GREENHOUSE OPERATION AND MANAGEMENT

Unit IV: Plant Growth

Lesson 2: Growing Media and Containers

Competency/Objective:

Distinguish components of growing media, their uses, and basic types and sizes of containers.

Study Questions

1. **What is the importance of growing media?**
2. **How is field soil pasteurized?**
3. **Why is soilless media preferred for growing greenhouse crops?**
4. **What are the ingredients in soilless mixes and soil amendments?**
5. **What are some considerations in selecting growing containers?**
6. **What are the basic types of containers?**
7. **What are the most common materials for growing containers?**

References/Supplies/Materials

1. G*reenhouse Operation and Management* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.

2. Transparency Masters

   TM 4.2 Composition of Soil-Based Growing Medium
   TM 4.3 Soil Texture Triangle
   TM 4.4 pH Scale
   TM 4.5 Peat Containers
   TM 4.6 Identifying Cell Packs
   TM 4.7 Container Shapes

3. Activity Sheets

   AS 4.5 Growing Media and Containers
   AS 4.6 Materials Update
   AS 4.7 Container Shopping

4. *Soil Science*. University of Missouri-Columbia: Instructional Materials Laboratory, 1995 (catalog numbers 10-5050-I, 10-5050-S).

5. *How Water Moves Through Soil* (Video). Available from University of Missouri-Columbia: Instructional Materials Laboratory (catalog number 10-5600-V).

TEACHING PROCEDURES

A. Review

The previous lesson described elements required to promote successful plant growth. This lesson continues with a discussion of what the plant is grown in, both the media inside and the container.

B. Motivation

To identify the ingredients of an ideal growing media, use the previously planted seeds to start a discussion of the differences in soil, amended soil, and soilless media. Point out container shapes, sizes, and material.

C. Assignment of Study Questions

Students should continue to water their plants.

D. Supervised Study

Lead students in collecting the information needed to answer and discuss the study questions. Instructor may choose to work on one study question at a time or have students answer all the study questions before the discussion. Another option is to have students work in a cooperative learning environment and have groups work on different study questions.

E. Discussion

Lead students in a discussion of the study questions. Supplement students' responses and information with additional materials when needed.

1. What is the importance of growing media?

Ask the students to brainstorm about the functions and qualities of growing media. Why is the selection of the growing media a vital aspect of plant growth?

A. Material in which the roots of plants grow
B. Functions
    1. Support the plant upright
    2. Hold mineral nutrients
    3. Hold water
    4. Allow for exchange of gases (oxygen, CO_2, nitrogen)

C. Important considerations
   1. Water-holding capacity
   2. Drainage
   3. Porosity - pore space between solid particles
      a. The total amount of pore space determines how well the growing medium can retain air and water.
      b. The levels of available oxygen are a function of porosity.
         i. Inadequate pore space means that a shortage of oxygen develops when too much water is supplied.
         ii. The size and distribution of individual pores determine the rate of gas exchange and drainage. These two factors influence the effectiveness of the growing medium.
         iii. The ideal medium has a mixture of large and small pore spaces.
   4. Effect of temperature on growing medium
      a. Affects activity of microorganisms
      b. Affects absorption rate of water and fertilizer
      c. Above 32^{o}F to slightly over 110^{o}F - microorganisms converting organic nitrogen fertilizers in soil to forms that can be readily absorbed
   5. Desirable features
      a. Loose and well aerated
      b. Suitable pH level and cation exchange capacity
      c. Good drainage, holding enough water for plant growth
      d. Free of unwanted seeds, weeds, insects, and pathogens

D. Physical characteristics of ideal field (mineral) soil (TM 4.2)
   1. Composition
      a. 50% solids
         i. 5% organic matter (decayed plant and animal residue)
         ii. 45% mineral matter
            (a) Sand - largest particle
            (b) Silt - formed by water breaking down minerals; smaller than sand
            (c) Clay - smallest particle; fills the gaps between the other particles
      b. 25% water
      c. 25% air (pore spaces - consist of oxygen, carbon, and hydrogen)
   2. Texture - size; distribution; proportion of sand, silt, and clay particles (TM 4.3)
      a. Water retention and air porosity are related to the soil's texture.
      b. Soil containing mostly sand (large particles) is composed of large pores.
      c. Soil with a majority of small, finely textured particles (clay) has small pores that resist the flow of water and therefore increase the soil's water-holding capacity.
      d. Equal amounts of all three particles in soil are called "loam."
      e. Pure loam is not found in the field.
      f. The combination of particles determines whether the soil texture is fine, medium, or coarse.
   3. Structure - arrangement of solid particles
      a. Affects water-holding capacity, porosity, soil's ability to transmit water into the plant (permeability), and the rate of water absorption into the roots (infiltration)
      b. Rearranging soil structure to achieve ideal composition for crop

