to pack so should be stirred up occasionally. The material also has a high potash content which will leach into the soil causing damage when too much is used.

3. Crushed Corncobs - Excellent mulch material. May be colored for use in landscape plantings. Usually quite inexpensive. Additional nitrogen should be applied.

4. Corncobs (whole) - Used to limited extent in farm gardens where the material is available. Can be used in utility gardens where appearance is not the main objective.

5. Hops (spent) - Can be obtained from local breweries. Excellent color and non-inflammable. The odor may be offensive but subsides in a few weeks.

6. Lawn Clippings - This material is used to a limited extent. It should be applied loosely because it mats. Heat must be produced during decomposition.

7. Leaf mold - Obtained from composting fallen leaves in the fall of the year. This is partially decomposed by the spring. Good mulch but hard to apply evenly and is not particularly neat looking.

8. Leaves - Used rather extensively in areas with many trees. The most inexpensive material available.

9. Mushroom Compost (spent) - In areas where commercial mushrooms are produced this material is often available. It is usually inexpensive and has a good color which blends into the landscape.

10. Peanut Hulls - Can be obtained in some garden centers or in areas where peanuts are processed. This is an excellent mulch and usually quite attractive.

11. Peat Moss - This is probably the most common mulch. It is quite rich looking when used correctly. The cost of this material is usually prohibitive when large areas are mulched, unless mixed with soil mats like paper mache.

12. Sawdust - Very commonly used in areas where readily available. Nitrogen deficiency is almost certain if fertilizer is not applied regularly. Reports of toxic materials have not been substantiated by experiment stations.

13. Shredded Bark - In recent years, this material has become a popular item in garden stores. The material makes an excellent mulch and is very attractive in landscape plantings. Shredded bark lasts as long or somewhat longer

than peat moss and adds valuable organic matter to the soil.

14. Straw - Used for winter protection and as a summer mulch. This material is highly inflammable so should not be used where a cigarette could be carelessly flipped into the material.

15. Wood Chips or Wood Shavings - In recent years this material has become available in large quantities. Wood chips decompose slowly and may be the cause of nitrogen deficiency if additional fertilizer is not applied.

When to Apply Mulch

The time to apply mulch to the garden on established plants is mid-spring when the soil has warmed up sufficiently for active root growth. If it is applied before this time, the mulch will keep the ground too cool and root growth may be slow. If you are applying mulch to newly planted material, do so after the plants are put into place and watered-in well. If you are planting material in the late summer or early fall, apply the mulch immediately after watering so that the soil temperature will be kept warmer in the cool nights of autumn. It is important that there is sufficient root growth in fall-planted stock so that the material does not heave due to freezing and thawing during the winter months.

How Deep to Apply Mulch

For best results, the mulch should be at least 2-3" deep over the whole area during spring, summer and early fall. Tender plants which need winter protection may require an additional 1-2" during the winter months around the crown or base of the plant. In the spring this additional material should be fanned out away from the stems or crowns of the plants before additional material is added for summer mulching.

When and How to Fertilize Plant Material

Many of the materials used for mulching require an addition of fertilizer to reduce the chance of nitrogen deficiency or starvation of the growing plant material. Woodchips, sawdust, crushed corncobs and shredded bark need additions of nitrogenous fertilizers. A report from the U.S.D.A. suggests that $\frac{1}{2}$-1 pound of ammonium nitrate or ammonium sulfate be added to each bushel of mulch material applied to the garden. The application of a complete fertilizer such as

4-12-4, 6-10-4, 5-10-5, or 5-10-10 at the rate of 2 pounds per 100 square feet can be recommended. This should be applied in early spring before another application of mulch material is made. If there is yellowing of the lower foliage and the plants lack vigor during late summer, apply additional fertilizer. (This material was taken from the Ohio State University Department of Horticulture Mimeograph, "The Use of Mulches in the Home Landscape," pages 1-5.)

Mulching Materials
Student Class and Laboratory Guide Sheet #5

1. What is a mulch? ______________________________

____

____

Class demonstration on the value of mulches in conserving soil moisture

	Un-mulched Soil	Mulched Soil
Soil Treatment	____	____
Weight of Container	____	____
Weight of Container and Soil-Start	____	____
Weight of Soil-Start	____	____
Weight of Container and Soil after 24 hours	____	____
Weight of Soil after 24 hours	____	____
Loss in Weight	____	____

This demonstration showed that ______________________________

____

____

3. Mulches are used for:

   a. ______________________________

   b. ______________________________

   c. ______________________________

4.

Mulching Material	Advantages	Disadvantages	Best Used for

5. How deep should mulches be applied to the soil surface?

____

6. When should mulches be applied? ______________________________

____

7. Why is it necessary to add nitrogen fertilizer to the soil when mulches such as straw or corn cobs are turned under? ______________________________

____

Record of Experience in Using Mulches

Date	Type of Crop Mulched	Type of Mulch Used	Depth of Application

Suggested Teaching-Learning Activities

1. Introduce the competency area.

2. Do the demonstration showing the value of mulches in conserving soil moisture. Follow the demonstration with a working definition for a mulch, the reasons for using mulches, the types of mulches, and the ways in which mulches are used.

3. Place on display the mulching materials commonly used in the geographic area. A card with appropriate descriptive information should be placed with each display material. The materials should be referred to in the class discussion made in number 2 above.

4. Give the students an opportunity to see a straw mulching machine as used by state highway departments and landscape contractors.

5. Have students observe and participate in some mulching operations in the school landscape. Students allergic to any mulching materials should tell the teacher.

6. Show pictures or 2 x 2 slides of a strawed, newly seeded lawn area, an annual bed where block plastic mulch was used, rose and flower beds, and trees and shrubs which have been mulched.

7. Suggested time for developing the competency

Classroom teaching	2 hours
Laboratory activity	2 hours
Total time	4 hours

Suggested Instructional Materials and References

Materials

1. Slides or pictures of mulched areas

2. Two pneumatic troughs or other shallow-wide containers

3. Two quarts of top soil

4. Balance scales and metric weights

5. Measuring cup

6. Appropriate mulching materials as used in the area

References

State Experiment Station Publications on mulching materials and practices

VI. To develop the effective ability to maintain a soil fertility level as required for good plant growth.

Teacher Preparation

Subject Matter Content

Suggestions for Introducing the Competency

Display the six plants that you have been growing in the six different soil materials. (See Competency I.) By this time the differences in growth rate and general state of health should be quite striking. If these plants are not available, display a group of plants of the same type, some plants doing much better than others.

The following may be helpful in beginning the class discussion:

As I was walking through the greenhouse yesterday and as I passed by the plants which we were growing in different kinds of soil, I thought that we should take some time to examine them more closely at this stage of their development.

How many of you like tomato plants? Why do you like tomato plants? (For food) Why does the commercial grower like tomato plants? (For income) Why does the supermarket like tomato plants? (For income)

Which of these six plants would you like to grow in your garden if you were going to grow tomato plants? Why?

Which kind of tomato plants would a grower for the Acme Catsup Factory like to grow? Why? Which kind of tomato plants would the officials of the Acme Catsup Factory like for the grower to grow? Why?

Point to the poorest, weakest, plant in the group and raise the questions: What if all the plants such as our grass, our flowers, our trees, our food plants in the country were like this? What if all the plants in the state or nation were like this one?

Why did some plants grow better than others?

At this point call for class response to the above question.

Possible responses as to why some plants were not doing so well:

1. Not enough fertilizer
2. Poor soil - Poor in terms of what?
    a. Structure
    b. Fertility
    c. Reaction
3. Poor variety of plant
4. Disease
5. Insect damage
6. Lack of water
7. Too much water
8. Not enough sunshine

Elaborate on the "not enough fertilizer" and "poor soil" responses to lead into problems involving the fertility level of soils.

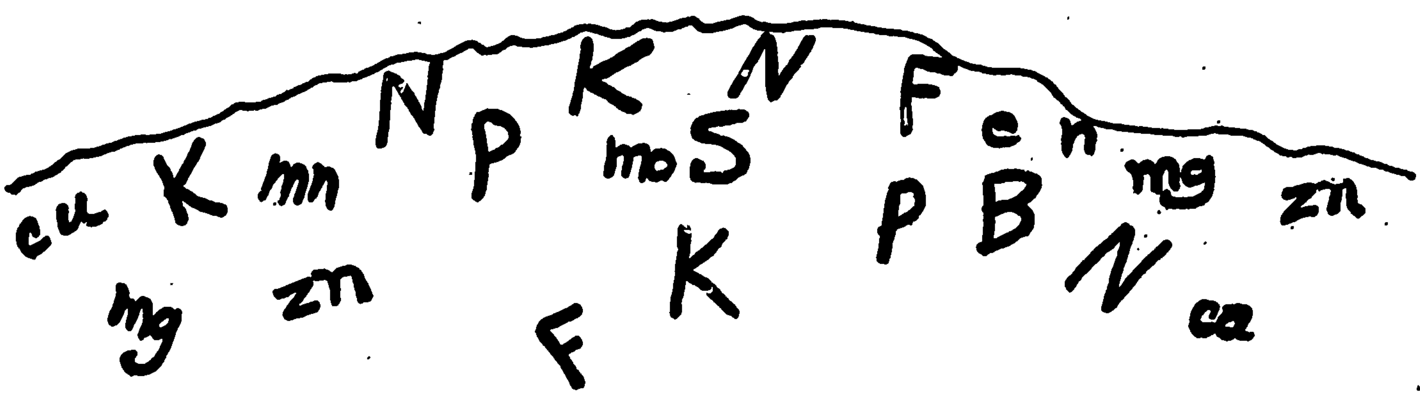
Plant Nutrients

Before studying soils, people are accustomed to thinking of soil fertility in terms of richness of the soil. Thus, the terms rich soil and poor soil will be more meaningful than the term soil fertility.

When we think of richness we might think of:

OR

Some persons may think of a soil which has adequate amounts of the minerals for good plant growth.



Research has proven that the soil or other media in which plants grow should have enough minerals for proper growth.

Sources of Common Plant Nutrients

Nutrients Used by Plants in Large Amounts		Nutrients Used by Plants in Small Amounts
Nutrients Obtained Mostly From Air and Water	Nutrients Obtained From Soil	Nutrients Obtained From Soil
Carbon Hydrogen Oxygen	Nitrogen Phosphorus Potassium Calcium Magnesium Sulfur Hydrogen Oxygen	Iron Manganese Boron Copper Zinc Chlorine Molybdenum

Some Convenient Nutrient Groupings

Grouping	Nutrients
Primary elements	Nitrogen Phosphorus Potassium (Potash)
Secondary elements	Calcium Magnesium Sulfur
Fertilizer elements	Nitrogen Phosphorus Potassium (Potash)
Lime elements	Calcium Magnesium
Trace elements or Micronutrients	Iron Copper Zinc Boron Chlorine Manganese Molybdenum

Some principles of plant-nutrient relationships for good plant growth

1. An adequate supply of nutrients must be maintained in the soil.
2. The nutrients must be in a form available to plants.
3. The nutrients must occur in the soil in proper proportions.

