DOCUMENT RESUME

ED 330 805 CE 057 456

TITLE	Agricultural Education Science Activity--Nos. PS 1-6.
INSTITUTION	Ohio State Univ., Columbus. Agricultural Curriculum Materials Service.
PUB DATE	90
NOTE	27p.
AVAILABLE FROM	Ohio Agricultural Education Curriculum Materials Service, 254 Agricultural Administration Bldg., Ohio State University, 2120 Fyffe Road, Columbus, OH 43210-1099.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Agricultural Education; Classroom Techniques; Fertilizers; Higher Education; Horticulture; *Integrated Curriculum; Learning Activities; Lesson Plans; *Plant Growth; *Plant Propagation; Plants (Botany); *Science Activities; Science Experiments; Science Instruction; Secondary Education; *Soil Science; Teaching Methods; Vocational Education; Zoology

ABSTRACT

This packet contains six science learning activities that can be used in agricultural education courses. The activities cover these topics: (1) determining the effects of soil drainage on plant growth and development; (2) determining the effect of soil compaction on plant growth and development; (3) inoculating legume seeds to promote nodule formation; (4) propagating plants; (5) determining the effects of rhizobium japonicum and nitrogen fertilizer on nodulation and plant growth; and (6) determining effects of frost/hail damage on plant growth. The lesson plans for the activities consist of the following elements: agricultural subjects and science principles included in the lesson, agricultural applications, student objectives, activity length, group size, vocabulary, materials required, instructional strategies and procedures (overview and results), key questions, and evaluation. One to three references are given for each activity, and each includes a data record and observation sheet. (KC)

AGRICULTURAL EDUCATION SCIENCE ACTIVITY
Nos. PS 1-6

Ohio Agricultural Education Curriculum Materials Service
254 Agricultural Administration Bldg.
The Ohio State University
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Columbus, OH 43210-1099

Determining the Effects of Soil Drainage on Plant Growth and Development

Agricultural Subjects

■ Plant Science and Soil Science

Activity Length

■ Four weeks are required to grow plants.

Group Size

■ This activity can be conducted with an entire class or small groups (2 to 3 students).

Science Principles

■ **Soil drainage**: water movement can be controlled by natural or artificial means.

■ **Oxygen use**: plants require proper amounts of oxygen for good plant growth and root system development. Improper drainage can alter this process.

Agricultural Application

■ Crop growth and production are affected by soil drainage. Often natural drainage is inadequate and artificial drainage systems must be installed. If an artificial drainage system – such as tile – is correctly installed and maintained, crop growth and production increase. Also, when properly drained, fields become accessible earlier in the planting season. Therefore, agriculture students need a basic understanding of soil drainage principles in order to recognize and correct any drainage problems they may encounter.

Student Objective

■ To determine the effects of soil drainage on plant growth and root system development.

Vocabulary

drainage
water table
gravitational water
soil aeration
field capacity
wilting point

Materials Required

1. Two one-quart potting containers (One with drainage hole open, one with drainage hole blocked)
2. Fertile potting soil
3. Common field crop seeds (e.g., corn or soybeans)
4. Graduated watering container
5. Access to greenhouse or similar facility providing proper growing conditions (e.g., adequate light, humidity, and temperature)

Instructional Strategies and Procedures

■ Overview: Plant seeds in two potting containers: one with drainage, one without. Place each container in an area with proper growing conditions. Water the containers regularly. Allow the plants to grow for four weeks. At this time observe the plant growth and root system development of all plants. Record observations. Discuss how soil drainage affects plant growth and root system development.

Instructional Strategies and Procedures

(continued)

1. Fill potting container 1 with soil. Block the drainage hole in container 2 and also fill with soil.
2. Plant 5 to 10 seeds (of the same type) in each container at the same depth and spacing.
3. Water container 1 until water flows through the drainage hole. Note the amount of water used.
4. Water container 2 using the same amount of water applied to container 1.
5. Place both containers in a good growing location.
6. Using steps 3 and 4 as a guide, water each container as required for optimum growth.
7. As plants grow during the next four weeks, thin them according to the size of the potting containers.
8. At the end of four weeks gently remove the plants from both containers. Carefully wash the soil from the roots. Compare plant growth and root system development. Note your observations on page 3.

■ **Results**: In a few weeks you will note differences in the size, color, and vigor of the plants in the two potting containers. Plants require adequate amounts of water *and* oxygen for good growth. Since the plants in container 1 had adequate drainage, they received proper amounts of oxygen from the soil. Therefore, these plants show better growth and root system development (see Figure 1). On the other hand, the plants in container 2 did not receive adequate drainage or oxygen from the soil. This accounts for their small size and poor root system development (see Figure 2).

Key Questions

1. Since viewing this demonstration, what do you think are possible benefits of artificial drainage?
2. What causes wet soils?
3. How does moisture affect root system development?
4. How can drainage tile correct what nature has failed to do?

