Lesson A6–1

Understanding Hydroponics

Unit A. Horticultural Science

Problem Area 6. Hydroponics

Lesson 1. Understanding Hydroponics

New Mexico Content Standard:

Pathway Strand: Plant Systems

Standard: **I:** Apply principles of anatomy and physiology to produce and manage plants in both a domesticated and natural environment.

Benchmark: **I-A:** Analyze and evaluate nutritional requirements and environmental conditions to develop and implement a fertilization plan.

Performance Standard: **4.** Determine the environmental factors that influence and optimize plant growth. **6.** Describe nutrient application methods and appropriate practices.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Explain the meaning of hydroponics and describe some of its advantages and disadvantages.
2. Describe the basic requirements for hydroponically grown plants.
3. Identify common hydroponic systems.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the lesson:

Biondo, Ronald J. and Jasper S. Lee. *Introduction to Plant and Soil Science and Technology,* Second Edition. Danville, Illinois: Interstate Publishers, Inc., 2003.

Other Resources. The following resources will be useful to students and teachers:

Parker, Rick. *Introduction to Plant Science.* Albany, New York: Delmar Publishers, 1999.

Schroeder, Charles B., et al. *Introduction to Horticulture*, Third Edition. Danville, Illinois: Interstate Publishers, Inc., 2000.

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters

Terms. The following terms are presented in this lesson (shown in bold italics):

Aeroponics
Aggregate culture
Circulating systems
Hydroponics
Nutriculture
Nutrient film technique (NFT)
Parts per million (ppm)
Respiration
Rockwool
Soilless culture

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here:

Begin acquainting students with hydroponics by having them start plant cuttings in water. Bring plant samples to class. Tropical foliage plants, especially vines are ideal to use. They survive well and grow quickly. Be sure to include a leaf node that will be submerged in water. This is where the root will sprout from. Also, avocado seeds sprout well underwater, however they take longer to do so than tropical foliage plants. In either case, after the plants have started, ask the students how the plants are able to grow with-

out the presence of soil. Ask them if they are aware of any crops that are typically grown using hydroponics. Lead the discussion toward the first objective of the lesson.

Summary of Content and Teaching Strategies

Objective 1: Explain the meaning of hydroponics and describe some of its advantages and disadvantages.

Anticipated Problem: What is hydroponics? What advantages and disadvantages are associated with it?

I. The term hydroponics was first used in the 1930's by a California researcher named W.F. Gerike. It is a combination of two Greek words. "Hydro" means water and "ponics" means labor. Together they mean water labor. Simply defined, ***hydroponics*** is growing plants with their roots in a medium other than soil. Sometimes, hydroponics is referred to as ***soilless culture*** because soil is not used. Although it sounds new, hydroponics was documented over 300 years ago. In recent years, there has been widespread expansion in hydroponic systems due to a better understanding of plant growth, nutrient needs, and technological requirements.

   A. Some advantages of hydroponic production include the following:
      1. Because hydroponics does not use soil, harmful insects that live in soils cannot damage hydroponic crops.
      2. Soil contains dormant weed seeds. Given the right conditions, these seeds may germinate. These weeds may compete with crops for water, nutrients, and light. Hydroponic systems do not have weed seeds that might germinate.
      3. Hydroponic systems allow for every plant's optimal nutrient needs to be addressed. The plants do not have to compete for available nutrients and can therefore be placed closer together.
      4. The amount of nutrients needed by plants can be adjusted as they grow. As plants mature, the type and amount of nutrients can be easily adjusted in a hydroponic system.
      5. Hydroponic systems allow the pH levels available to plants to be adjusted quickly. This helps in nutrient uptake.
      6. Hydroponics allows for high quality yields in parts of the world where there is nonproductive land or poor growing conditions.

   B. Some disadvantages of hydroponic systems include the following:
      1. The initial investment in a commercial hydroponic system is high.
      2. Some diseases can spread rapidly throughout the system.
      3. Many hydroponic systems are set up in greenhouses. Flower pollination can be difficult in greenhouses.