The following content is for teacher reference and it is not implied that all of this material should be taught to disadvantaged youth.

Nutrient and Chemical Symbol	Form in Which Available to Plants	Role in Plant Growth	Deficiency Symptoms
Nitrogen (N)	NH_4^+	Gives dark green color to plants	A sickly yellowish green color
	NO_2^-	Induces rapid growth Improves quality of leaf crops	A distinctly slow and dwarfed growth

Nutrient and Chemical Symbol	Form in Which Available to Plants	Role in Plant Growth	Deficiency Symptoms
	NO_3^-	Increases protein content of food and feed crops. A constituent of all proteins. (Note: an overabundance of nitrogen leads to rark vegetative growth and tends to retard the date of plant maturity.	Drying up or firing of leaves which starts at the bottom of the plants and proceeds upward. The firing starts at the top of the bottom leaves and proceeds down the center along the midrib.
Phosphorus(P)	$PO_4^{\equiv}$ $HOP_4^{=}$ $H_2PO_4^-$	Stimulates easy root formation and growth. Gives a rapid and vigorous start to plants. Hastens maturity. Stimulates blooming and aids in seed formation. Essential to the transformation of insoluble carbohydrates to soluble carbohydrates. A constituent of all proteins.	Purplish leaves, stems, and branches. Slow growth and maturity.
Potassium(K)	K^+	Imparts increased vigor and disease resistance to plants. Increases plumpness of grain and seed. Essential to the formation and transfer of starches, sugars, and oils. Imparts winter hardiness.	Mottling, spotting, streaking or curling of leaves. Leaves are scorched or burned on the margins and tips. Firing starts at the tip of the leaf and proceeds down from the edge usually leaving the midrib green.

Nutrient and Chemical Symbol	Form in Which Available to Plants	Role in Plant Growth	Deficiency Symptoms
Calcium (Ca)	Ca^{++}	Promotes early root formation and growth. Improves general plant vigor. Influences the intake of other plant nutrients.	Young leaves in terminal bud become hooked in appearance and then die at the tips and along the margins. Leaves have a wrinkled appearance. In cases, the young leaves remain folded. There is a light green band along the margin of the leaves. Roots are short and much branched.
Magnesium (Mg)	Mg^{++}	A component of the chlorophyll molecule. Essential to the formation of fats,and aids in the transport of phosphorous from older to younger parts of the plant. Essential to fruit production. Influence uptake of other plant nutrients. Plays a role in the translocation of starch.	A general loss of green color which starts in the bottom leaves and later moves up the stalk. The veins of the leaf remain green. The plant stem is slender and weak with long branched roots. Leaves are mottled or chlorotic with dead spots. The leaf tips are turned or cupped upwards.

Nutrient and Chemical Symbol	Form in Which Available to Plants	Role in Plant Growth	Deficiency Symptoms
Sulfur (S)	$SO_4^{=}$ $SO_3^{=}$	Essential to the formation of proteins. Essential to all division and fruit development. Promotes root growth. Stimulates seed production. Encourages more vigorous plant growth.	The young plant leaves are light green in color and have even lighter veins. The stalks are short and slender. Plant growth is slow and stunted. Fruit is immature and light green in color.
Boron (B)	$BO_3^{=}$	A deficiency of this nutrient is associated with a decreased rate of water absorption and translocation of sugars in plants.	The young leaves of the terminal bud become light green at the base, with final breakdown here. In later growth the leaves become twisted and the stalk finally dries back to the terminal bud.
Iron (Fe)	Fe^{++} Fe^{+++}	Essential to chlorophyll production. Acts as an electron carrier in enzyme systems which bring about oxidation reduction reactions in plants. Essential to the synthesis of proteins contained in chloroplasts.	The young leaves are chlorotic with the principal veins remaining green. The stalks are short and slender.
Copper (Cu)	Cu^{+} Cu^{++}	Involved in plant respiration and the utilization of iron. Acts as an electron carrier in enzyme systems.	The young leaves are permanently wilted without spotting or marked chlorosis. The twig or stalk just below tip and seedhead is often unable to stand erect in later stages when the shortage is acute.

Nutrient and Chemical Symbol	Form in Which Available to Plants	Role in Plant Growth	Deficiency Symptoms
Zinc (Zn)	Zn^{++}	Zinc is believed to be concerned in the formation of some growth hormones and in reproduction processes of certain plants. The element also functions in enzyme systems for important reactions in plant metabolism.	Generalized leaf spots which rapidly enlarge involving areas between veins and eventually involving secondary and even primary veins. The leaves are thick and the stalks have shortened internodes.
Manganese (Mn)	Mn^{++}	This element functions in enzyme systems which are necessary for important reactions in plant metabolism. The element is also essential for certain nitrogen transformations in plants.	Spots of dead tissue are scattered over the leaf. The smallest veins tend to remain green producing a checkered effect.
Molybdenum (Mo)	Mo_4^-	Acts as an electron carrier in enzyme systems which bring about oxidation reduction reactions in plants. Oxidation reduction reactions are essential to plant development and reproduction and do not take place in the absence of micronutrients. The element is also essential to certain nitrogen transformations in plants.	

The trace elements or micro-nutrients are most likely to be deficient in

1. Highly leached acid soils

2. Muck soils

3. Soils which have been intensively cropped and fertilized with only primary nutrients

4. Soils having a very high pH

If plant nutrient elements are to be available to plants, three basic conditions must be met.

1. The nutrient must be in a chemical form that the plant root can absorb.

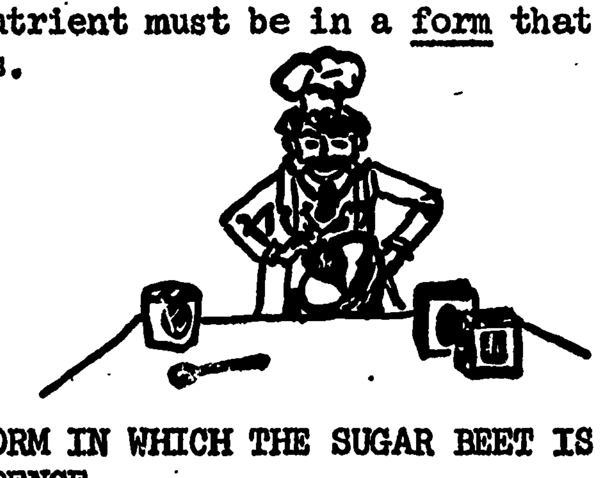
2. The nutrient must be in a position where it can be absorbed by the plant root.

3. The nutrient must occur in the soil in proper proportions.

Soil fertility then, does not depend only upon the <u>supply</u> of nutrients in the soil, but also upon the <u>form</u> in which the nutrients are found.

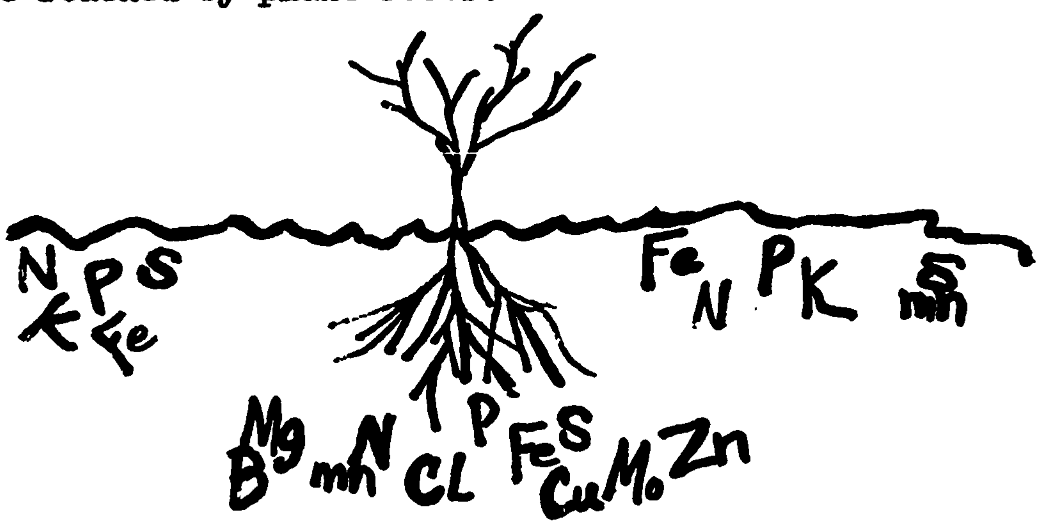
Getting the nutrient into the proper form for plant use is somewhat like processing and refining sugar cane or sugar beets into a clean, white, granular material before using the sugar in making items of food. If the recipe for your favorite cake icing calls for two cups of sugar, no one would throw in a stalk of sugar cane or a sugar beet in order to supply the sugar in the recipe. The sugar cane and beets are simply not in a form that can be used in making cake icing.