E. Chemical characteristics
   1. pH - measurement of the level of alkalinity/acidity (TM 4.4)
      a. Ranges from 0 to 14
         i. 7 - neutral
         ii. Above 7 - alkaline (base)
         iii. Below 7 - acidic
      b. Determines whether the soil can receive nutrients (See Unit IV, Lesson 4.)
      c. pH range for most greenhouse crops from 5.5 to 6.5
   2. Cation exchange capacity - measurement of the capacity to hold nutrients
      a. Fertile soil attracts and retains essential nutrients, promoting plant growth.
      b. A cation is a positively charged ion in a solution.
      c. The soil's clay, silt, and organic particles have negative charges that attract and hold cations.
      d. A clay particle in soil has a large surface area, making the cation's absorption more efficient.

2. How is field soil pasteurized?

Have students look at the plants that were sown in field soil and soilless media. What differences do they see in the containers? Have them complete AS 4.5. If possible, demonstrate the steam pasteurization of soil; instructions are in the second suggested activity in Section F - Other Activities and Strategies.

A. Field (mineral) soil alone is not an acceptable growing medium for plants grown in containers.
   1. Generally heavy with poor drainage and aeration
   2. Variable quantity and quality of nutrients
   3. May contain weeds, insects, or disease
B. Field soil must be pasteurized and amended to achieve desired characteristics.
C. Pasteurization has two main purposes.
   1. Kills majority of weed seeds
   2. Kills bacteria and fungi that could cause plant disease (does not kill most organisms that are beneficial to plant growth)
D. There are three basic methods of pasteurization.
   1. Steam
      a. Soil must be mixed before steaming.
      b. Typical treatment is 140-160°F for 30 minutes.
      c. Planting can be done as soon as soil cools.
      d. This method should not be used when soil contains slow-release fertilizer.
   2. Chemical
      a. Not as effective as steam
      b. Fumes highly toxic to humans
      c. Must allow time before planting
      d. Commonly used chemicals
         i. Chloropicrin
         ii. Basamid (DMTT)

iii. Vapam
3. Electrical
   a. Not commonly used in commercial greenhouses
   b. Feasible only for small amounts of soil

3. Why is soilless media preferred for growing greenhouse crops?

Have the students reiterate positive aspects of soilless growing media over field soil. If possible, have both organic and nonorganic greenhouse managers visit. Give each manager one class period to speak and answer questions.

A. Contain no naturally occurring field (mineral) soil
B. Soilless mixes generally preferred for greenhouse crops
C. Benefits
   1. Lightweight
   2. Essentially inert
   3. Excellent drainage and porosity
   4. Consistent in composition
   5. Free of unwanted seeds, weeds, insects, and pathogens
   6. Can be custom mixed or purchased ready-to-use
   7. Do not require pasteurization

4. What are the ingredients in soilless mixes and soil amendments?

Bring in leftover soilless medium from the plants for the students to examine. What is the medium made of? What amendments are the most desirable? Do these amendments have any drawbacks? Have students complete AS 4.6.

A. Organic materials
   1. Benefits
      a. Improve physical structure of soil-based media
      b. Increase water-holding capacity
      c. Increase aeration and drainage
      d. Increase cation exchange
   2. Types
      a. Peat
         i. Peat moss, sphagnum moss, humus, etc.
         ii. Decomposed plant and animal residue
         iii. Can hold 15-20 times its weight in water
         iv. Ample quantities of pore space that hold air and water
      b. Wood residues
         i. Leaf mold, composted sawdust, bark, etc.
         ii. By-products of lumber industry
      c. Coir
         i. Coconut parts
         ii. By-product of coconut industry

iii. Excellent air porosity and water retention; medium absorbs moisture easily and drains quickly

B. Mineral (inorganic) materials
   1. Benefits
      a. Improve physical structure of soil-based media
      b. Increase aeration and drainage
   2. Types
      a. Sand (mountain rock origin)
         i. Sand provides good porosity and aeration by admitting large quantities of air into the growing medium.
         ii. It promotes drainage but cannot hold sufficient quantities of water for the emerging plant.
      b. Perlite (volcanic rock origin)
         i. Neutral pH
         ii. Holds three to four times its weight in water
         iii. Improves drainage and aeration
         iv. Ideal as a seed-germinating medium for rooting cuttings
      c. Vermiculite (mica origin)
         i. Absorbs fertilizer
         ii. Contains sources of magnesium and potassium
      d. Calcined clay
         i. Retains nutrients in medium
         ii. Adds volume to the medium and improves the soil structure

C. Other materials
   1. Polystyrene flakes - by-product of polystyrene processing
   2. Rock wool
      a. Spun from basalt, coke, and limestone
      b. Not biodegradable, which poses environmental concerns

5. What are some considerations in selecting growing containers?

Primary influences of container selection are based on both the plant itself and the intended market. Another concern is how long the plant is in the container, e.g., hanging basket of fuschia versus flats of bedding plant plugs in the retail market. How might the wholesale market be different?

