Lesson A3–2

Propagating Plants Sexually

Unit A. Horticultural Science

Problem Area 3. Plant Propagation

Lesson 2. Propagating Plants Sexually

New Mexico Content Standard:

Pathway Strand: Plant Systems

Standard: **II:** Address taxonomic or other classifications to explain basic plant anatomy and physiology.

Benchmark: **II-A:** Examine unique plant properties to identify/describe functional difference in plant structures including roots, stems, flowers, leaves and fruit.

Performance Standard: **3.** Describe germination process and conditions.

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

1. Discuss the importance of sexual propagation of plants.
2. Describe the process of seed germination.
3. Describe the factors involved in planting seeds for transplanting.
4. Explain how to successfully direct seed outdoors.

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:

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

Reiley, H. Edward and Carroll L. Shry, Jr. *Introductory Horticulture,* Sixth Edition. Albany, New York: Delmar Publishers, 2002.

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

Ball, Vic. *Ball RedBook,* Sixteenth Edition. Batavia, Illinois: Ball Publishing, 1998.

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

Boodley, James W. *The Commercial Greenhouse,* Second Edition. Albany, New York: Delmar Publishers, 1998.

Hill, Lewis. *Secrets of Plant Propagation*. Pownal, Vermont: Garden Way Publishing, 1985.

Ingels, Jack E. *Ornamental Horticulture: Science, Operations, and Management,* Third Edition. Albany, New York: Delmar Publishers, 2001.

Plant Propagation Video. San Luis Obispo, California: Vocational Education Productions, 1987.

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of student lab sheets
Supplies and/or materials for student laboratory activities

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

Direct seeding
Dormant
Embryo plant
Germination
Hybrid
Indirect seeding
Medium
Planting date

Scarification
Seedling plant
Sexual reproduction
Stratification
Turgor
Viability
Vigor
Zygote

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.

Bring to class several varieties of blooming plants such as geranium or petunia. If plants are not available use a flowering plant seed catalog that contains color pictures of plant varieties. Ask students about the significance of variety. How does it happen? How has genetic variation impacted our world food resources?

Show students a variety of bean seeds. What do the seeds have in common? What is different about them? How does germination unlock the 'secret' within each seed?

Summary of Content and Teaching Strategies

Objective 1: Discuss the importance of sexual propagation of plants.

Anticipated Problem: How does the ability to sexually produce seeds benefit a plant?

I. ***Sexual reproduction*** in plants involves the union of the male pollen with the female egg and results in the formation of a seed. Sexual reproduction enables a plant to produce new combinations of genetic information that may add to the vigor of the developing young plant.

   A. Most plants reproduce their own kind in nature through sexual reproduction that forms some type of seed. A seed is a living entity that serves as a bridge between generations of a plant.

   B. The ***embryo plant*** is a little plant that eventually grows and develops into a mature plant. This embryo plant along with a source of stored food is inside the seed. The seed contains essentially all that is necessary for the growth and development of the embryo plant into a seedling plant. The seed contains the embryo plant, endosperm (the stored food) and is surrounded by a protective shell, the seed coat.

   C. The embryo plant within a seed is the result of a fertilized egg or ***zygote***. The genetic information from the male sperm and female egg are combined in the zygote that develops into the embryo plant.

D. The embryo plant that results from this new combination of genetic information is known as a ***hybrid***. Agricultural crops have been greatly improved through hundreds of years of hybridization.

E. Seeds are designed to wait until the conditions are favorable to begin growth. Therefore, the embryo plant is in a ***dormant*** or resting phase while inside the seed.

Many techniques can be used to help students master this objective. Use TM: A3–2A to help illustrate the germination and development of the embryo plant. Pre-soaked lima beans can be easily opened to view the embryo plant within. Use TM: A3–2B to help students understand the genetic combinations that produce a hybrid plant. Encourage students to discuss the impact of hybrid corn and other crop plants on world food resources and economy.

Objective 2: Describe the process of seed germination.

Anticipated Problem: What is germination and what conditions are necessary for germination to occur in a seed?