Evaluation

■ Ask students to draw conclusions based on what they have observed. Relate observations to field conditions and their effect on crop yield.

Bibliography

Donahue, R.L., et. al. *Our Soils and Their Management*, 6th ed. Danville, IL: Interstate Printers, 1990

Experiment submitted by Randy Crowl, Production Agriculture Instructor, Pike-Delta-York High School, Delta, OH 43515.

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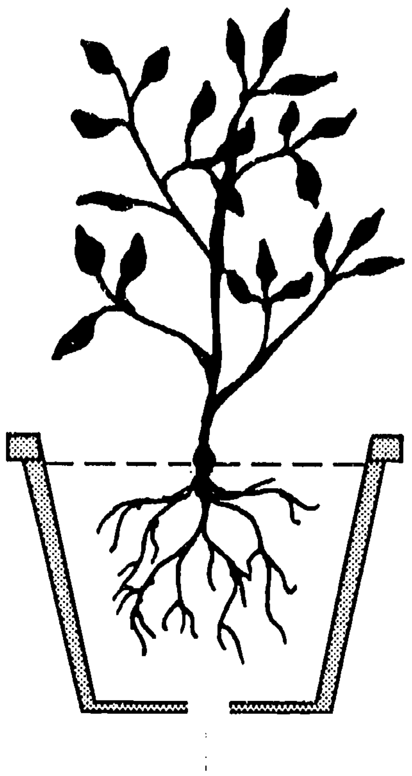
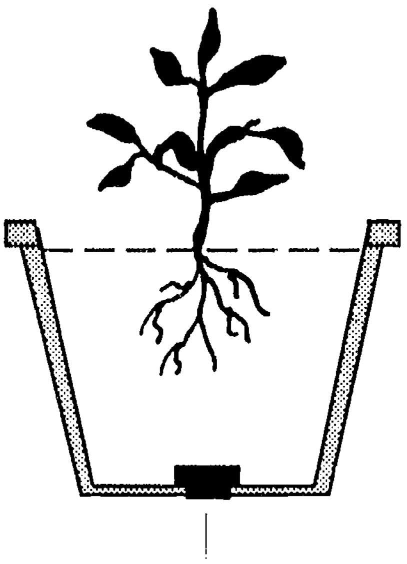
Container 1



drainage hole is open

Figure 1. This plant had adequate drainage and shows good plant growth and root system development.

Container 2



drainage hole is blocked

Figure 2. This plant had inadequate drainage and shows poor plant growth and root system development.

DATA RECORD AND OBSERVATION SHEET

Name ________________ Date ________ Period ______

Determining the Effects of Soil Drainage on Plant Growth and Development

Objective

Procedure

Observations and Results

Conclusions

Agricultural Subjects

- Plant Science
- Soil Science

Activity Length

- One class period is required for set-up; four to six weeks are required for growing plants. During this time the plants are to be maintained (watered and thinned).

Group Size

- This activity can be conducted with an entire class or small groups.

Science Principle

- **Growth restriction**: A typical soil sample is 45 percent mineral matter, 5 percent organic matter, 25 percent air space, and 25 percent water. Soil compaction causes the air and water content to decrease; thus, restricting plant growth and root system development.

Agricultural Application

- New farm equipment is larger and heavier than equipment used in the past. Consequently, as farmers use this new equipment more frequently in their fields, soil compaction increases. In turn, increased soil compaction reduces plant growth and root system development. Therefore, agriculture students must have a basic understanding of soil compaction principles in order to recognize, avoid, and correct any soil compaction problems they may encounter.

Agricultural Education Science Activity -- No. PS-2

Determining the Effect of Soil Compaction on Plant Growth and Development

Student Objective

- To determine the effect of soil compaction on plant growth and root system development.

Vocabulary

soil structure	soil particles	texture
soil conservation	erosion	soil tilth
compaction	mineral matter	organic matter
germination	nutrient	nutrient uptake
soil aggregate	plow layer	

Materials Required

1. Four one-gallon metal containers (available from school food service)
2. Drill or tool for making holes in bottom of each metal container
3. Fine-textured soil
4. Hydraulic press
5. Packing disks
6. Common field crop seeds (e.g., corn or soybeans)
7. Measuring container
8. Access to greenhouse or similar facility providing proper growing conditions (e.g., correct light, humidity, and temperature)

Instructional Strategies and Procedures

- **Overview**: Place equal amounts of soil in metal containers having good drainage. Using a hydraulic press, compact the soil in each container to varying degrees (except the control - no compaction). Place seeds in each container and cover with loose soil. Water all the containers on a regular basis with equal amounts of water. As plants grow, thin them according to container size. After four to six weeks, remove plants and note their growth and root system development. Record your observations. Discuss the effects of soil compaction on plant growth and root system development.