A. Plant growth habit
   1. Plant height
   2. Plant width
   3. Plant shape
   4. Plant requirement for root space

B. Intended market
   1. Retail (generally larger pots)
   2. Wholesale (generally smaller pots)

6. What are the basic types of containers?

Both organic and synthetic materials are used in greenhouses. Encourage the students to discuss what these materials are and how each might be beneficial, e.g., growing seedlings versus potted plants. Have students complete AS 4.7.

A. Rooting containers
   1. Used for seeding or root cuttings
   2. Made from organic materials
      a. Peat pellets and strips (TM 4.5)
         i. Self-contained growing units
         ii. Expand when watered
      b. Peat pots
         i. Made from compressed peat moss
         ii. Must be filled with growing media
   3. Made from other materials
      a. Plastic flats
      b. Metal flats
      c. Plastic foam cubes
      d. Rock wool fibers

B. Bedding plant containers
   1. Cell packs (TM 4.6)
      a. Generally made of plastic
      b. Usually contain 36, 48, or 72 cells per flat
      c. Used for producing plug seedlings
   2. Plant packs
      a. Generally made of plastic
      b. Usually contain one to six cells per unit and six to eight units per flat
      c. Used for bedding and garden vegetable plants
   3. Individual pots
      a. Generally made of plastic
      b. Range in size (most common: 2-4 in.)
      c. Used to produce larger bedding plants

C. Foliage and flowering plant containers (can range in size from 2 to 12+ in.) (TM 4.7)
   1. Standard pot
      a. Equal in width and depth
      b. Best for plants that are not top heavy
   2. Azalea pot
      a. Height - 3/4 of its width
      b. Ideal for shorter plants with spreading foliage
      c. Wide base - stability for top-heavy plants
   3. Rose pot
      a. Height - 1 1/2 times its width
      b. Ideal for plants with large, deep root systems
   4. Bulb pan
      a. Width twice the depth

   b. Best for shallow-rooted plants
5. Hanging baskets
   a. Generally made of plastic
   b. Suitable for a variety of plants

7. What are the most common materials for growing containers?

Containers in commercial greenhouse are composed of organic and synthetic materials. Discuss the benefits and drawbacks of each. Are some materials better for certain types of plants or the growers?

A. Plastic (most commonly used)
   1. Types
      a. Round (more air circulation between pots)
      b. Square (more space efficient but less air circulates among pots, leading to diseased leaves)
   2. Advantages
      a. Lightweight to lift and ship
      b. New pots - sterile; used pots - can be chemically sterilized
      c. Less prone to fertilizer residue/algae buildup
      d. Less watering required
      e. Wide selection of sizes, shapes, and colors
      f. Inexpensive
   3. Disadvantages
      a. Nonporous (does not "breathe")
         i. Less aeration for root system
         ii. Possibility that growing medium may become waterlogged
      b. Can crack and becomes brittle with age
      c. Disposal - environmental concern
B. Clay (used for centuries)
   1. Advantages
      a. Porous
         i. Excellent aeration and gas exchange
         ii. Excellent drainage prevents growing medium from becoming waterlogged
      b. Sturdy, less likely to tip
      c. Long lasting
      d. Can be steam sterilized
      e. Can be reused
   2. Disadvantages
      a. Plants drying out faster and requiring more frequent watering
      b. Prone to fertilizer residue/algae buildup
      c. Heavy to lift and ship
      d. Subject to breakage
      e. Relatively more expensive
C. Peat - peat moss pressed into sheets and formed into shapes
   1. Advantages

a. Can be transplanted along with plant (less trauma to plant when transplanted)
b. Roots penetrating container as plant grows

2. Disadvantages
   a. Does not last very long
   b. Dries out quickly and becomes difficult to rewet

F. Other Activities and Strategies

1. Invite a manager from an organic greenhouse and a traditional greenhouse manager on separate days to discuss issues of growing media and containers. A nearby university Extension office may be able to help you find an organic greenhouse grower. What kind of growing medium do they use, amended soil or a soilless mixture? Do they create their own soilless medium? What are the ingredients in it and why those particular items? Ask them to show the class what their growing medium looks like. Ask them to address concerns of chemical pasteurization (methyl bromide), vermiculite, rock wool, and polystyrene. With regards to containers, what type do they prefer and why? What are the costs involved in "being green"?

2. Steam Pasteurization of Soil - This smelly exercise requires an oven, soil, a meat or candy thermometer, ovenproof pan, some aluminum foil, and ventilation.

   A. Before using the soil, thoroughly sterilize the equipment. Wash containers and tools with soapy water to remove debris. Sterilize wood and plastic items by rinsing them in a solution of 1 part chlorine bleach and 10 parts water. Let dry before using.