II. Germination is the end of the period of dormancy for the embryo plant that occurs when favorable conditions are present for growth and development of the seedling plant. The ***seedling plant*** has a root system, stem, and leaves to produce the food necessary for the young actively growing plant.

A. This process by which an embryo plant inside the seed changes into a developing seedling is known as ***germination***. Many important crops are grown from seed. For example corn, soybeans, cotton and vegetables are all started from seeds. It is important to have a high percentage of the seeds germinate.

B. Some plants produce seeds which germinate immediately, others produce seeds that remain dormant, perhaps for years, until the conditions are correct.

C. Germination is a complex process that begins when favorable conditions exist for the survival of the developing seedling plant. The conditions for germination are adequate warmth, moisture, and oxygen.

D. The first important step in germination is usually the absorption of water. Water enters the seed by diffusion. The moisture triggers several important processes. Water also causes the seed to expand and create pressure within the seed. This pressure, known as ***turgor***, causes the rupturing of the tough seed coat. Through this split in the seed coat will emerge the primary root or radicle, which will later form the root system of the plant.

E. The water also stimulates the production of plant hormones that begin the process of digestion to provide energy for the embryo plant. In addition, growth hormones cause mitosis (cell division) that results in formation of the radicle or first root that emerges from the seed to absorb water and nutrients for the embryo.

F. Seeds germinate at a wide range of temperatures. The temperature range is from 32 to 104°F, with the optimum range for most seeds being between 65 and 80°F. The germination temperatures are as unique to the plant as the environment in which it is surviv-

ing. Some plants require very warm germination temperatures and other plants must have cool temperatures.

G. All seeds need oxygen to germinate. The oxygen is necessary for the aerobic respiration necessary for the growth and development of the embryo plant. It is important that the soil not be too wet because it will not have sufficient space for oxygen resulting in death of the embryo plant within the seed.

H. Seeds of some plants need exposure to light before they will germinate. Other plants produce seeds that do not need light to germinate or germinate poorly when exposed to light.

I. Two additional mechanisms affect germination in certain plant seeds. The first is ***stratification*** which is a required period of cold temperature. This is especially important for plants that produce their fruit in the fall. If the seeds of these plants (i.e. apple, pear) germinated immediately they will die from the cold winter temperatures. These plants survive by producing seeds that remain dormant and will not germinate until the warmer temperatures of spring. The second mechanism is ***scarification*** that results in breaking down the seed coat. The tough protective seed coat prevents diffusion of both water and oxygen into the seed. The seed coat must be broken before germination can begin. Plants have evolved many interesting methods to accomplish this task. The seed coat can be damaged or broken by the acid produced in the animal stomach, soil micro organisms, repeated freezing and thawing, mechanical stress from the grinding in the gizzard of birds, being stepped upon, chewed etc.

Many techniques can be used to help students master this objective. There are many activities to demonstrate germination, from very simple (radish seeds on a moist filter paper inside a petri dish) to more complex activities such as LS: A3–2A. Use TM: A3–2C to help students understand the flow of steps involved in the germination process. Use TM: A3–2D to illustrate to students the various ways in which seeds can be subjected to scarification. The incredible force of turgor can be demonstrated by filling a common jar of any size with lima beans (LS: A3–2B). Then add sand to the jar, filling the jar to the top. Add water to the jar until all the sand is wet and screw on the lid tight. Place the jar in a paper bag and set aside. Within a few hours the turgor pressure within the seeds will cause the glass to fracture.

Caution: The fractured glass has sharp edges. Allow students to view the fractured glass. Discuss the amount of force necessary to so perfectly fracture the glass and what purpose this force plays in germination

Objective 3: Describe the factors involved in planting seeds for transplanting.

Anticipated Problem: What factors should be considered to successfully grow seeds indoors from seedlings to mature plants?

III. Seeds can be planted indoors until they grow into seedlings that are then transplanted into larger containers or a permanent location outdoors. This is called ***indirect seeding***. The primary factors that affect germination and growth of plants indoors are moisture, temperature, oxygen and light.