Instructional Strategies and Procedures

(continued)

1. Drill or punch an equal number of holes in the bottom of each one-gallon metal container to provide adequate drainage.
2. Place equal amounts of fine-textured soil in each container.
3. Using a hydraulic press and packing disks, vary the amount of soil compaction in each container (see Figure 1). For example:
   - Container 1 - no compaction (control)
   - Container 2 - a designated amount of compaction
   - Container 3 - twice the designated amount of compaction
   - Container 4 - three times the designated amount of compaction
4. Place seeds (of same type) on top of soil in each container. Cover them with enough loose soil to meet the desired planting depth (see Figure 2).
5. Place the containers in a location favorable for plant growth.
6. As the plants grow during the next four to six weeks, thin them according to the size of the containers.
7. Regularly water all the metal containers with equal amounts of water.
6. At the end of four to six weeks gently remove the plants from the containers. *Carefully* wash the soil from the roots. Compare plant growth and root system development. Note your observations on page 8-3.

■ **Results**: The plants grown in the control container are the largest and have the most developed root systems. However, the plants in container 2 are smaller and have less developed root systems. In turn, the plants in container 3 are even less developed. Finally, the plants in container 4 are the smallest and have the least developed root systems. This shows that as soil compaction increases, plant growth and root system development decrease.

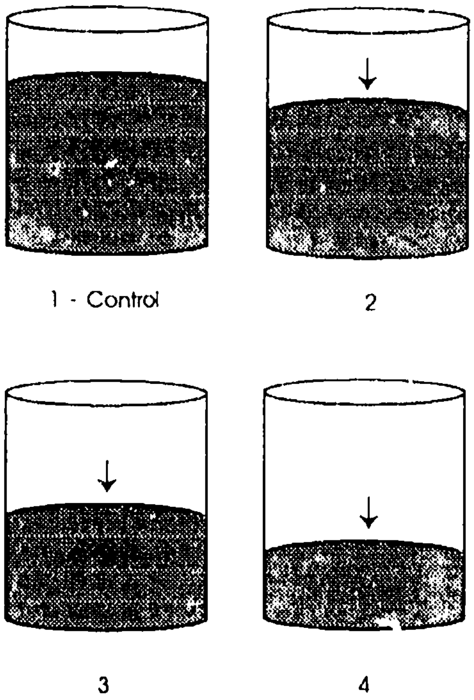


Figure 1. The soil in each container is compacted to varying degrees. (1 = no compaction; 4 = most compaction)

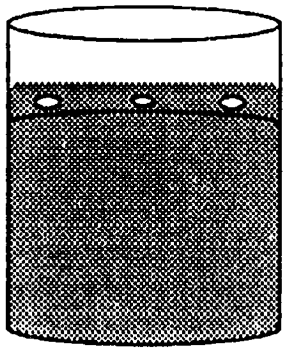


Figure 2. Place seeds on top of soil and cover with loose soil.

Key Questions

1. How is soil structure altered by compaction?
2. How does soil compaction restrict root system development?
3. How does soil compaction affect crop yield?

Evaluation

■ Ask students to compare results of demonstration.

Bibliography

Aldrich, S.R., et. al. *Modern Corn Production*, 3rd edition. Champaign, IL: A & L Productions, Inc., 1986.

Experiment submitted by Randy Crowl, Production Agriculture Instructor, Pike-Delta-York High School, Delta, OH 43515.

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DATA RECORD AND OBSERVATION SHEET

Name ______________________ Date ______________ Period ________

Determining the Effects of Soil Compaction on Plant Growth and Development

Objective

Procedure

Observations and Results

Conclusions

Inoculating Legume Seeds to Promote Nodule Formation

Agricultural Subjects

■ Plant Science and Nutrition

Activity Length

■ Approximately four weeks

Group Size

■ This activity can be conducted with groups of 8 to 15 students.

Science Principles

■ **Plant nutrition:** A plant's ability to attain and maintain maximum growth and development is directly related to the availability of essential elements.

■ **Symbiosis:** Two organisms working together for mutual benefit.

Agricultural Application

■ Plant nutrients are necessary to increase plant growth and production. Legume plants have the unique ability to meet their own nitrogen requirements through the process of nitrogen fixation. This nitrogen fixation occurs on the roots. It reduces the need and expense of applying commercial fertilizer to legume crops. Therefore, agriculture students need a basic understanding of this nitrogen-fixation process in order to economically raise healthy legume crops.

Student Objective

■ To determine that legume inoculation promotes nodule formation.