   B. Place moist but not wet soil in an ovenproof pan. Cover with foil, sealing the edges. Insert the thermometer in the middle of the soil mass, making a small hole in the foil. Bake in a 250°F oven until the thermometer reads 160-180°F. Remove from oven and let cool.

      Note: The amount of time to sterilize the soil varies depending on soil volume and moisture content. Remember that dry soil does not pasteurize well.

3. Show the class any or all of the following videos, which are available from CATER (Career & Technical Education Resources), 2 London Hall, University of Missouri-Columbia: *How to Grow Plants in a Greenhouse: Bedding Plant Production*, Vol. I (AG V162); *How to Grow Plants in a Greenhouse: Foliage Plant Production*, Vol. II (AG V163); and *Growing Media for Landscape Plants* (AG V172).

G. Conclusion

The growing media's water-holding capacity, porosity, drainage, and aeration foster healthy plant growth. Soilless medium is preferred over field soil. By amending the composition through the addition of organic and inorganic materials, soil-based media can be substantially improved. The selection of plant containers and the choice of materials depend on usage and the intended market.

H. Answers to Activity Sheets

AS 4.5 Growing Media and Containers

Instructor's discretion

AS 4.6 Materials Update

Instructor's discretion

AS 4.7 Container Shopping

Instructor's discretion

I. Answers to Assessment

1. A
2. C
3. B
4. D
5. B
6. Any two of the following for A-C:
   A. Rooting/seeding plants: peat pellets, peat strips, peat pots, plastic flats, metal flats, rock wool fiber, plastic foam cubes
   B. Foliage/flowering plants: standard, azalea, rose, bulb, and hanging pots
   C. Bedding plants: cell packs, plant packs, and individual pots
7. Any two of the following:
   A. Lightweight
   B. Essentially inert
   C. Excellent drainage and porosity
   D. Consistent in composition
   E. Free of unwanted seeds, weeds, insects, and pathogens
   F. Can be custom mixed or purchased ready-to-use
   G. Do not require pasteurization
8. Steam - cannot be used in conjunction with slow-release fertilizers
   Chemical - not as effective as steam, fumes are toxic to humans, growing media must aerate before planting can occur
   Electrical - can be used only on very small areas
9. E
10. C
11. A
12. F
13. D
14. B

UNIT IV: PLANT GROWTH

Name_____

Lesson 2: Growing Media and Containers

Date_____

ASSESSMENT

Multiple Choice: Circle the letter of the best answer.

1. What is the composition of an ideal field (mineral) soil?

   A. 50% solids, 25% water, and 25% air
   B. 15% organic matter, 40% water, 5% air, and 40% silt
   C. 45% mineral, 1% water, 1% air, and 53% sand
   D. 30% air, 30% mineral, 20% water, and 20% silt

2. What are three most popular container materials?

   A. Peat, vermiculite, and clay
   B. Plastic, metal, and perlite
   C. Clay, peat, and plastic
   D. Rock wool, peat, and plastic

3. What three features are essential for a good growing medium?

   A. Porosity, lightweight, and pasteurization
   B. Water-holding capacity, drainage, and porosity
   C. Drainage, silt, and sand
   D. Porosity, water-holding capacity, and loam

4. What are two disadvantages of using mineral (field soil)?

   A. Cation exchange capacity and CO_2 levels
   B. No need for pasteurization and is too heavy
   C. Superior aeration but not enough water
   D. Poor aeration and potential contaminants

5. When selecting a type of container, what are the two most important considerations?

   A. Growth media and pot size
   B. Plant growth and market
   C. Container material and plant growth
   D. Market and porosity

Short-Answer Questions: Write the answers in the space provided.

6. What are two examples of container types for the following types of greenhouse plants?

   A. Rooting/seeding plants

      1.

      2.

   B. Foliage/flowering plants

      1.

      2.

   C. Bedding plants

      1.

      2.

7. What are the two benefits of soilless media for growing plants?

   A.

   B.