A. It is important to start with good quality seed. The quality of seed used is very important. Quality seed should produce the desired or expected plant. It should also be clean or free of dirt, weed seeds and chaff. Seed quality includes both viability and vigor. ***Viability*** is the ability of seeds to germinate under optimum conditions. Quality seed should have high viability of over a 75 percent germination rate. ***Vigor*** is the ability of seeds to germinate under different conditions and still produce healthy seedlings. Commercial seed is often graded according to size to aid in planting.

B. Seed production is an important link in insuring quality seed for the next generation of plants. Individuals or commercial seed producers must harvest and collect seeds either mechanically or by hand. The seed must then be cleaned and stored. Most seed is stored cool and dry and usually for a period of one year. Seed is tested for percent germination and labeled for the consumer. Many state and federal laws regulate the shipment and sale of seeds.

C. Seeds can be planted indoors to increase the length of the growing season, increase production and for economy of space. The seeds may be planted in flats or containers of germinating medium. The germinating ***medium*** is the material which is a source of nutrients and holds the roots in place for the growing plant. Start with clean containers with drainage holes. Level the medium and moisten it before planting the seed. Label the flat with the seed variety and the date seed was sown.

D. Sow the seed in rows to reduce the spread of disease. In flat planting, the rows or shallow furrows may be about two inches apart and the seeds are planted closely. Plant the seed at the recommended depth and if recommended cover the seed with medium.

E. Maintain the proper temperature. The recommended temperature for most seed germination is between 55 and 70°F.

F. Water seed flats lightly from the top using a sprayer or mister. It is recommended that the water be barely warm never hot, nor cold. Cover seed flats with poly or glass to maintain moisture level and humidity. Remove the covering once the seeds start to germinate.

G. The developing seedlings require higher amounts of oxygen. The germination medium must be porous or contain air spaces. Avoid over-watering of seed flats. Over-watering and lack of proper drainage reduce the oxygen level by filling the air spaces with water.

H. Seedlings should be transplanted when the first true leaves are fully developed. A few days before transplanting, the root systems should be pruned. Use a knife to cut through the soil medium between each row in both directions. This will confine the roots of each plant to its own area and encourages them to branch. When transplanting, care should be used in handling seedlings. Seedlings should only be held by their leaves and not by their stems.

I. Transplanting is a shock to the plant seedling and should be done soon after the first true leaves develop. Use care when lifting the plants from the flats and when transplanting into containers. Make a hole with a dibble, stick, or forefinger in the new location and place the seedling in the hole at a depth slightly below the former depth. Compress the medium lightly around the root and stem of the seedling. After transplanting, the

seedlings should be watered and placed in the shade to help prevent wilting. After recovery from wilting the plants should be placed in proper lighting and watered to promote good root growth.

A number of activities are available to help students in gaining mastery of this objective. The recommended resources have a good deal of information on this objective. LS: A3–2A and LS: A3–2C may be used to help students understand seed viability. If at all possible students should have the opportunity to prepare, plant, and care for a seed flat.

Objective 4: Explain how to successfully direct seed outdoors.

Anticipated Problem: What factors determine the success of plants grown from the direct seeding method?

IV. Many flowers, vegetables, and grass seeds are planted directly into the soil outdoors into their permanent location. This method is called ***direct seeding***. Factors that should be considered when direct seeding are: site selection, seed bed preparation, planting date, planting depth and spacing, and care of the seedlings.

A. The site should have sufficient light for the plants to grow. Soil drainage is important and water should drain from the soil surface after a rainfall.

B. The soil needs to be loose, fine textured, and not compacted to allow for adequate moisture and aeration in seed germination and growth. Seed beds should also be free of weeds that compete with the seeds for moisture, oxygen and sunlight.

C. The ***planting date*** is the date to plant seeds that is determined by the germination temperature required by the seeds. Timeliness of planting may be extremely important for some crops. Planting date is also influenced by the time of maturity, harvest dates of vegetables and peak bloom dates of flowers.