Vocabulary

nodule	inoculation	unifoliate
bacteria	embryo	trifoliate
nitrogen fixation	seed coat	radicle
symbiosis	leaf	epicotyl
germination	cotyledon	stem
hypocotyl	legume	stem tip
primary root	secondary root	

Materials Required

1. Viable soybean seeds
2. Sterile soil material or soil free of soybean bacteria
3. Two 12-ounce styrofoam cups
4. One 1" x 8" x 12" aluminum foil tray
5. Soybean inoculant
6. Water
7. Labels and pen
8. Access to good growing conditions (e.g., proper light, humidity, and temperatures between 50° and 86°F.)
9. Paper and pen for recording results

Instructional Strategies and Procedures

■ **Overview:** Fill several styrofoam cups with sterile soil material. Divide the soybean seeds into two equal groups. Inoculate one group of seeds. Plant both groups of seeds in separate cups and label each cup. After the seeds germinate, place the cups in sunlight. Fourteen days after emergence, examine plant roots for nodules. Record observations and discuss results.

Instructional Strategies and Procedures

(continued)

1. Punch five or six drainage holes in the bottoms of two styrofoam cups. Number each cup (1 and 2) and fill with sterile soil material to within one inch of rim.
2. Now, divide seeds into two equal groups (groups 1 and 2). Discuss the seed parts (see Figure 1).
3. Inoculate the seeds in group 1. (Follow the directions on the inoculant package.) *Do not* inoculate the seeds in group 2.
4. Next, plant the inoculated seeds in cup 1 and the noninoculated seeds in cup 2. Plant all seeds 1 1/2 inches deep in the prepared cups. (Label each cup indicating whether the seeds are inoculated or not.)
5. Water the soil in each cup. Keep the soil moist, but not saturated. (Soybean seeds must be 50 percent moisture to germinate.)
6. When the seeds germinate, place the cups in sunlight. (At this point cups can be placed in an aluminum pan containing water. Capillary water movement will irrigate roots.) Discuss the plant parts shown in Figure 2.
7. Fourteen days after emergence gently remove the seedlings from the soil. Use water to *carefully* rinse the soil off the roots. Examine the plants for nodules. If not handled carefully, the nodules can dislodge from the roots.

■ **Results:** Seeds germinate in five to seven days. Fourteen days after emergence, nodules form on inoculated plants. The inoculated plants that are permitted to continue growth produce nodules greater in size and number than those previously examined.

Key Questions

1. What is a legume?
2. What fixes the nitrogen for the legume?
3. What is a nodule's function?
4. What is symbiosis?
5. What precautions need to be taken when seeds are inoculated?
6. What financial benefits result from legume seed inoculation?

Evaluation

- Test knowledge of vocabulary words and seed/plant parts.
- Ask students to visually evaluate nodule development on inoculated plants as compared to non-inoculated plants.

Experiment submitted by Ray Griffith, Production Agriculture Instructor, River View High School Warsaw, OH 43844.

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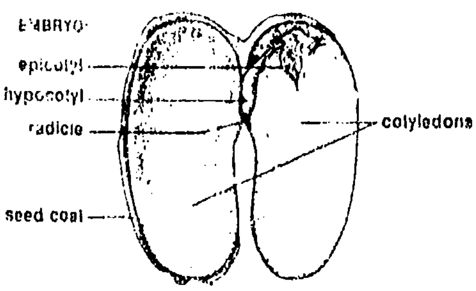

Figure 1. The parts of a halved soybean seed

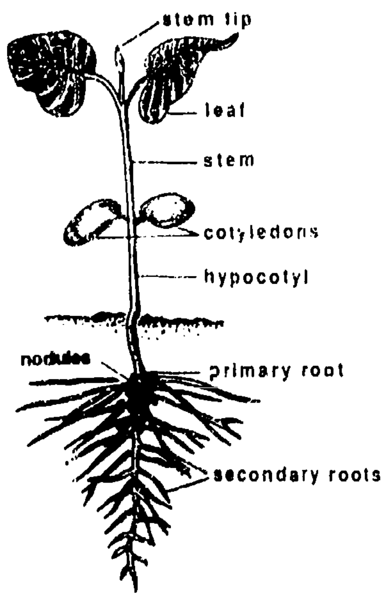

Figure 2. The parts of a soybean seedling approximately one week after emergence

Bibliography

1. Fridline, Clarence, and Charles Miller. *Plant Growth and Development - Transparency Masters*. Columbus, OH: The Ohio State University, Ohio Agricultural Education Curriculum Materials Service, 1989.
2. *Ohio Agronomy Guide*, 12th ed. Ohio Cooperative Extension Service, The Ohio State University, Bulletin 472. Columbus, OH: 1988.
3. Scott, Walter O., and Samuel Aldrich. *Modern Soybean Production*, 2nd ed. Champaign, IL: S & A Publications, Inc., 1983.

DATA RECORD AND OBSERVATION SHEET

Name ______________________ Date ______________ Period _______

Inoculating Legume Seeds to Promote Nodule Formation

Objective

Procedure

Observations and Results

Conclusions

Propagating Plants

Agricultural Subjects

■ Plant Science

Activity Length

■ One to two weeks, depending on the plant being propagated.

Group Size

■ This demonstration can be conducted with the entire class or small groups (2 to 3 students).

Science Principle

■ **Reproduction** - Living things are able to reproduce their own kind from a part of themselves.