Display TM: A6–1A and use it in reinforcing the definition and general history of hydroponics in the United States. Use TM: A6–1B to reinforce both the advantages and disadvantages of hydroponic systems. Ask the class to develop additional advantages and disadvantages. Introduction to Plant and Soil Science presents good introductory information on hydroponics. The activity manual also has an excellent lab on building a hydroponic system. As an introductory activity provide the class with a list of the needed materials and have them develop a budget for such a project.

Objective 2: Describe the basic requirements for hydroponically grown plants.

Anticipated Problem: What requirements must hydroponic systems meet in order for plants to grow?

II. Hydroponically grown plants have the same basic requirements as plants grown in soil. All hydroponic systems must supply support, water, nutrients, and air. The major differences in a hydroponic system are the way in which plants receive support and the method in which nutrients are made available.

A. Temperature—since most hydroponic systems are in greenhouses or confined areas, temperature can be set. Each type of plant has an optimal temperature range for maximum growth.

B. Light—all vegetables and most flowering plants need large amounts of light. Hydroponically grown vegetables require 8 to 10 hours of direct sunlight daily for healthy growth. Commercial operations sometimes use high powered lamps to increase light intensity and duration.

C. Water—providing plants with enough water is not a problem with water culture systems. Water quality can be an issue. The pH of water should be tested, and if necessary adjusted for the particular crop being grown. Softened water may contain harmful amounts of sodium and should be avoided.

D. Oxygen—perhaps the most critical factor is supplying the root system with enough oxygen. Plants and plant root systems require oxygen for respiration. ***Respiration*** is the chemical process in which a plant can convert stored energy in order to carry out plant functions.

E. Nutrients—hydroponically grown plants have the same nutrient requirements as those grown in soil. However, since hydroponic systems do not use soil, essential nutrients must be provided via a water solution. These solutions require careful calculations to insure that the optimal amounts of macronutrients and micronutrients are provided. Nutrients in a solution are measured in part per million. ***Parts per million (ppm)*** means that for every million molecules of a solution, a certain number of those molecules are made up of a particular nutrient. For example, a solution of 200 ppm nitrogen means that 200 out of one million molecules would be nitrogen.

F. Support—soil provides a firm anchor for plants to grow upright. In hydroponic systems, artificial support can be provided. This can be accomplished through string stakes, trellises, and mesh materials.

Display TM: A6–1C and use it in reinforcing the requirements for plant growth. The Preparing Nutrient Solutions for Water Culture Systems Exercise in the Introduction to Plant and Soil Science Activity Manual offers good practice for students in calculating parts per million. Use TM: A6–1D to provide an example of how plants can be artificially supported in a hydroponics system. Refer the class back to the hydroponics system construction activity featured in the activity manual of the recommended resource. Ask students to identify the method of support in this system.

Objective 3: Identify common hydroponic systems.

Anticipated Problem: What are some of the common types of hydroponic systems and how do they operate?

III. Hydroponics is used to describe many different types of systems. Since most are unique designs, they can vary in size, appearance, and method of operation. Generally, all systems can be placed in one of two categories.

   A. One category, ***aggregate culture*** involves the use of aggregate or substrate materials that help support plants. Such materials allow the plants to take root.

      1. Common substrates include sand, perlite, vermiculite, gravel, peat moss, and rockwool. ***Rockwool*** is a spongy fibrous material spun from molten volcanic rock. All of these materials are considered inert. They do not provide nutrients to the plants.

      2. Nutrient solutions provide the plants with essential nutrients. Common methods of supplying the solution are through drip, trickle, and sub-irrigation. One method involves flooding the aggregate for ten minutes. The aggregate is allowed to drain for 30 minutes and then flooded again.

   B. The second category, water culture, is also referred to as ***nutriculture***. In this type of system, no substrate is used. Although plants may be started in rockwool, most of the roots are growing in a nutrient solution. Most systems of this type have a continuous flow or mist of nutrient solution that is recycled and are referred to as ***circulating systems***.