D. Seeds should be sown at recommended planting depths and spacing. A general rule, if the planting depth is unknown, is to plant seeds at a depth of three to four times their greatest thickness. Many commercial crops have very specific row spacing to allow for machine cultivation. For example, sweet corn is planted in rows 30 to 40 inches apart. Width of tractor tires, type of cultivator, length of sprayer booms and the manner of harvesting are some considerations when determining spacing of crops.

E. The seedling plants that emerge in outdoor plants need a sufficient supply of moisture, oxygen, nutrients and light. It is also important to control weeds to prevent competition from the weeds for these essential needs.

Many techniques can be used to help students master this objective. Have students plan a flower or vegetable garden including the site selection, steps for seed bed preparation, planting dates, and planting depth and spacing. Seed catalogs can be used to find important information for many flower and vegetable seeds.

Review/Summary. Use the student learning objectives to summarize lesson. Have the students explain the response to the anticipated problem of each objective. Student response can be used to determine which objectives need to be reviewed.

Application. Application can involve the following student activity. Students may plan, plant, transplant and care for a flat of annual plants.

Evaluation. Evaluation should focus on student achievement of this lesson objectives. Various techniques can be used, such as student performance on the application activity. The self-check section at the end of each chapter in the suggested references will be helpful. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1. j 2. i 3. f 4. d 5. g 6. h 7. a 8. e 9. b 10. c

Part Two: Completion

1. direct seeding
2. Transplanting
3. dormant
4. Scarification
5. zygote
6. turgor
7. seedling

Part Three: Short Answer

1. The advantage of hybridization is desired traits of different parent plants can be combined in the offspring.
2. Water is necessary for seeds to germinate. At the same time, seeds need oxygen to germinate. Seeds need optimum temperatures. They may also have light requirements.
3. By starting seeds in a greenhouse early, growers can extend the length of the growing season.
4. a. plants that are difficult to transplant.
   b. plants that are easy to germinate and grow from seed.

Sample Test Name_____

Test

Lesson A3–2: Propagating Plants Sexually

Part One: Matching

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

a. germination
b. medium
c. planting date
d. indirect seeding
e. embryo
f. sexual reproduction
g. viability
h. hybrid
i. stratification
j. vigor

_____ 1. The ability of seeds to geminate under different conditions and still produce healthy seedlings.

_____ 2. The process whereby the seed must go through a period of cold temperature to germinate.

_____ 3. Reproduction of plants by seeds.

_____ 4. Seeds are planted in containers, to be transplanted to larger containers or to a permanent location outdoors.

_____ 5. The ability of seeds to germinate under optimum conditions.

_____ 6. The offspring of genetically different parents.

_____ 7. The resumption of growth by a seed embryo that results in a seedling plant.

_____ 8. A miniature plant contained within the seed.

_____ 9. The material in which plants are grown that provides support and nutrients for the plant.

_____ 10. The date when seeds are planted determined by the germination temperature of the seed.

Part Two: Completion

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

1. Many seeds are planted directly into the soil outdoors into their permanent location. This method is called _____.

2. _____is the moving of seedlings from the seed bed and setting them into the ground.
3. When the life cycle of a plant is slowed or inactive, the plant is said to be _____.
4. _____is the breaking or softening of a seed coat to allow the absorption of water.
5. The fertilized egg resulting from the union of nuclei of sperm and egg cells is also known as the _____.
6. The force that water pressure creates against the seed coat is _____.
7. A young plant grown from a seed is a _____.

Part Three: Short Answer

Instructions. Provide information to answer the following questions.