1. The nutrient must be in a <u>form</u> that can be used by plants.



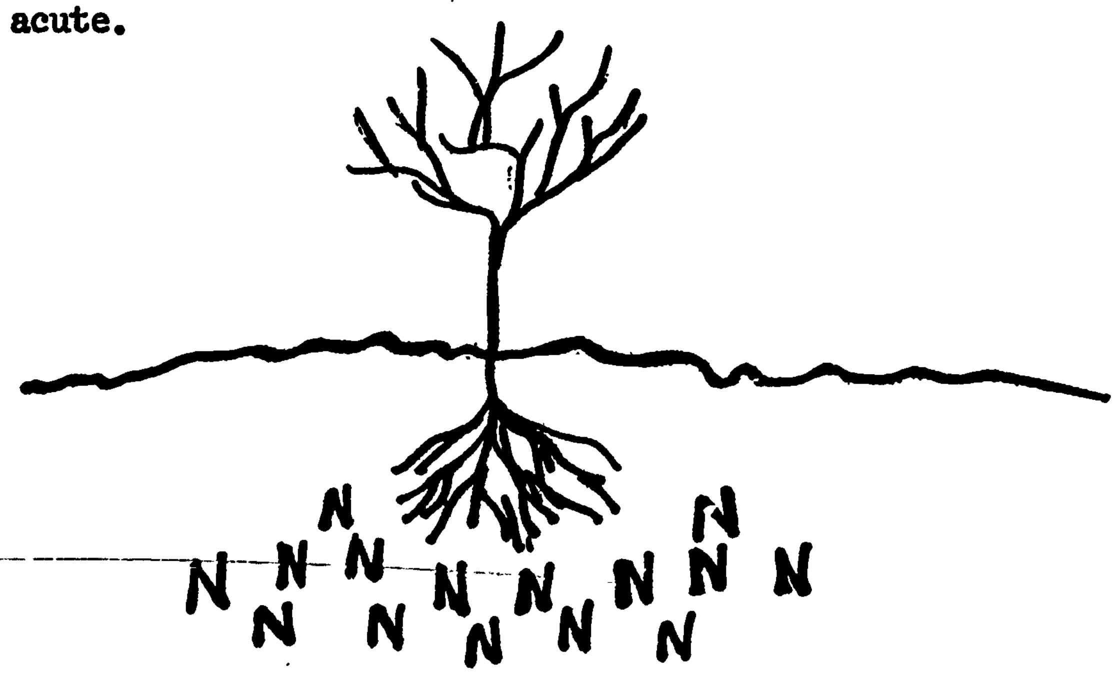
THE FORM IN WHICH THE SUGAR BEET IS IN DOES MAKE A DIFFERENCE.

2. The nutrients must be in a position where they can be reached by plant roots.



I CAN'T REACH YOU.

3. The nutrients must be found in the proper <u>proportion</u>. Plants, like humans and animals, need not only enough food, but a balanced diet if they are to make healthy growth. When any one of the plant food elements is not available to the plant in sufficient quantity, growth is affected whether or not the deficiency is acute.

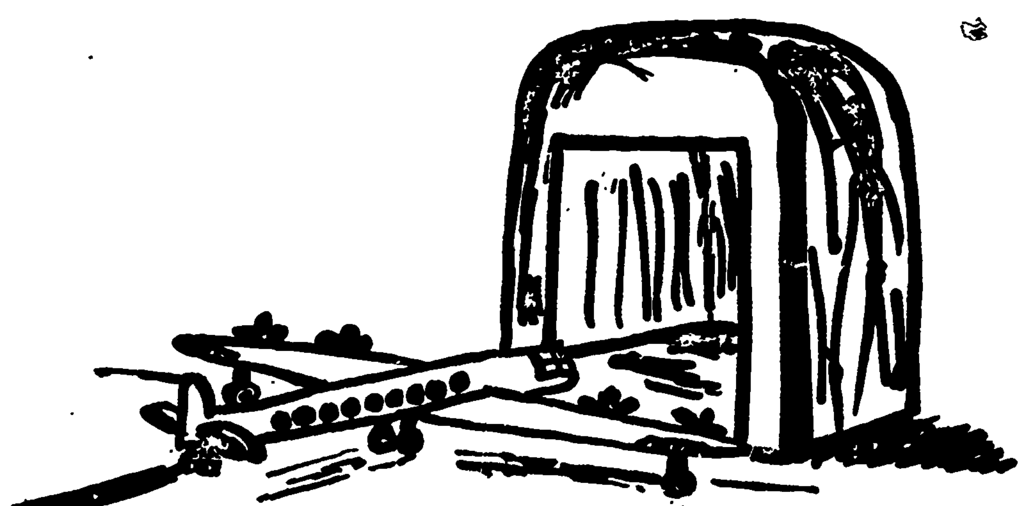


CAN'T I HAVE SOMETHING BESIDES NITROGEN?

4. Sometimes materials are not in the form that can be used and, therefore, must be changed into other forms if they are to be useful for plant growth. Examples of this are shown on the following page.

Name of Material	Intended Use	Change that Must Be Made to Make This Material Useful
Ores of metals	Manufactured products	Smelting, refining
Crude Oil	Fuel, manufactured products	Fractional distillation, refining
Apple pie	Sustain living cells	Digestion
Ice cream cone	Sustain living cells	Digestion
Timber	Lumber	Sawing, milling
Plant nutrients	Availability for food manufacture and synthesis	Oxidation, soil reaction adjustment

Whether soils are acid or basic determine whether or not the plant nutrients are in a form which can be used by plants.



The Hanger does not have the Right Form to Accommodate the Plane.

This class demonstration may be helpful in understanding soil reaction.

Materials required

1. Weak acid (acetic, hydrochloric, sulfuric)
2. Weak base (sodium hydroxide)
3. Water
4. Red litmus paper
5. Blue litmus paper

Procedure

Using forceps, place a piece of blue litmus paper first in the base and then in the acid. Now place a piece of red litmus first in the base, and then in acid. Finally, place pieces of both red and blue litmus in the water.

This demonstration will provide the following:

1. Materials may be acid, basic, (alkaline) or neutral. This is true of soil.

2. The term "soil reaction" is used to refer to whether the soil is acid, basic, or neutral.

3. Whether a soil is acid, neutral, or basic affects whether nutrients will be available or unavailable for plant use. Chemistry may be too complicated to be discussed here.

4. Plants differ in their tolerances to acid and alkaline conditions of the soil.

5. Litmus paper is not used to determine whether or not a soil is acid, neutral, or basic. This test would not indicate how acid or how basic the soil is. It is very important to know the exact soil reaction in order to add the proper materials to make the soil reaction correct for plant growth.

6. There are better tests than red and blue litmus paper for determining whether a soil is acid, basic, or neutral.

The exactness of soil acidity is measured by the pH scale on the following page.

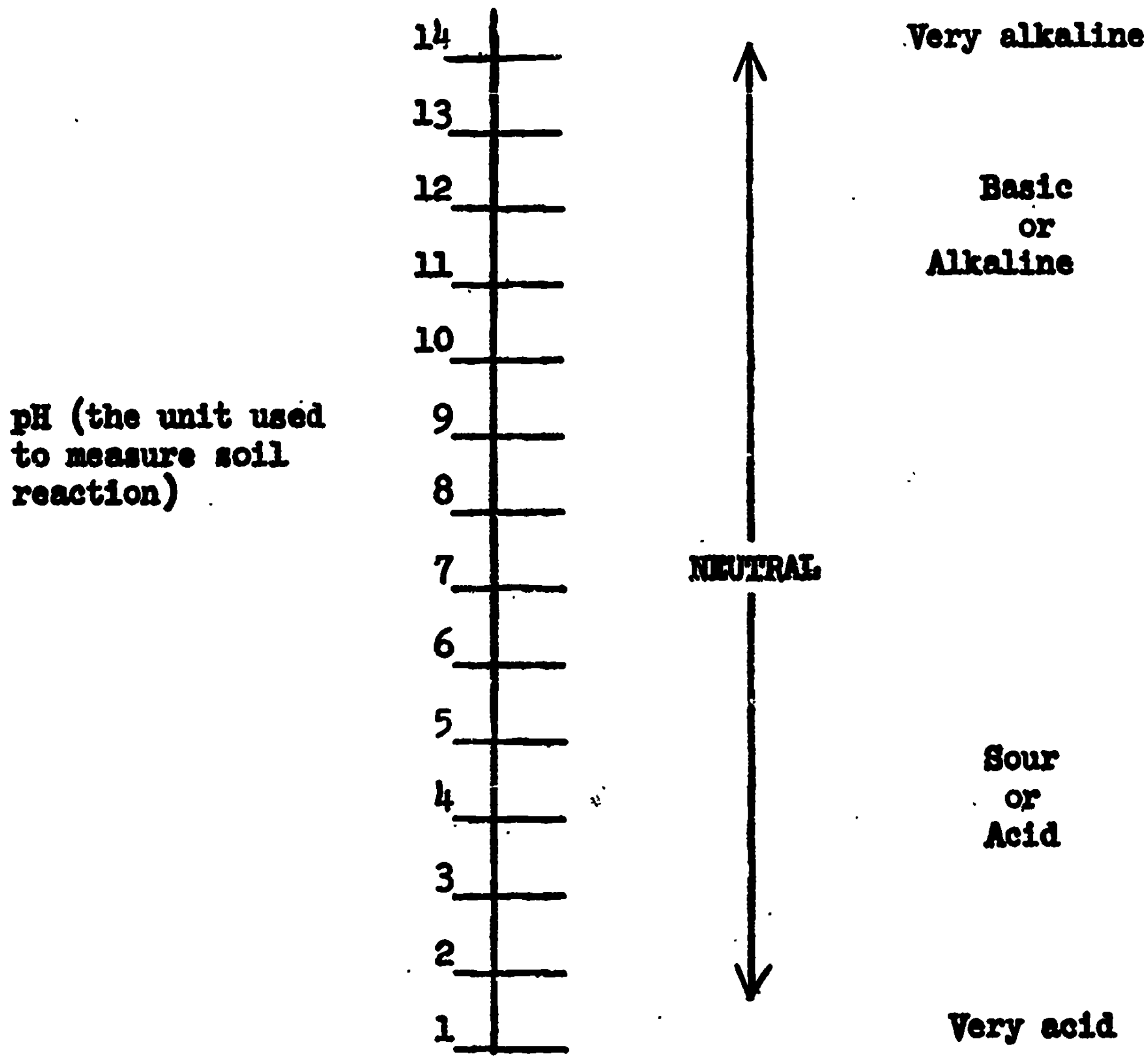
1. On the scale, pH 7 is the neutral point. This means that a material having a pH of 7 is neither acid nor basic (alkaline).

2. A soil or other material having a pH of any number below 7 is said to be acid.

pH 5.0 - 5.5	Strongly acid
pH 5.6 - 6.0	Moderately acid
pH 6.0 - 6.9	Slightly acid

As the numbers below 7 get smaller, that soil or other material is becoming more acid.

FIGURE I



3. A soil or other material having a pH of any number above 7 is said to be basic or alkaline. As the numbers above 7 get larger, it is indicated that a soil or other material is becoming more basic in reaction.

4. A soil of pH 5 is ten times more acid than a soil of pH 6. A soil of pH 4 is 100 times more acid than a soil of pH 6. A soil of pH 10 is 100 times more alkaline than a soil of pH 8.

The pH to maintain in the soil depends to a large extent on the crop to be grown.

1. Examples: Ericaceous plants such as rhododendrons, azaleas, gardenias, camellias, cranberries, and blueberries require a low pH (4.5 to 6.0).

2. A low pH is often helpful in controlling soil-borne diseases, such as Theilaviopsis in poinsettias and scab in potato.

3. The color of the bloom of the hydrangea is affected by pH. A pink bloom is associated with an absence of aluminum in the soil, combined with a soil pH of 6.5. A blue bloom is obtained by maintaining a soil pH of 6.5 and using fertilizers containing only nitrogen and potassium.