      1. The water culture system most commonly used in commercial operations is called ***nutrient film technique (NFT)***. In NFT systems, a continuous flow of nutrient solution runs through a series of tubes or troughs. A pump raises the nutrient solution to desired levels, and gravity allows it to drain. The system is constantly recycling the nutrient solution.

      2. Aeroponics is another type of water culture system. ***Aeroponics*** systems are designed to have plant roots suspended in the air within a closed container. Inside the container, spray nozzles are used to mist the roots.

Display TM: A6–1E to illustrate the basics of aggregate culture and water culture systems. Refer back to the system construction lab in the Introduction to Plant and Soil Science Activity Manual. Have students identify what kind of system it is. If the construction of such a system is not possible at your school, investigate constructing a simple water culture system using an aquarium as illustrated in TM: A6–1E. Ask the class to identify plants that would best be grown in such a system.

Review/Summary. Focus the review and summary of the lesson around the student learning objectives. Call on students to explain the content associated with each objective. Use their responses as the basis for determining areas that need to be covered again or in a different manner. Use the lab activities to review and reinforce the lesson's content. The questions at the end of appropriate chapters in Introduction to Plant and Soil Science and Technology may also be used in the review/summary.

Application. Application can involve one or more of the following activities:

Preparing Nutrient Solutions for Water Culture Systems—*Introduction to Plant and Soil Science and Technology Activity Manual*

Building a Tabletop PVC Hydroponic System—*Introduction to Plant and Soil Science and Technology Activity Manual*

Evaluation. Evaluation should focus on student achievement of the lesson's objectives. Various techniques such as student performance can be used on the lab activities. A sample written test is also attached.

Answers to Sample Test:

Part One: Matching

1 = d, 2 = b, 3 = a, 4 = c, 5 = e

Part Two: Completion

1. nutriculture
2. Nutrient film techniques (NFT)
3. aggregate culture, water culture
4. soilless
5. water labor

Part Three: Short Answer

1. Use TM: A6–1B as a guide in grading.
2. Use TM: A6–1B as a guide in grading.
3. Use TM: A6–1C as a guide in grading.

Sample Test Name _____

Test

Lesson A6–1: Understanding Hydroponics

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. respiration
b. hydroponics
c. rockwool
d. aeroponics
e. circulating

_____ 1. The type of hydroponic system that is designed to have plant roots suspended in the air within a closed container.

_____ 2. Growing plants in a medium other than soil.

_____ 3. The chemical process in which a plant can convert stored energy in order to carry out plant functions.

_____ 4. A spongy fibrous material spun from volcanic rock and often used as a substrate.

_____ 5. A type of system that has a continuous flow or mist of nutrient solution that is recycled.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. Water culture is often referred to as _____.
2. In _____ _____ _____ systems, a continuous flow of nutrient solution runs through tubes or troughs.
3. The two general categories of hydroponic systems are _____ _____ and _____ _____.
4. Sometimes, hydroponics is referred to as _____ culture because a medium other than soil is used.
5. The literal translation of the Greek words "hydro" and "ponics" means _____ _____.

Part Three: Short Answer

Instructions. Provide information to answer the following questions.

1. List and explain four advantages of hydroponic production.

2. List and describe three disadvantages of hydroponic production.

3. List five requirements for hydroponically grown plants

Hydroponics—the growing of plants with their roots in a medium other than soil.

In Greek, "hydro" means water. "Ponics" means labor. Together they = water labor.

Use of hydroponics was first documented over 300 years ago.

The term hydroponics was coined in the 1930's by W.F. Gerike, a California researcher.

TM: A6–1B

ADVANTAGES OF HYDROPONIC PRODUCTION

1. Greatly reduced risk of damage caused by insects that attack below soil level.
2. No dormant weed seeds in soil.
3. Plants can be placed closer together.
4. Easier to adjust nutrient levels based on a plant's maturity.
5. pH level can be adjusted easily.
6. Allows for high quality yields in areas with poor growing conditions.