1. Explain the advantage of hybridization.

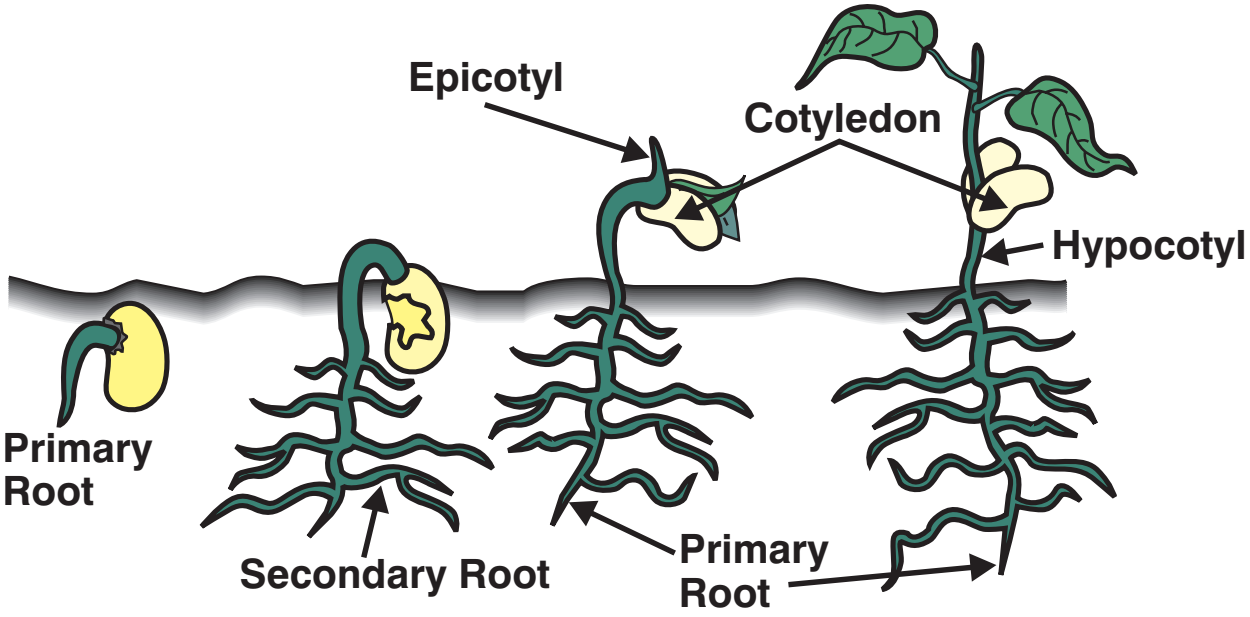
2. What factors are involved in seed germination?