Agricultural Application

■ There are many ways of **propagating** or reproducing plants. The most common method of reproducing flower, vegetable, and cereal crops is by seeds. However, plants that are not produced directly from seeds, or do not produce seeds that will grow, need another method of exact reproduction. To produce exact duplicates of these plants, asexual reproduction is used. This is not a sexual process and no seeds are used in this method. Instead, the plant is propagated from one of its parts, such as the leaf, stem, or root.

Student Objective

■ To propagate one or more plants asexually using the leaf or stem.

Vocabulary

asexual	propagate	rooting hormone
sexual	lateral	rooting media
rooting	perlite	rootstock

Materials Required

1. Parent plant material from which to take cuttings (e.g., ivy geranium)
2. Plastic bag for storing cuttings
3. Labels and marking pen
4. Propagating knife
5. Propagating container (flat, pot, or similar item)
6. Rooting medium (sphagnum moss, perlite, or sand)
7. Rooting hormone
8. Watering can
9. Plastic cover or sprinkling system
10. Paper and pen

Instructional Strategies and Procedures

■ **Overview**: Make 10 to 12 plant cuttings. Treat half of the cuttings with a rooting hormone. Then place all of them in rooting medium. Develop conclusions and write them on the board. Discuss the effects of using different types of cuttings (ranging from geraniums to semi-hardwoods).

Safety Note: Rooting hormones are acids! Wear rubber gloves when working with all chemicals. Do not allow the chemicals to touch your skin.

Instructional Strategies and Procedures

(continued)

1. Fill the propagating container with rooting medium. (Discuss why cuttings are not placed in water for rooting.)

2. Collect the plant cuttings from ivy geraniums or similar flowers. Take each cutting from a young, healthy plant. Using a sharp propagating knife, make a basal cut below the nodes (see Figure 1). (Discuss why a sharp knife is used.) Do not allow the cuttings to dry out.

3. Treat half of the cuttings with a rooting hormone. Rooting hormones are either mixed with a talc and used as powders, or dissolved in liquid and used as a wet dip. Liquid dips penetrate the plant stems better than powders. However, when using these dips adjust their strength by diluting them with water. Follow the recommendations on the label. All rooting hormones should also use a fungicide such as *Captan* to keep the cuttings from rotting. (*Captan* also promotes faster rooting.) Chemicals most commonly used are indolebutyric acid (IBA) and naphthaleneacetic acid (NAA). *Rootone* is a common rooting hormone. Many woody plants require some assistance with the rooting hormone for the majority of the cuttings to root successfully. It should also speed the development of geranium and similar plant roots by a couple of days. However, they would not need the hormone to develop roots.

4. Insert each cutting in rooting medium (see Figure 2).

5. Water to settle the medium around the cutting.

6. Label the rooting container.

7. Control the atmosphere around the cuttings by covering with plastic or placing them under a mist system.

8. After one week remove one treated plant and one untreated plant. Gently rinse each plant to remove the rooting medium.

9. Observe the root development and record on page 4.

10. Repeat observation daily until no significant difference between the two plants is noted or until all the plants have been checked.

■ **Results:** The plants treated with rooting hormone will produce root shoots much faster than the untreated. Eventually there will be no significant difference between the root shoots of the treated plants and the untreated plants.

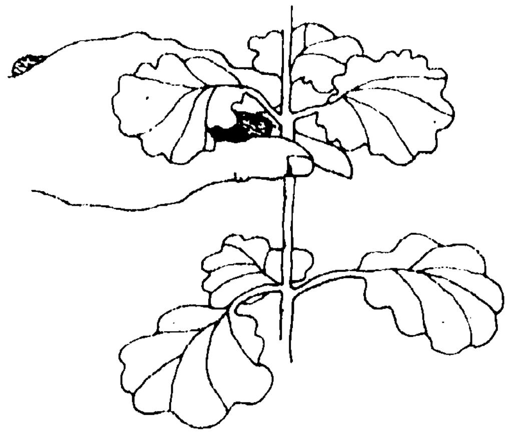

Figure 1. Using a sharp knife, make a basal cut below the nodes.

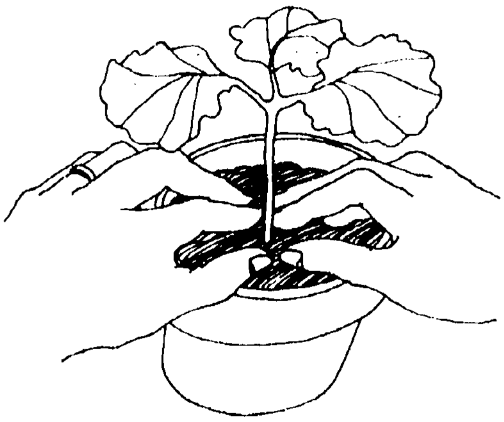

Figure 2. Insert the cutting in the rooting medium

Key Questions

1. What is asexual plant propagation?

2. What type of plants are usually propagated asexually?

3. Why is it necessary to propagate plants asexually?

4. What parts of the plants can be used for propagation?

Bibliography

1. Reiley, H. E., and C.L. Shry (Jr.). *Introductory Horticulture*. Albany, NY: Delmar Publishers, Inc., 1988.

2. Wells, R.N. Owner-operator, Wells Greenhouses, Inc., Warsaw, OH: personal interview.

Evaluation

- Ask the students to write a report based on what they have observed.