8. What are the three methods of soil pasteurization? What is one drawback of each technique?

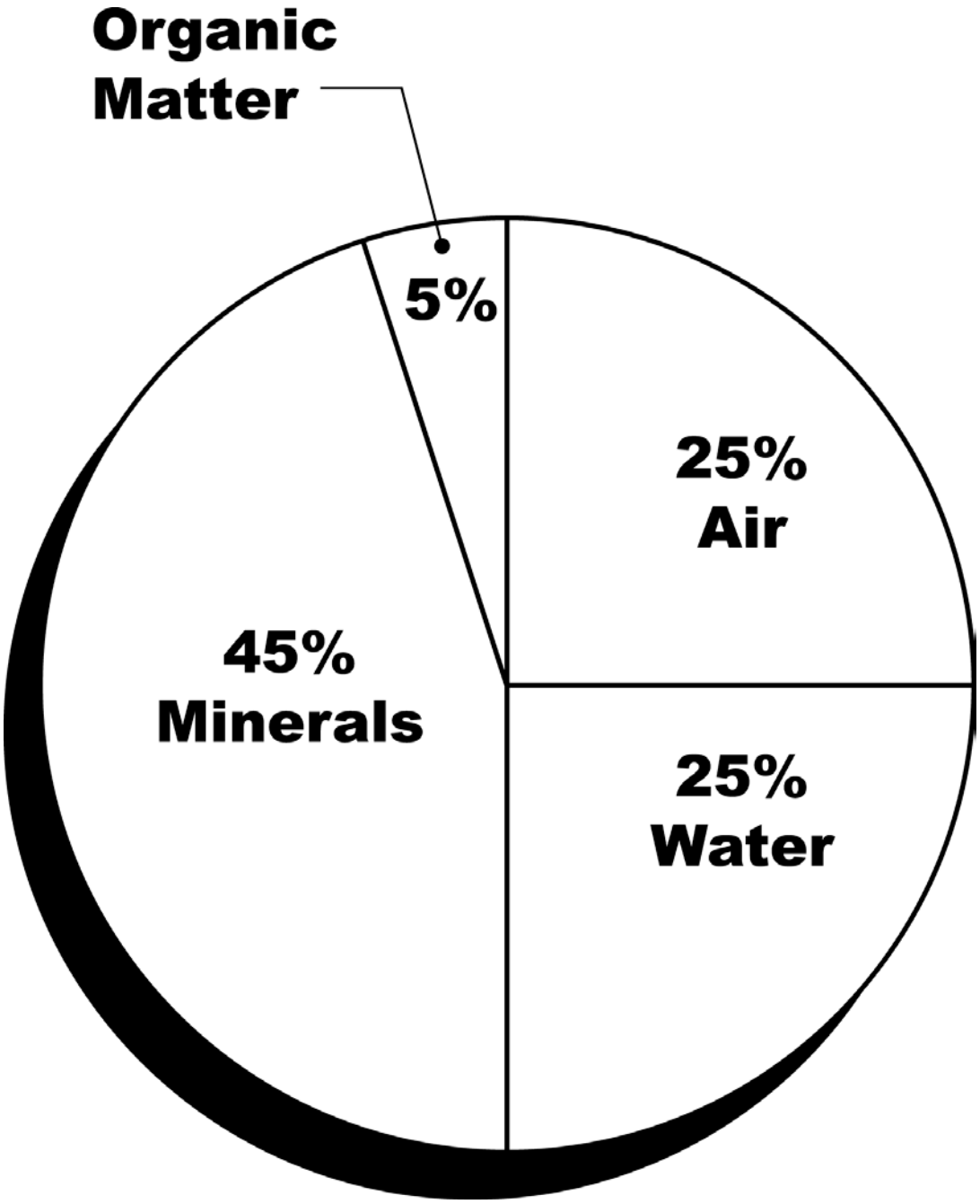
Method	Drawback
A.	A.
B.	B.
C.	C.

Match the ingredients in soilless mixes and soil amendments on the left with their origin on the right. Write the letter in the space provided.

____9.	Rock wool	A.	Mica
____10.	Coir	B.	Mountain rock
____11.	Vermiculite	C.	Coconut by-product
____12.	Sphagnum peat moss	D.	Volcanic rock
____13.	Perlite	E.	Spun basalt, coke, and limestone
____14.	Sand	F.	Decomposed plant and animal residue