3. What are the advantages of planting seeds for transplanting?

4. List two situations where direct seeding would be the most practical.

TM: A3–2A

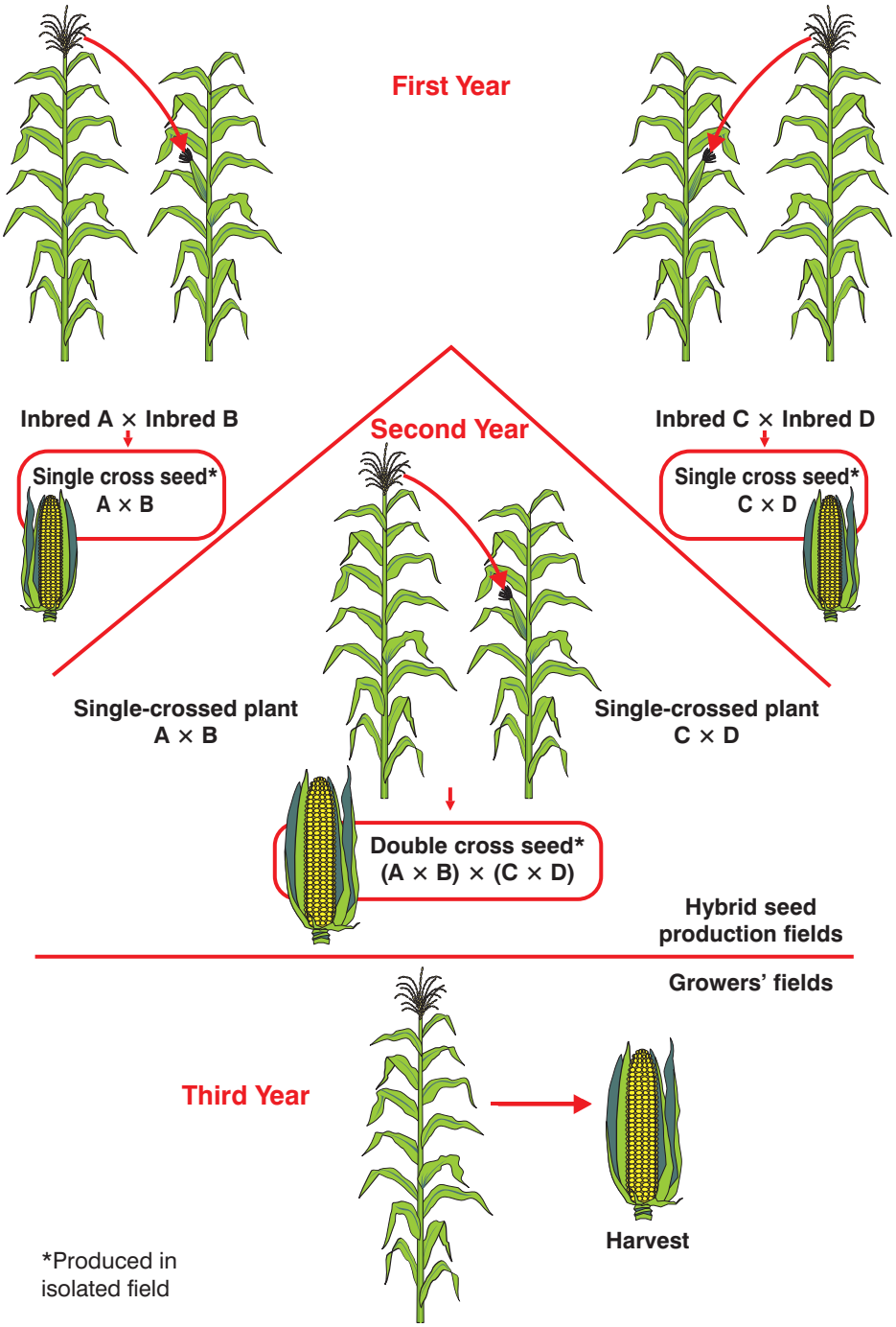
DEVELOPMENT OF AN EMBRYO PLANT



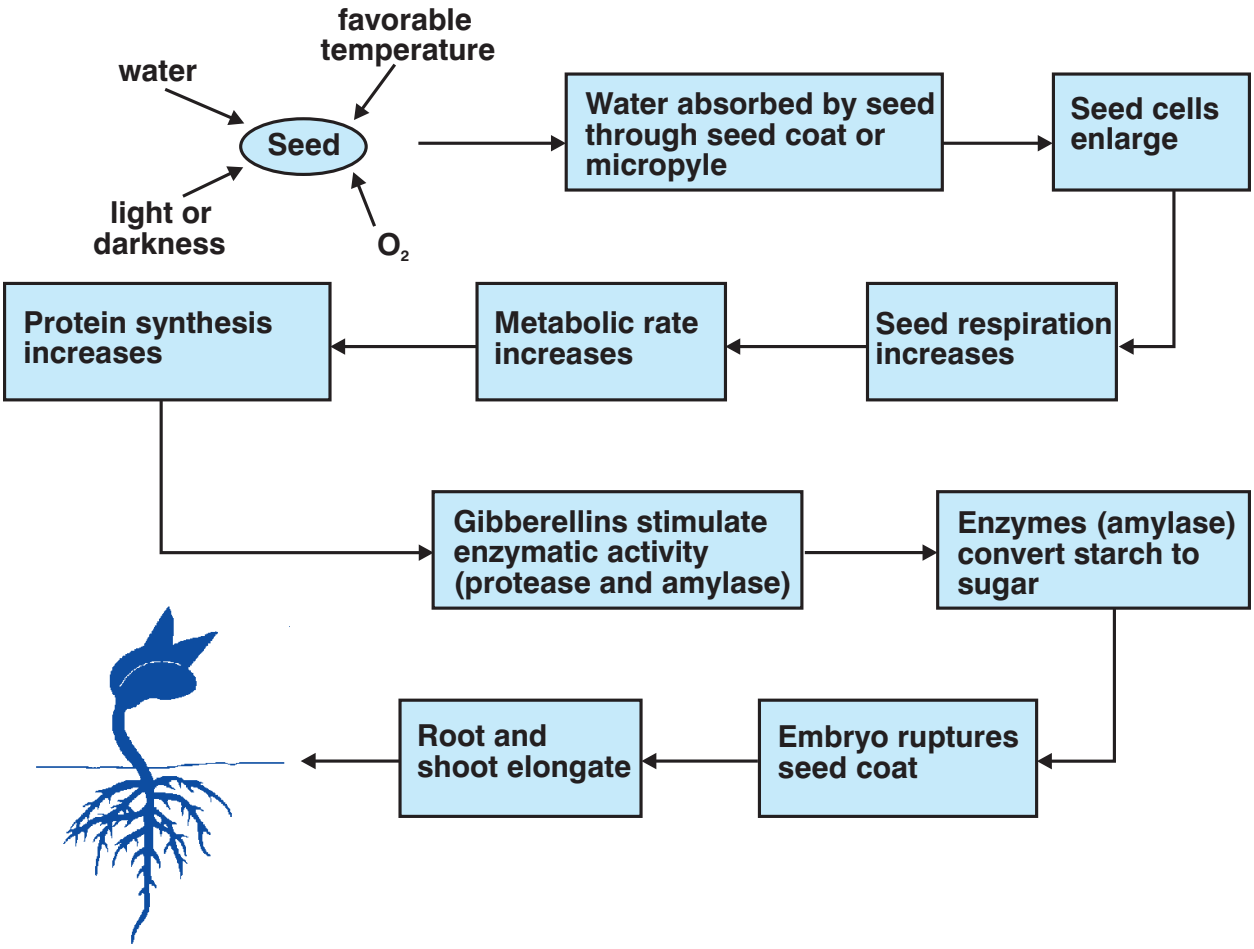
(Courtesy, Interstate Publishers, Inc.)

TM: A3–2B

DOUBLE-CROSS HYBRIDIZATION OF CORN



THE GERMINATION PROCESS



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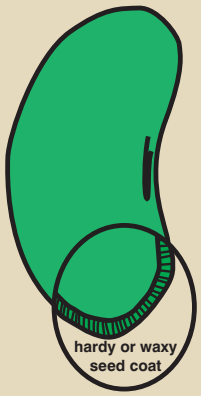
TM: A3–2D

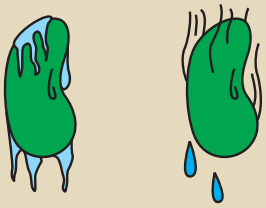
SCARIFICATION



The seed coat must be weakened to allow water and oxygen to enter the seed.

ACTIONS BY NATURE

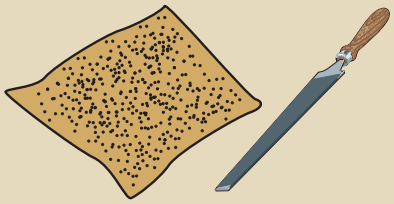
Microbial Activity (bacteria, fungi, etc.)



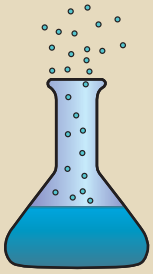
Freezing and Thawing

Animal Digestion

ACTIONS BY HUMANS



Sandpaper and File



Acid

Pressure and Force

Name_____

Lab Sheet

Warm Germination Test

Background Information:

Germination of seed is a critical step in the process of seedling establishment, whether in field crops, lawns, gardens, or greenhouse crops. The production of high quality seed is a tedious and expensive process. Seed quality is primarily a matter of the germination potential of the seed. All commercially produced seed is subjected to a trial germination test. Nearly all crop seed purchased is certified seed, which means it has met established standards for overall quality and germination percentage. Several tests have been developed to estimate the germination potential of a seed lot, but the warm germination test is the universally accepted procedure for estimating germination percentage.