DISADVANTAGES OF HYDROPONIC PRODUCTION

1. High initial investment for commercial systems.
2. Some diseases can spread rapidly.
3. Flower pollination can be difficult in greenhouse settings where pollinators are absent.

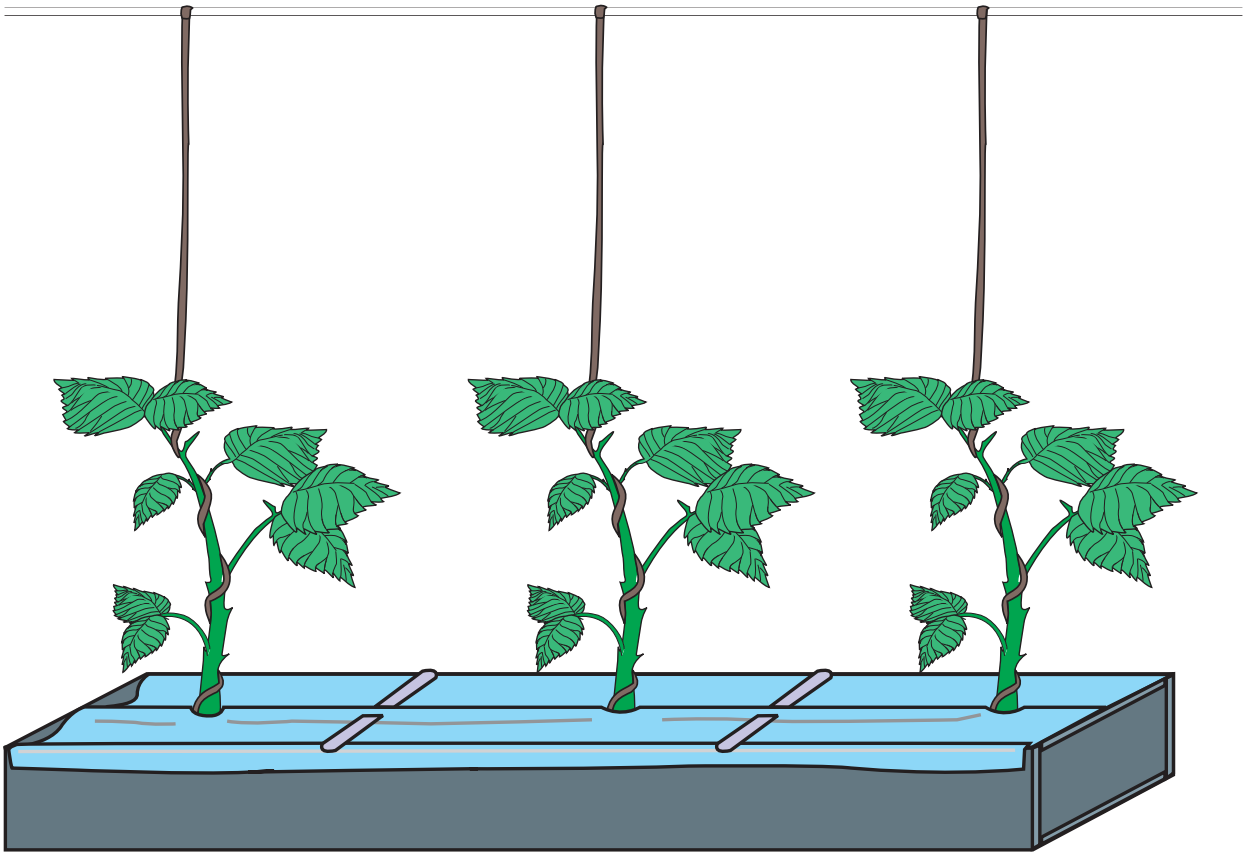
TM: A6–1C

REQUIREMENTS FOR PLANT GROWTH

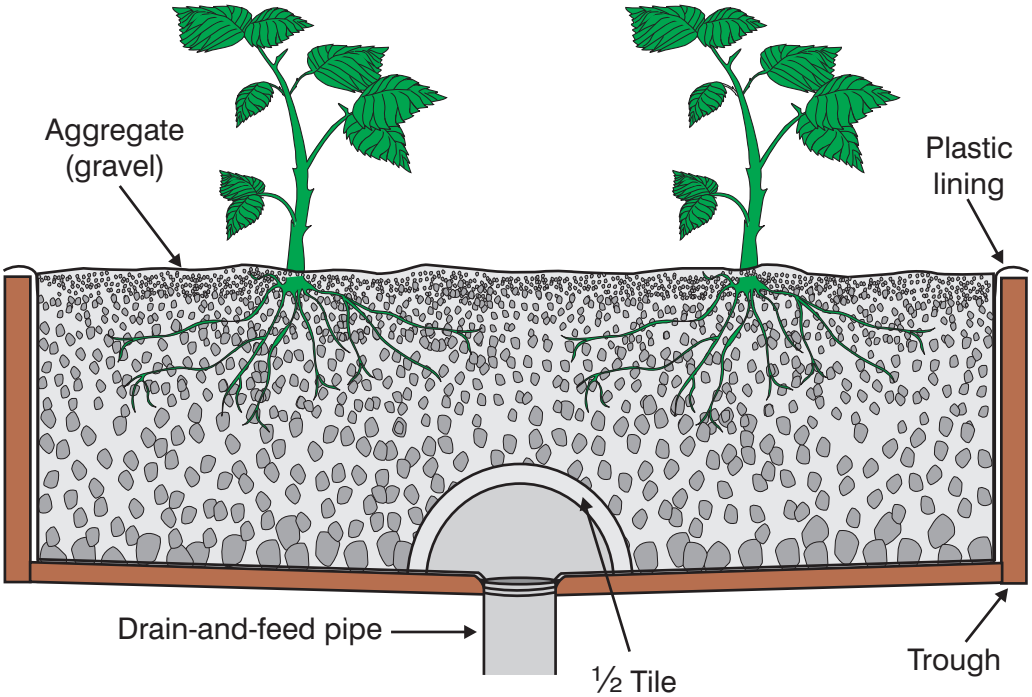