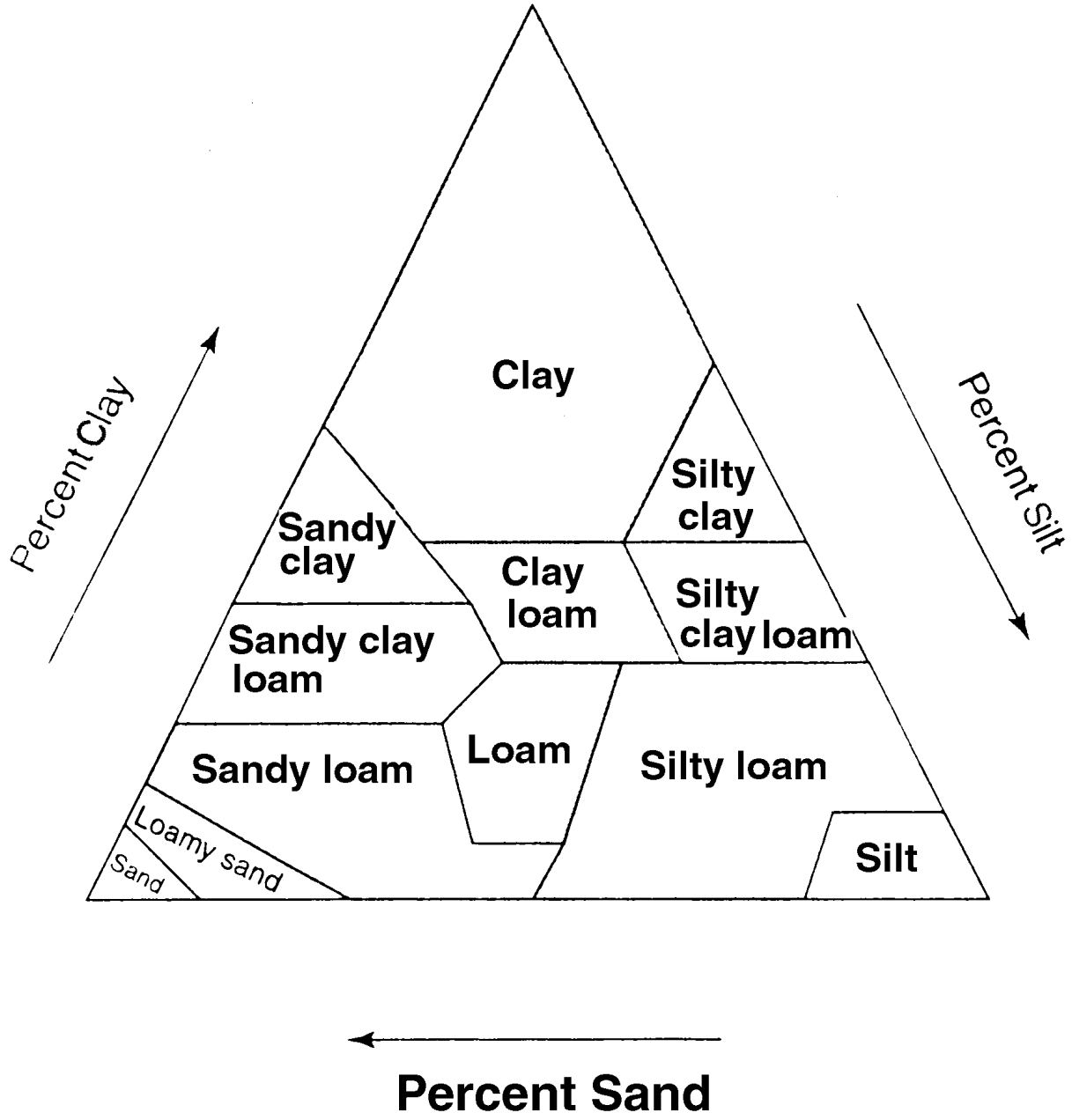
TM 4.2

Composition of Soil-Based Growing Media



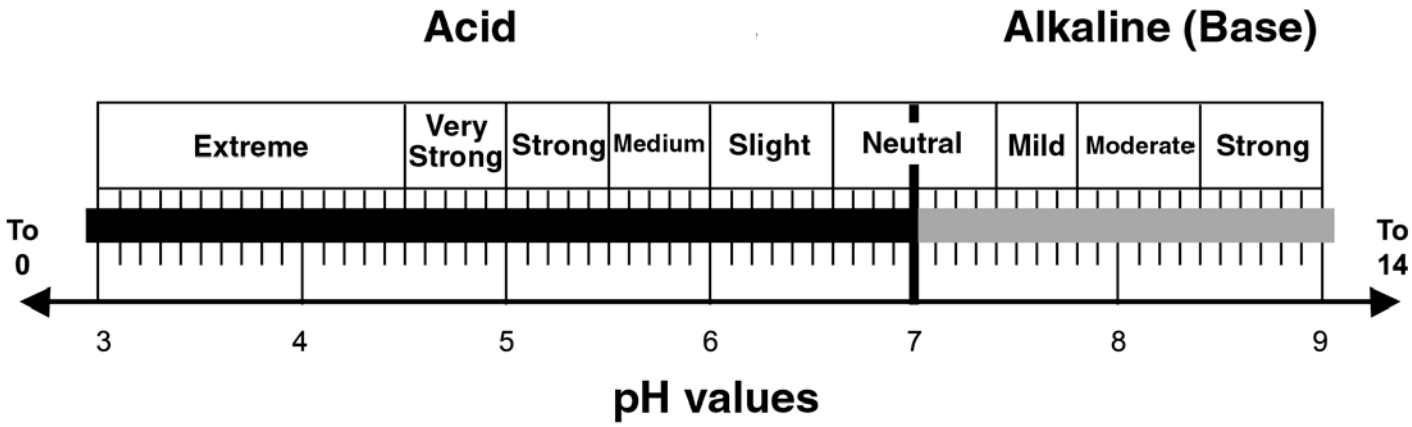
TM 4.3

Soil Texture Triangle



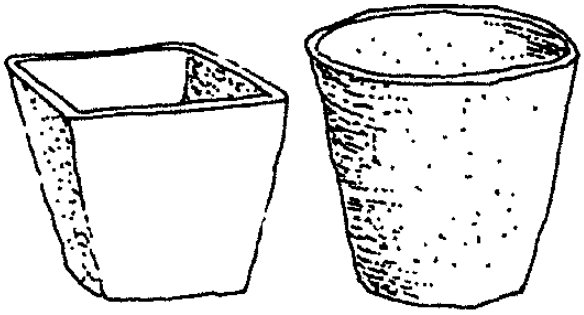
TM 4.4

pH Scale



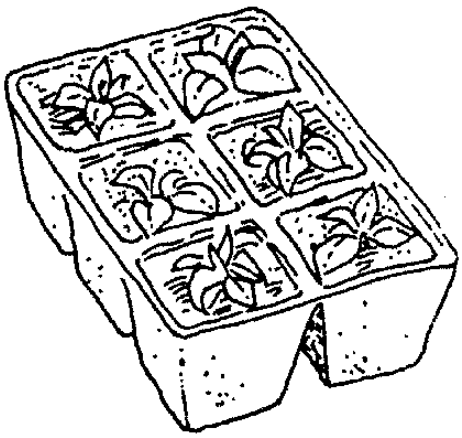