Experiment submitted by Robert Buxton, Agriculture Education Instructor, River View High School, Warsaw, Ohio 43844.

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DATA RECORD AND OBSERVATION SHEET

Propagating Plants

Name ______________________ Date __________ Period ______

Date	Plants with Rooting Hormone (Note root development)	Plants without Rooting Hormone (Note root development)

Agricultural Education Science Activity - No. PS-5

Determining the Effects of Rhizobium Japonicum and Nitrogen Fertilizer on Nodulation and Plant Growth

Agricultural Subject

- Plant Science

Activity Length

- Three to four weeks

Group Size

- This activity can be conducted with an entire class or small groups (2 to 3 students).

Science Principles

- Symbiotic relationship between bacteria and plants
- Inoculation
- Nitrogen fixation of legumes

Agricultural Application

- Nodules formed on soybean roots in a symbiotic relationship with the bacteria Rhizobium japonicum have the ability to fix atmospheric nitrogen into a form the plant can use. This is an important nitrogen source for the soybean plant. Therefore, agriculture students need a basic understanding of the effects of rhizobium japonicum and nitrogen fertilizer on nodulation and plant growth.

Student Objective

- To determine the effects of rhizobium japonicum and nitrogen fertilizer on nodulation and plant growth.

Vocabulary

vermiculite
symbiotic relationship
legumes
nitrogen fixation
rhizobium japonicum
inoculation
nodules
bacteria
vigor
nodes

Materials Required

1. Four six- to eight-ounce cups
2. Growing medium (vermiculite)
3. Sixteen soybean seeds (eight inoculated, eight not inoculated)
4. Labels
5. Fertilizer (e.g., *Hyponex* or *Rapid Grow*)
6. Paper and pen for recording results

Instructional Strategies and Procedures

- **Overview**: Plant 16 soybean seeds (8 inoculated, 8 not inoculated) in four cups. As seedlings grow, note growth differences. At end of four weeks examine seedling roots for nodules. Record data and discuss growth results.

Instructional Strategies and Procedures

(continued)

1. Punch small drainage holes in each cup.
2. Fill each cup with vermiculite to within one inch of the rim.
3. Plant four seeds one inch deep in each cup (see Figure 1). Label each cup with the type of treatment and the date. For example:
   - Cup #1 - inoculated, no fertilizer (today's date)
   - Cup #2 - inoculated, fertilizer (today's date)
   - Cup #3 - not inoculated, no fertilizer (today's date)
   - Cup #4 - not inoculated, fertilizer (today's date)
4. Place cups in trays. (Instructor should water and fertilize as needed. Use *Hyponex* or *Rapid Grow*. Apply fertilizer on top of soil; use recommended amount for plant environment.)
5. Allow time for all plants to reach 6 to 12 inches in height (3 to 4 weeks).
6. At the end of this time, note plant growth and record on page 4. Next, gently remove seedlings from cups. Carefully rinse roots with water until soil is removed. Count the number of nodules per plant for each treatment.
7. Record data on page 4 (e.g., plant height, number of nodes, number of nodules, and similar items). Also note plant vigor and the processes that took place (refer to **Science Principles** on page 1).

■ **Results:** See how closely your results resemble these *estimated* results.

	1 Inoculant, No Fertilizer	2 Inoculant + Fertilizer	3 Control (no treatment)	4 Fertilizer, No Inoculant
Plant height	7"	12"	11"	12"
# nodules/plant	16	2	0	0
Plant vigor	yellow and weak	very green and healthy	yellow and weak	very green and healthy
# nodes/plant	5	7	5	8

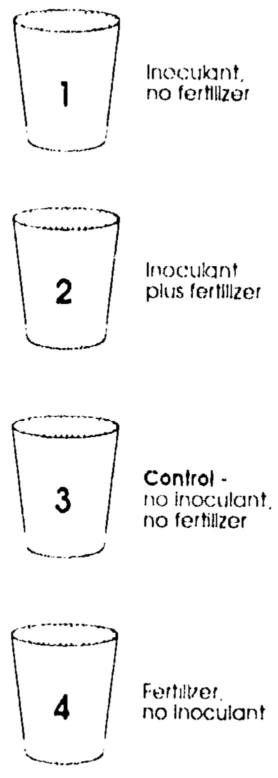

Figure 1. Plant seeds in each each cup as shown here.