1. Temperature
2. Light
3. Water
4. Oxygen
5. Nutrients
6. Support

TM: A6–1D

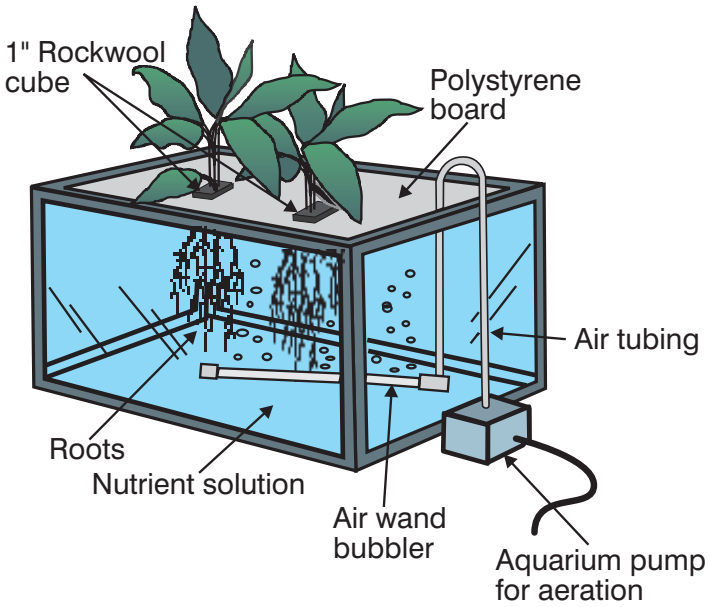
ARTIFICIAL SUPPORT IN A HYDROPONIC SYSTEM



(Courtesy, Interstate Publishers, Inc.)



An example of a aggregate culture system.



An example of a water culture system.

(Courtesy, Interstate Publishers, Inc.)