4. In general, most horticultural plants do well with a pH of between 6.0 and 6.5.

Maintaining Soil Fertility with Fertilizers and Lime

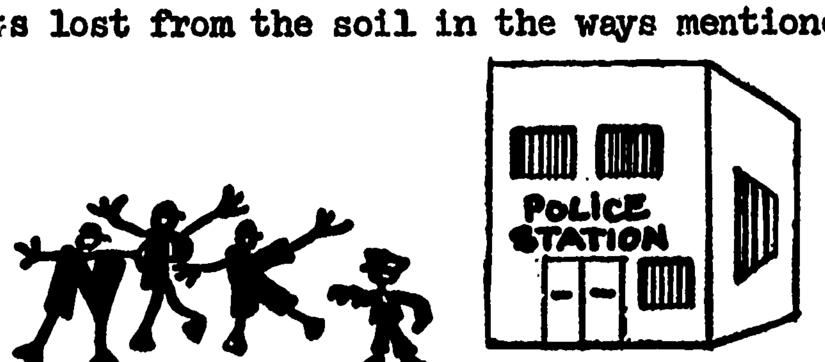
Often our valuable soil is taken for granted. To many, the soil represents an exhaustible storehouse of plant nutrients, which will continue to produce beautiful lawns, flowers, trees, and shrubs year after year with little or no attention. Such is not the case. Plant nutrients are removed from the soil in several ways:

1. Erosion - Top soil high in plant nutrients is carried from the land by wind and water.

2. Crop removal - Raking grass from lawn clippings and burning it is an example of this.

3. Leaching - Drainage water moving through the soil dissolves and carries away many plant nutrients.

This means that nutrients must be added to the soil to replace nutrients lost from the soil in the ways mentioned above.



HELP--WE'RE LOST!

The following may be useful in dealing with fertilizers.

You know as I was driving to school this morning, I drove over a real long bridge over a real deep river and I began wondering what would happen to me if this bridge would collapse. Then I began to think, "Gee whiz, I am glad that this bridge was strongly built." You know, if we are going to build good bridges, or houses, or factories, or sky-scraper buildings, we need good building materials.

Remember the story of the three little pigs? How---

One built his house of straw - - -

One built his house of sticks - - -

One built his house of bricks

Which one is the better house? Why?

If we aren't careful, we can "build" or grow plants that are like the houses that were built of straw and sticks. They will not hold up when we need them...they fail to meet our standards of producing good plants.

When we try to grow a plant without enough fertilizer of the right kind, we get a poor plant. The plant, like the sky-scraper building, needs a strong foundation if it is to survive and be valuable to us.

Let's see what it takes to make a good house and compare it with what it takes to grow a good plant.

The Good House	The Good Plant
A good plan	A good soil
A good carpenter	A good grower
Good materials	Good seed or cuttings and good environmental conditions, (fertilizer, for example)
Skill in putting all the parts together	Skill in combining the factors of plant growth
The result - a good house	The result - a good plant

Fertilizer is a substance which contains one or more of the chemical plant food elements in forms that, when in solution, can be absorbed by plants. These elements promote the growth of plants.

This may be helpful in your teaching.

How many of you have ever gone hunting? (look for hands) What did you use as a weapon? (gun) What did you use for ammunition? (shells) How do you buy shells? (by the box) How did you know how many you were buying? (display a box of shotgun shells) It gives the number on the box. (Point this out to the class)

Hold up a small bag or box of fertilizer. How do we know what we are buying? It tells us on the bag (box).

On a box of shells it says--25 shells. On the fertilizer bag it doesn't say 25 shells, but it reads--4-12-4. What does this mean? Does anyone know? Would you like to find out? What can we do to find out more about "What's in the bag"?

Display a large empty fertilizer bag with the number of the analysis quite prominently pointed out. The numbers on this bag will provide the following:

1. The numbers refer to the amount of the major plant nutrients; nitrogen, phosphorus, and potassium, which are present in the bag.

2. The numbers refer to the percent of each ingredient present in the bag. Percent refers to the number of parts per one hundred parts.

3. The numbers are called fertilizer analysis.

4. The order of the numbers is significant. The first number in the sequence always indicates the percent of available nitrogen in the container. The second number always indicates the percent of available phosphoric fertilizer, while the third number always indicates the percent of potassium (expressed as potash) present in the container.

5. The bag contains something else besides plant nutrients. This extra material is known as filler. Law requires the fertilizer analysis to be on all bags to inform the buyer of what is being purchased in terms of actual plant nutrients.

Example:

An eighty pound bag of fertilizer has an analysis of 10-6-4. Determine the amounts of the following materials found in the bag:

1. Nitrogen (N)

2. Phosphorus (P_2O_5)

3. Potassium (K_2o)

4. Filler

Steps in solving the problem (It will be necessary for the teacher to go into great detail here.)

1. Convert the numbers in the analysis to decimals by moving the decimal point two places to the left in each number.

2. Multiply the weight of the bag by the first decimal. The answer is in pounds. This gives the amount of nitrogen in the bag.

3. Multiply the weight of the bag by the second decimal. Again the answer is in pounds. This gives the amount of phosphate fertilizer in the bag (as P_2O_5).

4. Multiply the weight of the bag by the third decimal. The answer is in pounds. This gives the amount of potassium fertilizer in the bag (as potash, K_2O).

5. Add the weights of the nitrogen, phosphorus, and potassium together. Subtract this number from the weight of the contents of the bag. This gives the pounds of filler in the bag.

Changing the percent to a decimal

10	-	6	-	4
10%		6%		4%
.10.		.06.		.04.
.10		.06		.04

Calculating the amount of nitrogen

```
   80 pounds
 X .10 percent of nitrogen
  8.00 pounds nitrogen
```

Calculating the amount of phosphorus

```
   80 pounds
 X .06 percent of phosphorus
  4.80 pounds phosphorus (P2O5)
```

Calculating the amount of potassium

```
   80 pounds
 X .04 percent of potassium
  3.20 pounds potassium (K2O)
```

Total nitrogen, phosphorus, and potassium in the bag

```
    8.0 pounds nitrogen
    4.8 pounds phosphorus
 +  3.2 pounds potassium
   16.0 pounds nitrogen, phosphorus, and potassium in the
          80 pound bag of fertilizer
```

Determining the amount of filler

```
   80 pounds
  -16 pounds
   64 pounds of filler
```

Check your work by adding the amount of fertilizer and filler together.

```
    8.0 pounds nitrogen
    4.8 pounds phosphorus (P2O5)
    3.2 pounds potassium (K2O)
 + 64.0 pounds filler
   80.0 pounds fertilizer elements and filler
```

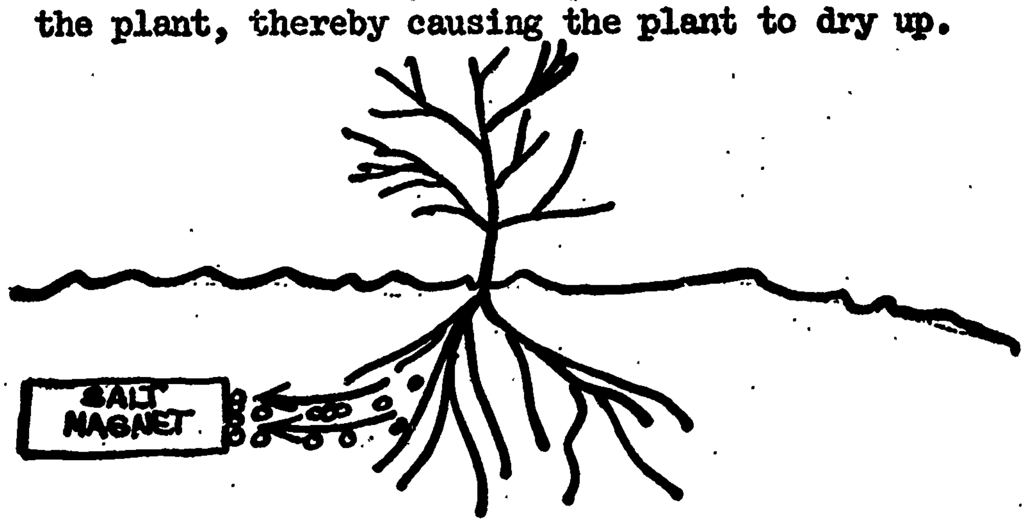
Use fertilizers for promoting plant growth.

Some believe that if one teaspoon of fertilizer per flower pot will do the plants lots of good, then three teaspoons of fertilizer should do the plant three times as much good. It is very easy to use too much fertilizer for good plant growth.

DON'T BE CAUGHT IN THE TRAP

How can too much fertilizer be harmful to plants? The following example may be useful.

> To understand why too much fertilizer is harmful to plants, let us think about the medical practice of soaking a sore finger in epsom salts to help draw out excessive and undesirable fluids, thereby reducing the soreness. The fluids are drawn out of the sore finger and into the surrounding water due to the presence of the large amount of salt in the water. Just how the salt does this is too complicated for us to explain here, but too much fertilizer in the soil acts like the salt in the water by drawing water out of the roots of the plant, thereby causing the plant to dry up.



TOO MUCH FERTILIZER IN THE SOIL ACTS AS A MAGNET TO DRAW WATER OUT OF THE PLANT.

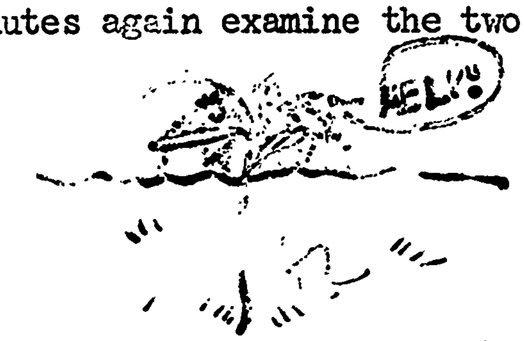
A class demonstration to show the effect of a strong salt solution on a potato

Materials required

1. Two identical glasses of water
2. Heaping tablespoon full of table salt
3. Two slices of potato as might be prepared for french frying
4. Stirring rod

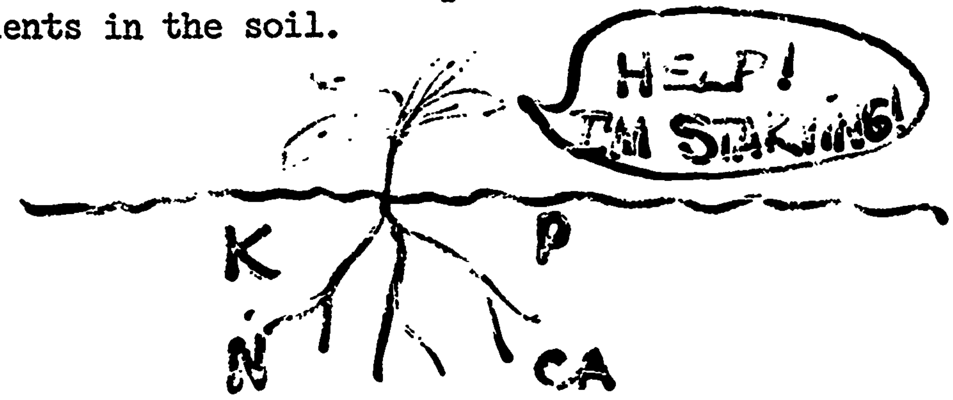
Procedure

Allow the class members to observe the firm, turgid condition of the potato slices. Place the tablespoon full of salt in one of the glasses of water and stir. Now place one slice of potato in each glass and after fifteen or twenty minutes again examine the two potato slices.