Null Hypotheses

■ Inoculated seeds produce nodules.

■ Supplemental nitrogen produces healthier looking plants.

Key Questions

1. What did the rhizobium japonicum do for the plants that did not have nitrogen?
2. Which nitrogen source lasts longer?
3. How can we tell which nodules are actually working?
4. How are seeds inoculated?
5. What is nitrogen fixation?
6. Which nitrogen source acts more quickly?

Bibliography

1. *How a Soybean Plant Develops.* Iowa State University of Science and Technology Cooperative Extension Service, Special Report No. 53. Ames, IA: 982

   Publication and Distribution, 112 Printing and Publishing Bldg., Iowa State University, Ames, IA 50011 (Send orders here.)

2. Dr. William Wiebold, Assistant Professor. Agronomy Department, The Ohio State University, Columbus, OH. (personal interview, 1989)

Evaluation

■ Have students prepare a one- to three-page report of the experiment in scientific form. This report should include a data table, discussion, and conclusion.

Experiment submitted by Dan Fulk, Production Agriculture Instructor, Northwestern High School, West Salem, OH 44287.

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DATA RECORD AND OBSERVATION SHEET

Determining the Effects of Rhizobium Japonicum and Nitrogen Fertilizer on Nodulation and Plant Growth

Name ______________________ Date ____________ Period ________

Treatment	Date	Plant Height	Number of Nodules per Plant	Plant Vigor	Number of Nodes per Plant	Process(es) Taking Place
1 Inoculant, No Fertilizer						
2 Inoculant + Fertilizer						
3 Control (no treatment)						
4 Fertilizer, No Inoculant						

Agricultural Subject

■ Plant Science

Activity Length

■ Five weeks. Weekly observations are required after seedling emergence.

Group Size

■ This activity can be conducted with an entire class or small groups (2 to 3 students).

Science Principles

■ Plant growth and development from germination through flowering and seed development.

■ Plant regeneration: regrowth of plant parts after damage to original parts.

Agricultural Application

■ Corn and soybean crops planted early may be subjected to a late spring frost. When the frost is severe enough to damage foliage, the farmer must decide to replant or wait for regrowth. The point of growth can aid in this decision. Therefore, agriculture students need a basic understanding of possible frost and hail damage in order to make educated decisions about recovering damaged crops.

Determining Effects of Frost/Hail Damage on Plant Growth

Student Objectives

■ To assess plant damage caused by frost or hail.

■ To determine the importance of growth point positions as related to future plant growth.

Vocabulary

vermiculite	foliage	cotyledons
axillary buds	vigor	emergence
growth point	frost damage	regeneration
germination		

Materials Required

1. Two planting flats
2. Growing medium (vermiculite) for each flat
3. Twelve corn seeds
4. Sixteen soybean seeds
5. Scissors or razor
6. Labels
7. Fertilizer
   - starter fertilizer for germination (6-12-12)
   - additional fertilizer thoughout remainder of growing period: 6 ounces of liquid fertilizer OR *Hyponex* or *Rapid Grow*
8. Paper and pen for recording results

Instructional Strategies and Procedures

■ Overview: Plant three hills of corn (designate one as a control) and four hills of soybeans (designate one as a control). After growth has begun, simulate frost damage by cutting plants as instructed. Make periodic observations. After five weeks compare plant growth to control groups. Discuss results.

Instructional Strategies and Procedures

(continued)

1. Fill each flat with vermiculite to within one inch of the rim.

2. Plant three hills of corn and four hills of soybeans (four seeds in each hill). Plant seeds 1 1/2 inches deep.

3. Label each flat with its number, type of seeds planted, and planting date. (Instructor should water and fertilize plants over the next five weeks. Use a starter fertilizer for germination. Then use a liquid fertilizer throughout the remainder of the growing period.)

4. When all plants have emerged from the vermiculite, simulate frost damage by removing plant parts with a razor or scissors. Use the following guidelines when cutting plants:

   CORN
   Hill 1 - At the beginning of the fourth week, cut off the plants from below the oldest (lowest) leaf (see Figure 1).
   Hill 2 - At the beginning of the fifth week, cut off the plants from ground level (see Figure 2).
   Hill 3 - No cutting (control group)

   SOYBEANS
   Hill 4 - At the beginning of the third week, cut off only the cotyledons (see Figure 3).
   Hill 5 - At the beginning of the fourth week, cut below the cotyledons. Remove all of the plant parts above these cuts, including the cotyledons (see Figure 4).
   Hill 6 - At the beginning of the fifth week, cut above the cotyledons. Remove all of the plant parts above these cuts *except* the cotyledons (see Figure 5).
   Hill 7 - No cutting (control group)

5. Record procedures and observations on pages 4 and 5. Include plant height, number of nodes/leaves, growth location, and similar items Also indicate plant vigor and the growth processes that took place (refer to **Science Principles** on page 1). Compare this data to the control groups.