TM 4.5

Peat Containers



Peat Pots

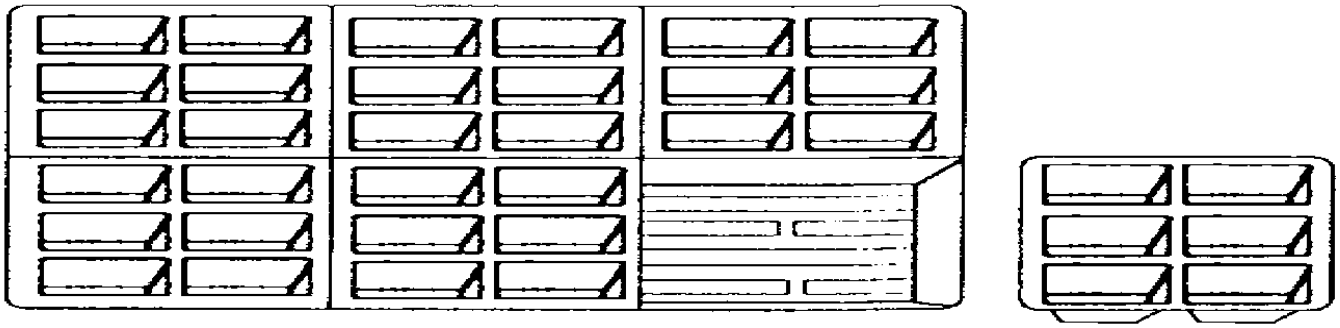
Peat Pellet



Peat Strip

TM 4.6

Identifying Cell Packs



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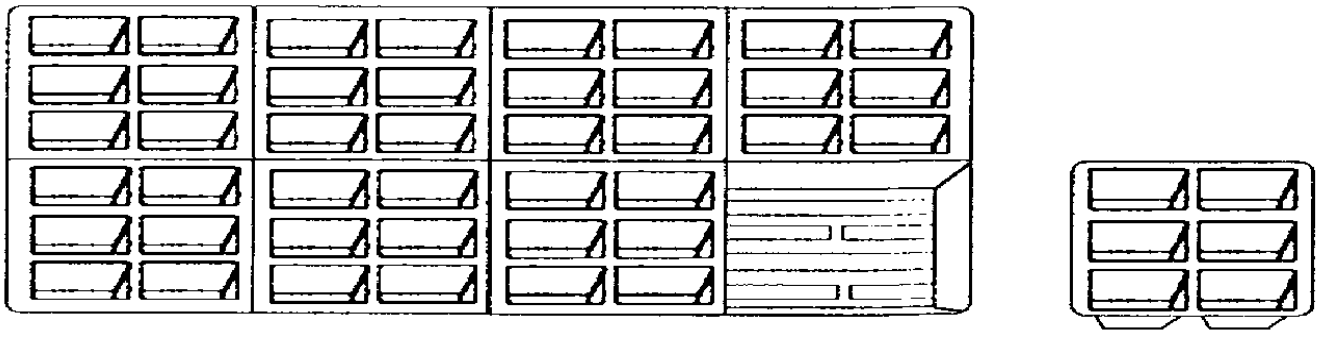