REMEMBER--BE CAREFUL ABOUT HEAPING THE FERTILIZER ON THE SOIL.

Just as it is possible to use too much fertilizer for plants, it is also possible not to use enough fertilizer. In this case, poor growth results because the plants do not have enough available nutrients in the soil.



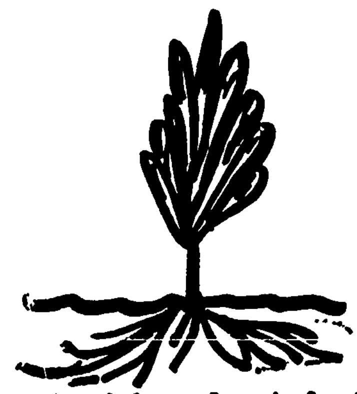
How do we know how much fertilizer to use in the soil? We can determine how much fertilizer to use in the soil by:

1. Testing the soil
2. Making plant tissue tests
3. Observing deficiency symptoms in plants
4. Doing field plot experiments

For a full report on the fertilizer needs of the soil, the soil should be properly sampled and forwarded to a well-equipped soil testing laboratory. Many of the modern laboratories also test plant materials by grinding up the leaves and determining whether or not the various nutrient elements are accumulating in the plant. If the nutrient is found to be accumulating, it is assumed that the nutrient is in sufficient supply in the soil. If the nutrient is not accumulating in the plant, then it is assumed that the soil supply of this nutrient needs to be increased.

This little plant had too much fertilizer.

This little plant didn't have enough fertilizer.



This big plant had just the right amount of fertilizer.

In using fertilizers remember the story of Goldilocks and the Three Bears. Not too much, not too little, but just the right amount of fertilizer should be our goal in plant growing.

It is easier to over-fertilize soils with a high-analysis fertilizer than it is with a low-analysis fertilizer.

Some fertilizers harm seeds and foliage if the material is placed in direct contact with them. Inorganic fertilizers harm plant foliage more than organic fertilizers. Often organic fertilizers are called non-burning fertilizers.

If you are to avoid harming seeds and foliage with fertilizers:

DO

1. Fertilize just before a rain. (Lawns for example)

2. Place the fertilizer below and to the side of the seed.

3. Mix fertilizer materials thoroughly in the soil before planting.

DO NOT

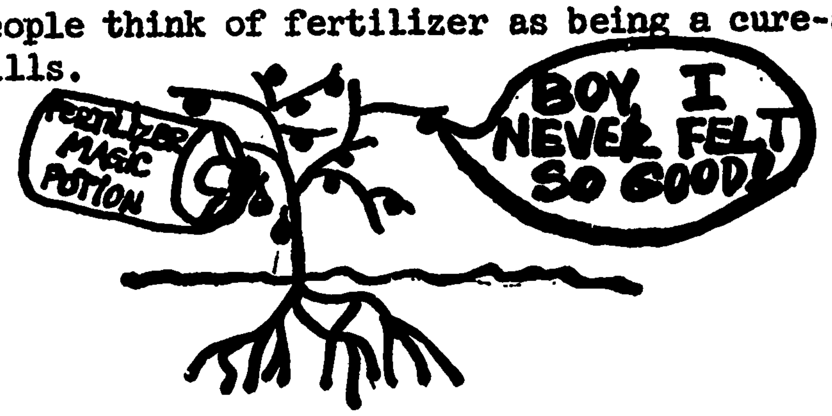
1. Apply dry fertilizers (particularly inorganic fertilizers) when the foliage is wet.

2. Plant seeds directly on a band or layer of fertilizer.

3. Spill the container of fertilizer contents and fail to remove the material from the foliage by scattering or leaching. (Many times lawn spreaders are filled on the lawn and spillage is not properly cared for. It is best to fill the spreader on the sidewalk.)

DON'T BE CAUGHT IN ANOTHER TRAP!

Many people think of fertilizer as being a cure-all for all plant ills.



Fertilizer is a valuable material for promoting plant growth, but there are many things it will not do, such as--

1. Correcting or improving a soil structure which does not allow good aeration or drainage

2. Adjusting an unsuitable soil reaction. There may be plenty of nutrients in the soil, but they may be unavailable to plants due to a high acid or alkaline condition.

3. Compensating for poor seed or plants

Many people were disappointed with the elixirs of the medicine man. They didn't cure their corns, help their rheumatism, or stop hangnails.

Don't be unnecessarily disappointed with the results of fertilizer. Realize that while there are many things fertilizer can do for plants, there are many other things that it can't do in promoting good plant growth. Fertilizer will do more good for the plants if they are kept free of weeds. For which plants is the fertilizer intended?

Fertilizers can be applied to the soils of the greenhouse or the landscape as--

1. Liquid fertilizers

    a. Hozon proportioners or fertilizer injectors (foliar or basal application)

    b. Applied in water solution with a sprinkling can (foliar application)

    c. Applied as a water solution around the base of the plant

2. Dry fertilizers

    a. Broadcast over the soil surface by means of a spreader

    b. Broadcast over the soil surface by hand (for small quantities). This is not the most accurate method of applying fertilizer, however.

    c. Deep drilling

    d. Side dressing

    e. Banding along the row

Adjusting Soil Reaction

The students should know that--

1. Soil reaction adjustments can only be made on the basis of good soil tests. The amount of material required depends upon

soil type	current soil pH
organic matter content	fineness of the material used

2. Crops thrive best when the pH is right.

3. Excessive soil acidity is basically corrected by using lime.

4. Excessive soil alkalinity is basically corrected by using sulfur compounds.

5. The pH value of most soils falls in the range of 4.0 to 8.0.

6. Most crops grow and produce best on slightly acid or neutral soils.

7. Liming not only corrects soil acidity, but adds a supply of calcium and magnesium nutrients to the soil.

8. For each crop, there is a pH range at which the crop makes the best growth.

9. The soil reaction is important from the standpoint of nutrient availability, disease control, activity of soil organisms, and nutrient toxicity.

10. Lime should be used in conjunction with fertilizers to produce better crops.

Suggested Teaching-Learning Activities

In developing this competency, the teacher will need to be quite careful not to make the material too complex for the students. Remember they don't have the background and vocabulary that the teacher has.

1. Introduce the competency. (See content for suggested introductory material.) The teacher will undoubtedly be confronted with the task of motivating the students to want to study a subject (soils) which many high school students may consider boring, and quite uninteresting.

2. Illustrate the results of using both good and poor soils for growing plants by using suggested fertility demonstrations and experiments. The results of such activities can be quite convincing. The teacher may allow the students to do experiments of this type. (See U.S.D.A. Publication, PA-341, Page 21 for an example.)

3. Adapt much of the content of this module to a comic-type student reference book if a student reference is desired.

4. Show colored slides, including pictures of plants having the various nutrient deficiencies.

5. Display the various fertilizer and liming materials. Encourage the students to examine these materials and answer any questions which they may have.

6. Show the films "Making the Most of a Miracle," "What's in the Bag?" and "The Big Test". These films are available from the National Plant Food Institute.

7. Secure different sized containers of the various fertilizer materials. Direct student attention to the numbers on the bag. Point out that all fertilizer containers have these numbers. Using a step by step procedure, show the students what the numbers are for and how they can be used. (See the content for suggestions in presenting this material.)

8. Take a field trip to a fertilizer plant.

9. Demonstrate the use of the hozon proportioner or fertilizer injector, or both.

10. Demonstrate how to prepare and use starter solutions and foliar applied fertilizers.

11. Provide instruction in procedures for sampling the soil for testing. Take soil samples from the school site to the soil testing laboratory for testing, and discuss the results of the test with the class.

12. Suggested time for developing the competency

Classroom teaching	5 hours
Laboratory activity	15 hours
Occupational experience	5 hours
Total time	25 hours

<u>Suggested Occupational Experience</u>

1. Demonstrate and have the students fertilize the school lawn and landscape plantings, using both granular and liquid fertilizers.

2. Have the students use lawn spreaders to apply lime and fertilizers to the soil at home (if possible) and for their neighbors.

VII. To understand the effect of the various soil organisms on plant growth in order that helpful organisms might be conserved and the harmful organisms controlled

Teacher Preparation

Subject Matter Content

This competency might be introduced in the following way.

Illustrate that:

Some Things Are Helpful	Some Things Are Harmful
1. An umbrella on a rainy day	1. Germs
2. A spare tire	2. Enemy spies
3. A pay check	3. Overdoses of medicines
4. Some living things in the soil	4. Some living things in the soil

Soil Organisms

Soils are composed of broken and weathered rocks, organic matter, water, and air. This material serves as a home for many kinds of plant and animal life. These plants and animals are both large and small in size. Some of these plants and animals are even so small that a microscope must be used to see them. The small plant life in the soil may be bacteria, fungi, or algae. The small animals in the soil include one-celled animals, and tiny, round worms called nematodes. The larger animals in the soil include worms, ants, snails, spiders, and insects. Some of these animals, especially the earthworms, help to make the soil better by burrowing through the soil, mixing it and making it possible for water and air to move easily through the soil. Also, some of the organisms in the soil are able to take nitrogen from the air and change it into a form that plant roots can absorb. Other organisms in the soil are not so helpful and actually do harm to plants by eating parts of the plant and causing various plant diseases.

Soil organisms make up about 1/1000 of the weight of an acre foot of soil. The living things in the soil use soil minerals for living activities. The minerals available to the plant then, are those that remain after the soil organisms have consumed a certain quantity for their life processes.