■ **Results:**

CORN

Procedure	Results
4th week - Cut off the plants from below the oldest leaf.	The plants grow with vigor, but not as well as before damage occurred.
5th week - Cut off the plants from ground level.	The plants die.
Control - no cutting	Plants grow very vigorously.

Figure 1. Hill 1: cut off the plants below the oldest leaf.

Figure 2. Hill 2: cut off the plants at ground level

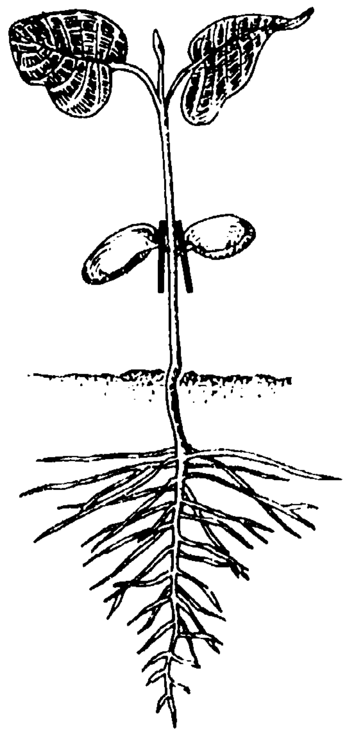

Figure 3. Hill 4: cut off only the cotyledons.

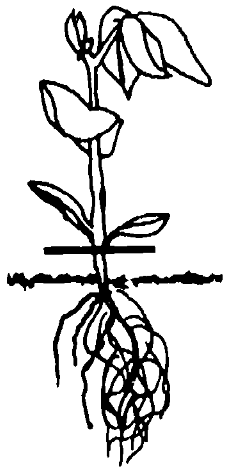

Figure 4. Hill 5: cut off the plants from below the cotyledons.

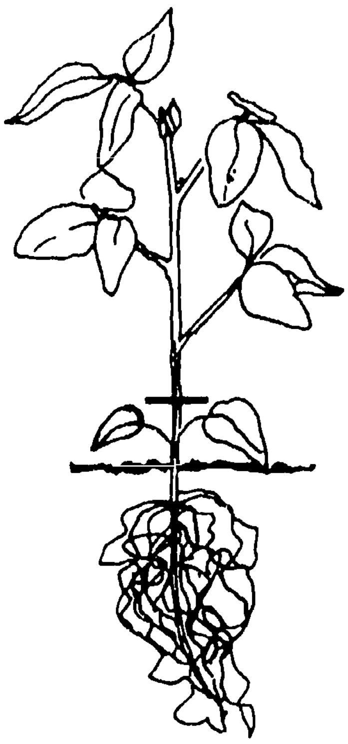

Figure 5. Hill 6: Cut off the plants from above the cotyledons; leave the cotyledons.

Null Hypothesis

■ A soybean or corn plant will survive if the growth point is not damaged or if it has axillary buds.

Evaluation

■ Have students prepare a one- to two-page report and a summary of their findings. They should include economic factors such as planting cost, seed, sufficient growing season remaining, and similar items.

■ **Results:** (continued)

SOYBEANS

Procedure	Results
3rd week - Cut off only the cotyledons.	Plants continue to grow, but at a lesser rate.
4th week - Cut off plants from below cotyledons.	Plants die.
5th week - Cut off plants from above cotyledons.	The plants grow 2 stems from the axillary buds. Plants grow vigorously. (Regeneration occurs.)
Control - no cutting	Plants grow very rapidly.

Key Questions

1. At the fifth week the soybeans were cut above the cotyledons. Where did growth occur?
2. Where is the soybean plant's growth point at the fourth week?
3. The soybean plant will not regrow after frost damage at the fourth week. Why not?
4. Where is the corn plant's growth point at the fifth week?
5. What other factors may prevent a soybean plant from emerging?

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DATA RECORD AND OBSERVATION SHEET

Determining Effects of Frost/Hail Damage on Plant Growth

Name ______________________________ Date ______________ Period ________

Hill Number and Crop	BEGINNING OF 4th WEEK List Procedures and Note Observations	BEGINNING OF 5th WEEK List Procedures and Note Observations	END OF 5th WEEK Note Observations
Hill 1 Corn			
Hill 2 Corn			
Hill 3 Corn (control)			

DATA RECORD AND OBSERVATION SHEET

Determining Effects of Frost/Hail Damage on Plant Growth

Name ______________________ Date ______________ Period ________

Hill Number and Crop	BEGINNING OF 3rd WEEK List Procedures and Note Observations	BEGINNING OF 4th WEEK List Procedures and Note Observations	Beginning of 5th WEEK List Procedures and Note Observations	END OF 5TH WEEK Note Observations
Hill 4 Soybeans				
Hill 5 Soybeans				
Hill 6 Soybeans				
Hill 7 Soybeans (control)				