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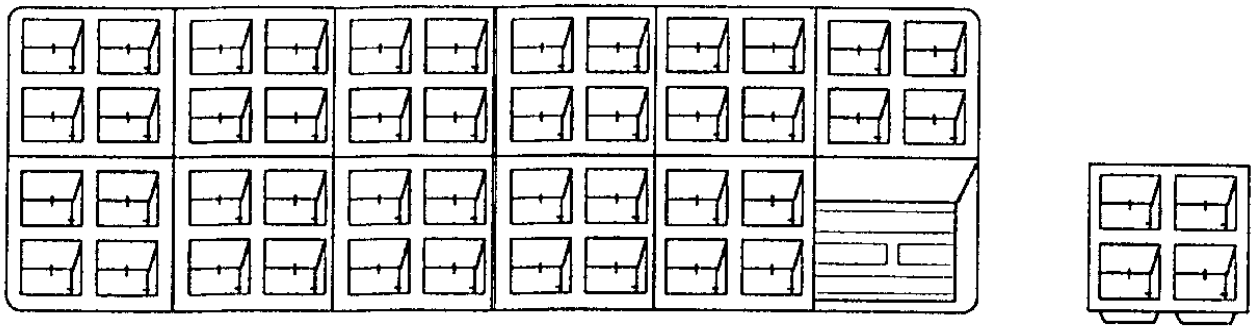

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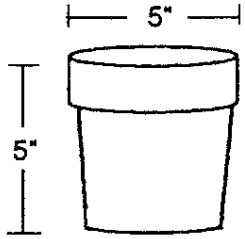
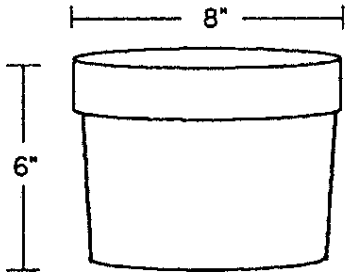
TM 4.7

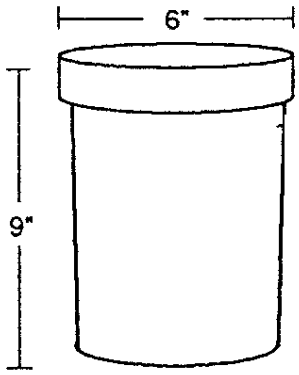
Container Shapes



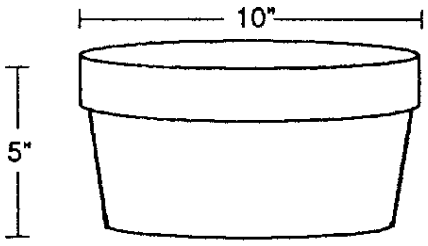
Standard Pot



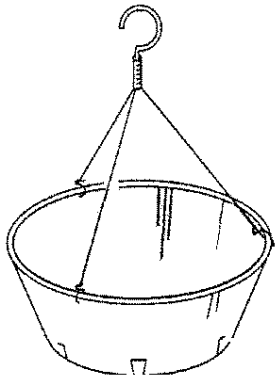
Azalea Pot



Rose Pot



Bulb Pot



Hanging

UNIT IV: PLANT GROWTH

AS 4.5

Lesson 2: Growing Media and Containers

Name_____

Growing Media and Containers

Objective: Identify the differences in soil and soilless growing media and evaluate types of containers used.

Directions: Use seeds planted earlier in this unit to assess the effectiveness of growing media. Remember that at the beginning of Unit I when the seeds were planted, half of the class' plants were randomly planted in soil. Then answer the following questions.

1. How do the plants look? Describe in detail.

2. Turn a little bit of the growing media and record observations. Describe the differences in the soil and the soilless media.

3. What kind of container is used to grow the plants? What is the container made of (clay, plastic, etc.)? Could the type of container or material influence the growth of the plants? Explain.

4. If this plant were grown for retail sale, what container would be the best option? For wholesale?

UNIT IV: PLANT GROWTH

AS 4.6

Lesson 2: Growing Media and Containers

Name_____

Materials Update

Objective: Evaluate the materials used in greenhouses.

Directions: Using the Internet and other sources, work in small groups to research one of the words listed below. Then answer the questions and present your findings to the class as a PowerPoint presentation.

- Bagasse
- Calcined clay
- Chloropicrin
- Hydrogel (Terrasorb)
- Methyl bromide
- Peat moss
- Perlite
- Rock wool
- Vermiculite

1. What is it?

2. What is its use?

3. What are the benefits of using it?

4. Are there negative aspects to its use?

5. Is there an alternative?

6. How cost-effective is the option?

UNIT IV: PLANT GROWTH

AS 4.7

Lesson 2: Growing Media and Containers

Name_____

Container Shopping

Objective: Compile a list of appropriate containers and prices to fill a greenhouse.

Directions: Using the Internet and other sources, research the price and types of containers it would take to fill a greenhouse the size of your school's greenhouse.

1. How many containers will it take to fill the greenhouse?

2. What size pots: just one size or a variety? Which sizes?

3. Is it necessary to buy any rooting containers?

4. How many cell packs and hanging baskets will you use?

5. How are cell packs sized?

6. How are cell packs sold?

7. What materials are the containers made from?

8. Why did you choose that material?

9. What types of plants are you growing? Did this influence your choice? Why?

10. How much money will these containers cost?