Table 1

The Average Weight of Soil Organisms in an Acre-Foot of Fertile Soil*

Organism	Low (lbs./acre-foot)	High (lbs./acre-foot)
Bacteria	500	1,000
Fungi	1,500	2,000
Actinomycetes	800	1,500
Protozoa	200	400
Algae	200	300
Nematodes	25	50
Other worms and insects	800	1,000
Total	4,025	6,250

*Source: Allen, Experiments in Soil Bacteriology, Burgess, Minneapolis, 1957.

Table 2

The Significance of Soil Organisms

Organism	Major Activity	Beneficial to Plant Growth	Harmful to Plant Growth
Earthworm	Mixes soil. Increases the availability of plant nutrients. (Especially nitrogen) Increases aeration. Promotes drainage.	X	
Nematode	Penetrates plant tissue, especially roots, and causes extensive damage.		X Only about 50 of the thousands of nematodes are harmful to plants.

Table 2 continued

Organism	Major Activity	Beneficial to Plant Growth	Harmful to Plant Growth
Protozoan	Feeds on soil bacteria. Contributes to the organic content of the soil.		X (if the bacteria fed upon are important in the production of available plant nutrients)
Algae	Aid bacteria and fungi in the decomposition of plant tissue, in making nutrients available to plants, and in the synthesis of humus.	X	
Fungi	Decompose organic residues. Promote the formation of humus. Cause many plant diseases.	X	X
Actinomycetes	Decompose organic matter releasing plant nutrients, especially nitrogen. Cause plant disease.	X	X
Bacteria	Decompose organic matter releasing plant nutrients; convert nitrogen from the air into a form available to plants (only certain bacteria are able to do this). Cause many plant diseases.	X	X

A demonstration may be used to stimulate interest in the activities and influences of soil organisms on plant growth as well as show how much life there is in the soil.

Materials required

1. One long-stemmed funnel

2. Twelve-inch length of rubber tubing

3. One hose clamp

4. One 250 ml. beaker

5. One six-inch square piece of screen wire

6. Tissue paper

7. Water

8. Field soil (not sterilized)

Procedure

Attach the rubber tube to the funnel stem and clamp it off. Shape and fit some screen wire to the funnel. Line the screen with wettable strength tissue. Remove the screen and tissue from the funnel and fill the funnel with water. Place the field soil sample in the screen wire and gently place in the water of the funnel. After a few hours, drain off a few cubic centimeters water and examine with a compound microscope.

The soil organisms which are beneficial to plant growth can be encouraged by adding organic matter, lime, and moisture to the soil.

The soil organisms harmful to plants need to be controlled. It has been estimated that the yearly loss in farm crops in the United States is five billion dollars. The cost of pesticides and required application equipment amounts to almost $350 million a year. A considerable amount of these expenditures is used to control harmful soil organisms.

Basically, there are three ways to control soil organisms which are harmful to seeds and plants. They are:

1. Soil sterilization with steam

2. Soil fumigation or drenching with chemicals

3. Seed treatment

Steam Sterilization
(more correctly, Pasteurizing)

This control measure is highly effective and is widely used in the greenhouse for controlling the various soil-borne pests. Steam sterilization is also used to some extent in outdoor areas and for steaming bulk soils prior to use in growing plants.

Why are soils steamed?

1. To kill soil-borne insects
2. To kill all of the bacteria, fungi, and virus organisms that are harmful to commercial crops
3. To destroy weeds
4. To promote soil granulation

Sources of steam:

1. Existing steam boilers
2. Portable oil-fired steam boilers
3. Package steamers
4. Bricked in permanent-type boilers

Preparing the soil for steaming:

1. Add humus or organic matter.
2. Water the soil lightly. Soil that is too dry will heat up slowly because of poor heat conduction and distribution. Soil that is too wet will also heat up slowly because it requires considerable heat to heat a large quantity of water.
3. Keep the soil moist a week prior to steaming so as to encourage weed seed germination. This will make the weeds easier to kill.
4. Rototill or otherwise loosen the soil. Be sure all soil is loosened and that all lumps are broken up.

5. Unroll the canvas steaming hose down the length of the bench if soil in raised benches is being sterilized. (Ground beds may have buried tile for steaming purposes.)

6. Cover the bench with a suitable cover. The cover may be draped over the bench, weighted down with pipe or held in place with "C" clamps.

The soil should be steamed at 180° F. for thirty minutes after a temperature of 180° F. is reached.

Table 3

Killing Time for Various Soil Organisms When Using Steam Sterilization

Organism	Time to Kill	Temperature
Nematodes	Instantly	140°F.
Soil Insects	Instantly	140°F.
Soil Fungi	10 minutes	140-160°F.
Soil Bacteria	10 minutes	140-160°F.
Weed Seeds	10 minutes	140-160°F.
Soil Virus	30 minutes	180°F.

The soil temperature during steaming is registered on a soil thermometer.

After steaming, it is often found that there are other problems which could develop.

1. Nitrifying and other beneficial soil organisms are killed.

2. Ammonia build-up in the soil which may cause root burn.

Solving after-steaming problems (Reference-Ball Red Book p. 42)

1. Use high quality, long lasting kinds of peat such as German or Canadian sphagnum peats or other forms of organic matter that break down slowly.

2. Avoid sterilizing in hot weather.

3. Discontinue feeding the previous crop after it shows color, and leach it during the last waterings.

4. Keep soils cultivated during critical periods to encourage air to enter the lower soil.

5. Keep soils medium dry when steaming; sterilizing wet soils encourages the build-up of ammonia.

6. Adding 4 pounds of gypsum or 40% superphosphate per 100 square feet of soil immediately after steaming seems to help tie up free ammonia.

7. Leach heavily after steaming.

Soil Fumigation

Situations under which chemicals are most extensively used for soil pasteurization:

1. Where overhead costs are so low that the time required for aeration is not expensive

2. If weeds and soil-borne insects are the main reasons for sterilizing

3. When steam boilers are not available for sterilizing

Chemical fumigants effective against fungi, bacteria, and nematodes are:

1. Chloropicrin (tear gas)
2. Methyl bromide
3. Mylone
4. Vapam or VPM
5. Vorlex
6. Trizone
7. Formaldehyde

Chemical fumigants effective against nematodes are:

1. Dichloropropene-dichloropropane mixtures

2. Ethylene di-bromide

Other fumigants include:

1. Bedrench

2. Zinophos

3. Trapex

4. Nemex

5. Brozone

Factors to consider in fumigating soil:

1. Soil temperature

2. Soil moisture

3. Soil texture

4. Organic matter content

5. Seals needed

6. Soil type

7. Depth of application

Methods and equipment for applying chemical fumigants

1. Tractor-mounted equipment which lays a plastic film and injects the fumigant under the plastic cover

2. Liquid water-miscible materials which are metered into sprinkler irrigation systems

3. Granules, liquids, and powders which can be worked into the soil from equipment mounted in front of a rototiller

4. Tractor-mounted chisel-tooth injection shanks can be used.

5. Materials in pressure cylinders can be released under plastic covers.

6. Hand-operated needle point injection guns can be used.

Plants should not be planted into a fumigant-treated soil for a period of two to three weeks.

Precautions to be observed in using soil fumigants:

1. Avoid inhaling the material.

2. Avoid contact of the fumigant with the skin.

3. Allow sufficient time for aeration after the material is applied.

Table 4

Advantages and Disadvantages of Steam and Chemical Soil Sterilization

Treatment	Advantages	Disadvantages
Steaming	A very effective job. Cost of treatment is less per acre than for chemicals. ($350-500 per acre)	High initial cost. Edges of benches and growing areas may not receive steam. After steaming, problems frequently occur.
Fumigation	Useful when a source of steam is not available. Gives good control of insects, weeds, and nematodes.	Cost of treatment per acre is high ($500-1,500 per acre). Not very effective against hard-to-kill organisms. A great deal of time is required for aeration after treatment.

Seed Treatment

Seed treatment is of three types:

1. Disinfestation

2. Disinfection

3. Seed protection

Protectants are materials which are applied to seeds to protect them from harmful organisms (mainly fungi) in the soil. The materials are applied as a soil drench either before or after seeding.

Suggested Teaching-Learning Activities

1. Introduce the competency area by allowing the class to examine soils for the presence of life. Demonstrating the presence of nematodes in the soil to the class may be quite helpful in making the students aware that some life in the soil is not readily visible to the unaided eye. Using group discussion, follow up the laboratory activity and develop a list of soil organisms found in the soil. Point out that some organisms living in the soil are large and some are small. Some organisms are beneficial and some are harmful to plants. Emphasize that just because organisms are small does not necessarily

mean that they are unimportant. Indeed, the small organisms of the soil are quite significant. Develop student understanding as to why soil sterilization is often essential to plant production.

2. Take the class on a field trip to a commercial greenhouse to observe steam sterilization practices. Direct attention to the equipment required and the way in which the equipment is used including step-by-step operating procedures.

3. Display and demonstrate the use of various soil fumigation equipment and materials. Stress the safety precautions which must be observed in fumigating soils.

4. Undertake a soil fumigation project in the school greenhouse or laboratory. Assign students to assist in the application of fumigation materials. The hozon proportioner can be quite useful in applying soil fumigants by the irrigation method.

5. Treat a lawn area for grub control.

6. Display, demonstrate its use, and allow the students to examine a soil thermometer.

7. Set up a controlled experiment in which plants are grown in sterilized and unsterilized field soil.

8. Examine actual specimens and pictures of plant damage caused by soil organisms.

9. Suggested time for developing this competency

Classroom teaching	4 hours
Laboratory activity	7 hours
Occupational experience	8 hours
Total time	19 hours

<u>Suggested Instructional Materials and References</u>

Instructional Materials

1. Soil fumigation materials and application equipment

2. Microscope

3. Seed protectants

References

1. Ball Red Book, 1960. pp. 30-51.

2. U.S.D.A. Farmer's Bulletin No. 2048, "Controlling Nematodes in the Home Garden."

3. Pictures and specimens of soil organisms and resulting damage

Suggested Occupational Experience

The students should have occupational experience either on a full-time or part-time basis in a commercial greenhouse during the periods when the soil is sterilized.

VIII. To learn how to control soil erosion in the landscape.

Teacher Preparation

Subject Matter Content

A suggested introduction to the competency

If we are not careful some things can get away from us. Examples of this include:

1. A fish on the end of a loose line

2. A gas-filled balloon that is loosely held

3. Cookies in a cookie jar

4. A horse with a defective bridle

5. An ice cream cone on a hot day

6. A wet bar of soap

and

Unprotected soils

The soil is the natural resource in which plants are grown.