Purpose:

The purpose of this experiment is to determine the viability of various seed samples using the standard warm germination test.

Materials:

Paper towels
Zip-lock plastic bags (gallon size)
100 seeds of each sample to be tested
water
rubber bands

Procedure:

Place two layers of moistened paper towels on a table and evenly space 25 seeds from the sample to be tested on top of the towels.

Cover the seeds with another two layers of moistened paper towels.

Fold over each edge of the towels about one inch, then roll the towels and enclosed seeds into a tube (called a rag doll).

Make three more rag dolls containing 25 seeds each for a total of 100 seeds. Place a rubber band around the top and bottom of each rag doll. Insert the rag dolls into the plastic bags to prevent moisture loss. Place the rag dolls upright at room temperature. If moisture loss occurs, re-water as necessary. Count the number of germinated seeds after 3, 5, and 7

days. The seventh day observation is the number used for recording final germination percentage. The germination percentage should be calculated for each observation and projected on graph paper.

In addition, for corn seeds count the number of germinated seeds that have a primary root length of at least one inch after seven days. Calculate the percentage of seeds meeting this standard.

Name_____

Lab Sheet

Turgor: the Force of Osmotic Pressure

Background Information:

Good seed germination is a result of careful execution of a number of proven procedures in seed bed preparation and planting. Germination may be reduced or delayed if these practices are not followed.

In greenhouse conditions soil/media characteristics are controlled. In field conditions, soil type cannot be modified. Thus, growers adjust the crops to be grown. Naturally heavy soils can lead to problems in planting, cultivating, and other soil disturbing operations. Due to the weight and compaction of some soils, germination may be less than desirable. A seed bed with many large clods or rocks may also hinder germination by obstructing seedling emergence. Soils with a hard surface crust, due to hot, dry conditions will have the same effects on germination. Finally, planting dept interacts with soil conditions, with deeply planted seeds failing to germinate or establish seedlings when soil conditions are undesirable.

Materials:

Lima bean seeds
Dry sand
Pint jar with lid
Large pan or plastic tub

Procedure:

Fill the jar with the dry lima bean seeds.

Add sand to the jar.

Shake the jar to mix the sand and beans completely.

Fill the jar to the top with sand.

Wet the sand, filling the jar to the top with water.

Screw the lid on tightly (it does not have to be air tight) and place the jar in a large pan or tub in an area away from people. (Note: The jar will not explode.)

After a few hours observe what has happened to the jar.

Name_____

Lab Sheet

TZ Test for Seed Germination

Purpose:

The purpose of this experiment is to determine the viability of seed using the TZ test.

Materials:

Samples of seed to be tested (10–20 seeds of each type, sweet corn works very well)
1 gram of 2,3,5 triphenyl tetrazolium (TZ)
a small container to soak seeds
single-edged safety razor
paper towels
magnifying lens (optional)
thermometer
hot water bath or temperature-controlled growth chamber

Procedure:

Soak seeds in warm water at a temperature of 85–100°F (29–38°C) for about two hours. A longer soaking time will not harm the seed. However, if the temperature exceeds 100°F, the live embryo within the seeds may be killed. Cut the seeds to be tested lengthwise through the center to expose the full length of the germ (embryo).

Place one-half of each sectioned seed immediately in a 1% solution of TZ. Discard the other half of the seed. Warm the solution to 85–100°F and let the seeds soak for 30 minutes to one hour. Alternatively, leave the solution at room temperature and let the seeds soak for two to four hours.

Remove the seed halves from the solution and wash several times in cool water. Enough water should be retained after the final washing to completely cover the seed. Examine the seeds for color changes. All actively respiring parts of the germ become red or pink. The more staining, the higher the degree of enzyme activity. The endosperm and all dead parts do not change color. When the entire germ of the seed is red, the seed is alive and capable of germinating. Use the illustrated guide for the **Tetrazolium Test for Seed Viability in Corn** to estimate the viability of the seeds tested.