These plants provide food, fiber, fuel, shelter, medicine, and beauty to man. Certainly soil is of utmost importance to the horticulturist. The horticulturist is more concerned about erosion in the landscape than in the greenhouse, although some erosion could occur in the greenhouse if watering equipment was improperly used.

In many areas of our nation, countless tons of good, fertile top soil which was capable of growing valuable plants, have been or are being lost because of a process known as erosion.

Pictures reveal the extent and damage of erosion.

Personal observation on trips reveals the harmful effects of erosion.

Poor plants and crops are dramatic and economic evidence of the harmful effects of erosion.

Erosion is the wearing away of the earth's surface by water, wind, and ice.

Some characteristics of erosion are:

1. It goes on all the time.

2. It may occur anywhere there is enough rain to cause runoff or where land is flooded by irrigation, snow melt, or other causes.

3. It is most harmful in areas where the soil is unprotected due to lack of plant cover.

4. It can remove in a few years, or in some cases, in a few hours, the surface soil that took hundreds of thousands of years to form.

5. It damages some soils more than others.

Soil erosion by water happens in three steps.

1. The soil particles are loosened either by the impact of raindrops or by the scouring action of runoff.

2. Loosened soil particles are moved by running water.

3. The transported particles are deposited in new locations.

There are three basic types of water erosion.

1. Sheet--
   Soil is removed more or less uniformly from every part of the slope.

2. Rill--
   Rapidly moving water scours out channels that join farther down the slope.

3. Gully--
   Rills join to form channels where runoff water concentrates and moves down a slope with increasing scouring action. A sudden drop in the channel increases the cutting action of the water and channels result that are so deep that they cannot be smoothed out by ordinary cultivation methods. These deep channels are called gullies.

Gullies can be stopped in several ways.

1. Use grass-sodded dams such as reed canary grass dams. Sod is placed across the bottom of the gully at intervals of 12 to 18 inches.

2. Plow the gully, shape a waterway and sow it to a "permanent" grass. Use a plowed diversion ditch to protect a waterway while working and seeding.

3. Use weir notch dams.

4. Use sod flumes.

5. Bulldoze the gully in to form gentle slopes and seed or sod the whole area.

6. Use a dam with a drop inlet.

7. Use concrete dams

8. Use cub dams

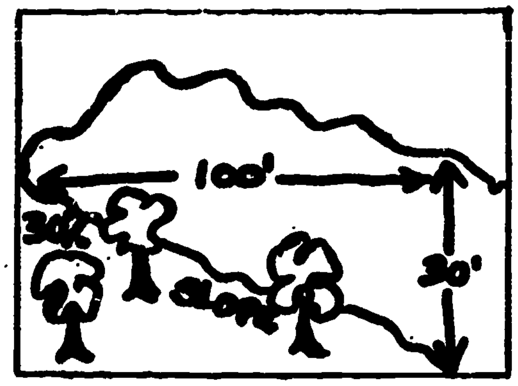
9. Use log or plank check dams

10. Use wire check dams

11. Use flow line staking

12. Use strip matting.

For more information on erosion control structures see Chapter 7 in the Grounds Maintenance Handbook.



Slope affects the speed of water running off the land and the amount of soil carried by the water. Percent of slope is the number of feet of fall in each 100 feet of run.

Soil erosion by wind

1. This generally starts on poor cropland that has sparse vegetative cover or on good cropland that is improperly managed.

2. It tends to spread from field to field.

3. It proceeds as wind blown soil particles strike bare ground, loosening other particles which in turn become new erosive agents which cut off, smother, or expose existing vegetation and loosen additional soil particles. This cumulative effect resembles an atomic chain reaction.

Bennet and Pryor in their book, This Land We Defend, pages 35-36, have made the following estimate of the annual loss in dollars through erosion in the United States.

Soil material (plant nutrients)	$3,000,000,000
Reduced farm income and Forced abandonment of the land	400,000,000
Damage to irrigation and reservoirs	63,000,000
Damage to highways, railroads, navigable streams	309,000,000
Flood damage to city and farm property	72,000,000
Total	$3,844,000,000

Erosion control measures

1. Using vegetative cover on the soil

Grasses, shrubs, ground cover, and trees break the force of rainfall with their leaves and stems and hold the top soil in place with their roots.

This method is quite appropriate to the landscape horticulturist in preventing soil erosion. Examples of some effective ground cover plants:

Hedera helix - English ivy
Vinca minor - periwinkle or myrtle
Pachysandra terminalis - Japanese pachysandra
Euonymus fortunei Coloratus - Purple wintercreeper euonymus

Juniperus horizontalis - creeping juniper
There are many, many others.

The following demonstration may be helpful in showing the effect of vegetative cover on reducing soil loss by erosion.

Materials required

1. Two seed flats made waterproof by lining with plastic film, tin, or tar paper

2. Two half-gallon sprinkling cans

3. Two half-gallon, wide mouthed jars or other suitable containers

4. One four foot piece of 1" x 3" lumber

Procedure

Cut a 1" to $1\frac{1}{2}$" V notch at the center of one of the end boards of each seed flat. Fit each notch with a tin spout to draw runoff water into a container.

Cut a piece of sod to fit one of the flats. Trim the grass to a height of one inch.

Fill the other box with soil from the same area from which the sod was taken. The soil in this flat should have no vegetative cover.

Set the flats on a table so that the spouts extend over the edge. Place the 1" x 3" piece of lumber under the other end of the flats to provide slope.

Place the empty containers on stools beneath the spouts.

Fill the two sprinklers with water and pour the water on both boxes at the same time from a height of about one foot. Pour steadily and at the same rate for both boxes.

Summarizing the demonstration

The water flowing over the sod will be reasonably clear. It will take longer for the flow to start and it will continue to flow for a longer period of time.

There should be more water in the jar or container under the flat of bare soil than is in the container under the flat of sod.

This demonstration illustrates one of the most fundamental principles of soil and water conservation, that of the protection which grass gives soil against the pounding of raindrops and the movement of running water. The grass breaks the force of the raindrops so that the soil is not pounded and broken apart by the drop impact. The grass roots open up channels to let water get into the soil and the grass stems slow down the speed of the running water so that the soil is not disturbed.

The above demonstration is taken from U.S.D.A. Publication PA-341, pages 12 and 13.

2. Using good fertility programs

By replenishing the organic matter content of soils with soil conditioning materials such as manure and peat moss, and by replenishing the nutrient level with lime and fertilizer, plants with large root systems and luxuriant top growth can be produced which are highly effective in reducing soil erosion. This method of soil erosion control is quite appropriate to use by the landscape horticulturist.

The value of soil mulches in protecting soil from erosion can be shown by the following demonstration.

Materials required

1. Two seed flats of soil, the flats notched and filled with spouts as in the previous demonstration

2. Straw, sawdust, peanut hulls or other suitable mulching material

3. Two half-gallon sprinkling cans

4. One four foot piece of 1" x 3" lumber

Procedure

Set the flats on a table with the spouts extending over the edge, placing the piece of lumber under one end of the flats to provide a slope. Position the catch containers under the spouts of the flats.

Cover the soil surface of one flat with the selected mulching material. Leave the soil surface of the second flat bare. Sprinkle water on both flats using the same amount of water and pouring at the same rate from an equal height.

A variation of this demonstration would be to drop water from a short height on soil that is not protected and on a soil that is protected by a mulch.

The above demonstration was taken from U.S.D.A. Publication PA-341, pages 13 and 14.

4. Using contour cultivation practices

The value of contouring in preventing soil erosion on steep areas in the landscape can be shown by using the materials of the two previous demonstrations and modifying the procedure to include contouring rather than vegetative cover or mulches.

5. Using terraces and retaining walls

6. Using diversion ditches and sod waterways

7. Using shelter belts of trees

Specific examples or circumstances where the landscape maintenance personnel can apply knowledge concerning erosion control could be as follows.

1. Steep areas between sidewalks and buildings where it is not convenient to use lawn mowers call for the use of ground cover from both the standpoint of appearance and erosion control.

2. In establishing lawns, consideration of erosion hazards will influence the decision as to whether to seed or sod the area. There is also the possibility that diversion ditches or sod waterways will be required to handle the water on certain properties which may be seeded to lawn.

3. Many homes are situated on rolling topography and landscape practices must provide for erosion control.

4. Any bare soil areas in the landscape should be protected from erosion with mulch or ground covers.

5. Sidewalks, driveways and patios will become cluttered with mud if provisions are not made to control erosion in the areas immediately adjacent to these structures.

6. Steep areas in the landscape create hazards in attempting to carry out a maintenance program with powered equipment, especially when cut up by gullies.

As a thought-provoker the teacher may wish to use this actual incident with his class when discussing erosion control.

An Oklahoma paper published a picture of a dilapidated house and a washed away field and asked readers to tell what this meant to them. An Indian won with this:

"Picture show white man crazy. Make big tepee. Plow hill. Water wash. Wind blow soil. Grass all gone. Squaw gone. Papoose too. No pig. No corn. No hay. No cow. No pony.

Great Spirit make grass. Indian no plow land. Keep grass. Buffalo eat grass. Indian eat buffalo. Hide make tepee. Moccasins too. Indian no make terrace. No build dam. Indian no care. All time eat. No hunt job. No hitch-hike. No ask relief, no shoot pig. Indian no wants anything. Indian no work. White man heap crazy."

Suggested Teaching-Learning Activities

1. Introduce the competency area by using introductory material as given in the content, by using pictures or slides, or by taking a field trip to an area where the effects of erosion are pronounced. Develop a strong case for using control measures.

2. Give the class members specific situations in the landscape where they will need to use knowledge they have gained pertaining to erosion control methods.

3. Show one of the following films which are available from the Soil Conservation Service, U.S.D.A.:

   "Adventures of Junior Raindrop" (Color 8 min.)
   "Erosion" (B&W 8 min.)
   "Raindrops and Soil Erosion" (Color 21 min.)

4. Do the class demonstrations and discuss their implications and applications.

5. Have the students make a survey of the need for erosion control measures either at home, at a particular site in the community, or at the school site. The students should consider the following items in making this survey:

   a. Topography - How much slope does the land have?

   b. Vegetative cover - Is the soil covered with plants most of the time? Is the soil covered or protected during the winter months?

   c. Soil structure - Is the soil compacted and of poor structure allowing rainfall to soak in?

   d. Extent of top soil - Is there any evidence of sheet erosion? (Considerable gravel or pebbles on the soil surface, light colored, heavy soil)

   e. Drainage - Does the soil drain rapidly or slowly? Is it subjected to flooding?

   f. Tillage operations - Is the soil often cultivated or tilled to keep the soil loose?

6. Provide the students with opportunities to:

   a. Plant ground cover plants

   b. Stop rill and gully erosion

   c. Build retaining walls

   d. Make a terrace in a landscape planting

   e. Sod a steep area in the landscape

   f. Apply a mulching material to an unprotected soil area

   g. Seed a cover crop

   h. Determine the slope of the land using a land judging scorecard

   i. Determine the extent of soil erosion in different parts of the school site

7. Suggested time for developing the competency

Classroom teaching	3 hours
Laboratory activity	4 hours
Occupational experience	7 hours
Total time	14 hours

Suggested Instructional Materials and References

Instructional Materials

1. Two seed flats
2. Plastic film, tin, or tar paper
3. Two half-gallon sprinkling cans
4. Two half-gallon, wide-mouthed jars
5. One four foot piece of 1" x 3" lumber
6. Sod

7. Soil

8. Straw or other selected mulching material

9. Pictures or slides of eroded areas

10. Films

References

1. Conover, H.S. Grounds Maintenance Handbook, Chapter 7.

2. Successful Farmings Magazine's Soil Book, Section 4.

3. "That Land Down There," Agriculture Information Bulletin No. 255.

4. "Soil Erosion - The Work of Uncontrolled Water," Agriculture Information Bulletin 260.

5. "Teaching Soil and Water Conservation, A Classroom and Field Guide," U.S.D.A. Publication PA-341.

6. "Man and the Soil," International Harvester Company Booklet. Pages 31; 65-72.

7. U.S.D.A. 1957 Yearbook - Soils

8. U.S.D.A. 1955 Yearbook - Water

IX. To learn how to properly prepare the soil for planting.

Teacher Preparation

Subject Matter Content

Proper preparation is very important in many fields of activity.

A soldier should be properly prepared before being sent to battle.

A doctor needs to be properly prepared before performing surgery.

Food needs to be properly prepared before it is served.

Soils need to be properly prepared before they are planted.

The physical condition of a soil is referred to as tilth. Tilth is associated with such soil characteristics as structure, texture, water holding capacity, and aeration. Soils which are easy to work, promote good root growth, and contain abundant microorganisms are said to be in good tilth. Crusting and puddling are indications of poor tilth.

The physical condition of the soil is influenced primarily by the supply of organic matter present. Organic matter is called the life of the soil. The original source of soil organic matter is plant tissue. Animals are secondary sources of organic matter. Organic matter helps the soil hold water, thereby decreasing the amount of water that runs off. It improves aeration of the finer textured soils and makes the soil easier to work; it improves the soil tilth.

Organic matter then affects the condition of the soil in the following ways:

1. Stabilizes soil aggregates

2. Aids water holding capacity

3. Makes for a warmer soil

4. Adds nutrients to the soil

5. Helps make minerals available

6. Serves as a food material for such microorganisms as bacteria, fungi, and protozoa

Organic matter can be added to the soil by using:

1. Peat moss, compost or leaf mold and various other organic mulching materials

2. Green manure crops

The following demonstration may be helpful in learning about organic matter.

Materials required

1. Two wide mouth glass jars

2. Two three by ten inch pieces of one quarter inch hardware cloth

3. Lumps* of loam soil from a sod in a fence row

4. Lumps* of soil from a cultivated field that has been heavily farmed

5. Water

*The lumps of soil should be about one half as large as a baseball.

Procedure

Fashion the hardware cloth into baskets that will extend down into the jars. Fill the jars with water to within one inch of the top. Place the lumps of soil in the baskets and lower them gently into the jars. Record the results of the demonstration.

The soil from the heavily cultivated field will tend to fall apart and drop to the bottom of the jar while the loam soil in a fence row will tend to hold its shape and cling together.

The tilth of a soil is very important to good plant growth. A soil with good tilth will have good:

1. Aeration

2. Moisture holding capacity

3. Drainage

Soil tilth is related to soil structure and texture. In many types of soil, good tilth can be destroyed by over-working the soil or by working the soil when it is too wet.

The students should be able to recognize when soils have been overworked, worked when too wet, and underworked. Students should also have the ability to use practices which will improve soil tilth.

The following chart is taken from Janick's Book, Horticultural Science, (P. 183) and may be helpful in determining when soil is dry enough to work.

Degree of Moisture	Feel
Dry	Powder dry
Fair (usual time to irrigate)	Crumbly, will not form a ball
Good	Forms a ball that will remain intact after being tossed five times, will stick slightly with pressure
Excellent	Forms a durable ball and is pliable; sticks readily; a sizeable chunk will stick to the thumb after soil is squeezed firmly
Too wet	With firm pressure water can be squeezed from the ball.

In addition to being able to determine when a soil is dry enough to work, it is also necessary to know when a soil has been worked sufficiently for planting.

The short time effect of tillage on soil aggregation is often favorable as the soil is loosened, organic matter is mixed with the soil and clods are broken up if the moisture content is favorable. Over longer periods of time, however, tillage hastens the breakdown of soil organic matter particles and soil aggregates are destroyed. When this occurs soil pore space is decreased, the soil surface crusts when exposed to heavy rainfall, and plant growth is retarded.

Suggested Teaching-Learning Activities

1. Spend several minutes at the beginning of the class period examining the structure of the various soils on the demonstration tables in the classroom. The students should write a brief description of the soil structure of the various soil materials.

   Soil materials to observe include:

   a. Soil under a heavy sod

   b. Soil overworked by a rototiller

c. Soil from a heavily eroded hillside

d. A clay soil worked when it was too wet

e. A sandy soil worked under both wet and dry conditions

f. A top soil

g. A subsoil

h. A clay soil to which considerable organic matter has been added

i. A sandy soil to which considerable organic matter has been added

The teacher should summarize the laboratory examination period by explaining which of the soils on display would be in the proper condition for planting and which would not be in proper condition. The reasons why the soils are or are not ready for planting should be made very clear to the students.

2. Using a particular soil material, add different amounts of water to several samples of the soil and ask the students to decide which samples would have the proper moisture content to be safely worked. Follow up this activity by taking the class on periodic trips to the land laboratory following a heavy rainfall to determine when the soil could be safely worked.

3. Be sure that the students have an opportunity to see the harmful effects on plant growth when soils are overworked and when they are worked in a too wet condition.

4. Ask the students to put the following descriptive items under the appropriate column headings of <u>Coarse Textured Soil and Fine Textured Soil</u>.

a. Good aeration

b. Easy tillage

c. Contains a large amount of clay

d. Loose and open

e. Tendency to puddle when worked wet

f. A "heavy" soil

g. Low moisture holding capacity

h. A "light" soil

i. Relatively large amount of micropore space

j. Tendency to be droughty

k. Relatively large amount of micropore space

l. Tendency to be wet

m. Generally well drained

5. Each student should be given several opportunities to develop proficiency in operating the rototiller and tractor and companion tillage equipment in preparing soil for planting.

6. Suggested time for developing this competency

Classroom teaching	3 hours
Laboratory activity	10 hours
Total time	13 hours

Suggested Instructional Materials and References

Instructional Materials

1. Soil samples as appropriate to illustrate good and poor tilth

2. Rototiller

3. Tractor and accessory tillage equipment

4. Two wide mouth glass jars

5. Two three by ten inch pieces of one quarter inch hardware cloth

6. Lumps of loam soil from a sod in a fence row

7. Lumps of soil from a cultivated field that has been heavily farmed

8. Water

Suggestions for Evaluating Educational Outcomes of the Module

If the competency areas of this module were effectively covered, the students should possess the understandings and abilities to:

1. Determine the suitability of soils for growing plants

2. Modify and mix soils, using the various soil conditioners and equipment

3. Work or till the soil at the proper time and to the proper degree

4. Apply fertilizers and lime, using the appropriate application equipment

5. Mulch landscape areas effectively

6. Render effective assistance in soil sterilization practices

7. Use soil conservation practices in the landscape

8. Exercise some caution in watering plants

9. Appreciate the worth of soil

The answers to the following questions will be helpful in evaluating students.

1. Do the students refer to soil as soil or "dirt"?

2. Are the students "safety minded" when using equipment and potentially dangerous materials?

3. Do the students strive to do their best in whatever jobs they are assigned?

4. Do the students recognize soil conditioners, equipment, and supplies on sight?

5. To what degree could an employer rely on the students in jobs requiring a knowledge of the soil?

Sources of Suggested Instructional Materials and References

1. Conover, H.S. Grounds Maintenance Handbook, New York: McGraw-Hill Book Company, 1958.

2. Donahue, Roy L. Our Soils and Their Management, Danville: Interstate Printers and Publishers, 1955.

3. Hartmann, Hudson, and Dale Kester. Plant Propogation: Principles and Practices, Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1961.

4. Janick, Jules. Horticultural Science, San Francisco: W.H. Freeman Company, 1963.

5. Ball Red Book, Tenth Edition, Chicago: Geo. J. Ball Co. 1960.

6. Fertilizer Handbook, National Plant Food Institute, 1700 K Street, N.W., Washington,D.C., 20006.

7. Soils Book, Ninth Edition, Successful Farming Magazine.

U.S.D.A. publications available from the Superintendent of Documents, Washington 25, D.C.

1. "Controlling Nematodes in the Home Garden," Farmers Bulletin No. 2048.

2. "Teaching Soil and Water Conservation, A Classroom and Field Guide," PA-341.

3. "Water Intake by Soil, Experiments for High School Students," Misc. Publication No. 925.

4. Agriculture Handbook No. 14.

5. Films of the U.S.D.A.

6. 1957 Yearbook, Soils.

7. 1955 Yearbook, Water.

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IN VOCATIONAL AND TECHNICAL EDUCATION
THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name____________________

2. Name of school____________________State__________

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
   _____Ornamental Horticulture--Service Occupations
   _____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report____________________

5. To what group (age and/or class description) was this material presented?____________________

6. How many students:
   a) Were enrolled in class (total) ________
   b) Participated in studying this module ________
   c) Participated in a related occupational work experience program while you taught this module ________

7. Actual time spent teaching module: / Recommended time if you were to teach the module again:

Actual time spent teaching module		Recommended time if you were to teach the module again
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (√) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE				NOT APPROPRIATE
8. The suggested time allotments given with this module were:					
9. The suggestions for introducing this module were:					
10. The suggested competencies to be developed were:					
11. For your particular class situation, the level of subject matter content was:					
12. The Suggested Teaching-Learning Activities were:					
13. The Suggested Instructional Materials and References were:					
14. The Suggested Occupational Experiences were:					

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____ No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____ No_____.
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

______________________ ____
(Date) (Instructor's Signature)

____
(School Address)