UNIT VI - PLANT TECHNOLOGIES

Lesson 1:   Traditional Plant Breeding

Competency/Objective: Describe traditional plant breeding processes.

Study Questions

      1.   What is natural crossbreeding?

      2.   What is selective breeding?

      3.   What are the advantages and disadvantages of selective breeding?

      4.   What is a hybrid?

References:

      1.   *Biotechnology: Applications in Agriculture (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1998, Unit VI.

      2.   Activity Sheet

            a)   AS 1.1:   Hybrids and Their Offspring

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TEACHING PROCEDURES

A.   Introduction

The selection of plants based on phenotypes has been going on for thousands of years. When humans stopped roaming the land and settled in one area, plants that were useful were planted in large quantities and allowed to breed naturally. People then began to notice that some plants were more productive than others, so they saved and grew seeds from these plants, beginning the practice of selective breeding. A major advance in selective breeding occurred in 1922 with the introduction of hybrid seed corn. In the mid-1990s, the first genetically modified crops were introduced, and a new era of plant breeding began.

B.   Motivation

Pioneer, DeKalb, and CIBA Seeds are well-known companies that have prospered by developing and marketing selected plant crosses. The sale of seed from these crosses, or hybrids, has yielded many billions of dollars over the last fifty years. These companies spent large sums of money in the 1920s and 1930s on plant breeding programs. In the 1990s, companies like Monsanto have invested billions of dollars in purchasing and developing gene patents and gene transfer technology. Why have companies like Monsanto made these investments?

C.   Assignment

D.   Supervised Study

E.   Discussion

1.   Review the parts of a flower, and ask students to recall the ways in which plants reproduce.

What is natural crossbreeding?

a)   Natural crossbreeding is a reproductive process in which two plant varieties, which have different genotypes, sexually reproduce without human intervention.
b)   It allows the random mixing of genes within a species.

2.   Ask students to define what selective breeding is in the livestock industry. Relate this definition to selective plant breeding.

What is selective breeding?

a)   Selective breeding is the process of identifying plants with desirable traits and causing them to reproduce.
b)   Selective breeding can be done asexually or sexually.
c)   Plants are selectively bred mainly for two reasons.
    1)   To increase the production of the useful parts of the plant
    2)   To increase the ability of a plant to withstand harsh environments, disease, and plant pests

3.   Compare the advantages and disadvantages of selective animal breeding to those of selective plant breeding.

What are the advantages and disadvantages of selective breeding?

a) Advantages
1) The occurrence of desired plant traits can be increased, especially traits that can raise crop yields.
2) The performance of a crop is more predictable since the crop of seeds is more uniform.
b) Disadvantages
1) The occurrence of undesired traits may be increased.
2) The genetic diversity of a crop species is reduced.
3) Crop plant uniformity can increase insect problems.

4. Ask students why nearly every producer who plants corn uses hybrid corn. Have students speculate about what a hybrid plant variety is.

What is a hybrid?

a) A hybrid is a plant produced by crossing two inbred lines of plants that are greatly different genetically.
b) Breeders use three common methods of hybrid development.
1) Single cross - crossing one inbred plant with another
2) Three-way cross - crossing a single cross with another unrelated inbred plant
3) Double cross - two single crosses are crossed
c) A hybrid displays extra growth vigor, or hybrid vigor (heterosis); however, it usually either is sterile or produces offspring that do not perform well.

F. Other Activities

Purchase Wisconsin Fast Plants and use them to show several types of selective breeding. Wisconsin Fast Plants grow and produce seed in a very short time so that several generations can be seen in a matter of a few weeks.

G. Conclusion

Since the mid-1980s, the yields of hybrid crops have not increased significantly, which has led some economic analysts to state that traditional hybrids have reached a limit in production capability. The fact that hybrid seed companies are focusing heavily on gene transfer technology for future profit potential further confirms this analysis. Some people disagree with the rationale of this new focus, but this group seems to be in the minority. Traditional plant breeding processes will undoubtedly be used in the development of new generations of crop seeds, but the real advances in yield and other desirable crop traits will most likely come from recombinant DNA technology.

H. Answers to Activity Sheet

Students will need guidance as they work through the activity sheet questions. The answers to these questions will vary, but some suggested answers are listed below.

1. How do the growth rates of a hybrid compare with the growth rates of the F_2 of a hybrid?

2. This information will vary but should reveal that F_2 generations of hybrids do not perform as well and that plant-to-plant variations are quite high.

3. Answers will vary but the given hypothesis must be measurable.

4. The experimental group should be defined as the F_2 hybrid group and should consist of a stated number of seeds. The control group is the hybrid seed group; it should also consist of a stated number of seeds.

5. Performance can be measured by the growth of the plant in millimeters per day, the change in the circumference of the stem in millimeters per week, germination rate, and nutrient uptake.

6. Examples include light, temperature, humidity, water, wind/chemical/insect stresses, etc.

7. Answers will vary.

I. Answers to the Evaluation

1. c
2. d
3. d

4. The occurrence of undesired traits may be increased, the genetic diversity of a crop plant population is reduced, and crop plant uniformity can increase insect problems.

5. To increase the production of the useful parts of the plant and to increase the ability of a plant to withstand harsh environments, disease, and plant pests

6. Natural crossbreeding is a reproductive process in which two plant varieties, which have different genotypes, sexually reproduce without human intervention.

7. A hybrid is a plant produced by crossing two inbred lines of plants that are greatly different genetically.

EVALUATION

Circle the letter that corresponds to the best answer.

1.   Selective breeding can be defined as the:

    a.   Process of sexual reproduction of a plant in which pollen from a plant fertilizes the eggs of the same plant.
    b.   Crossing of two inbred lines of plants.
    c.   Process of identifying plants with desirable traits and causing them to reproduce.
    d.   Reproductive process in which two plants with different genotypes reproduce sexually without human intervention.

2.   Of the three common methods of producing a hybrid seed, which involves crossing two unrelated inbred plants and then breeding the result with another unrelated inbred plant?

    a.   Hybrid cross
    b.   Single cross
    c.   Double cross
    d.   Three-way cross

3.   Selective breeding is:

    a.   A sexual process.
    b.   An asexual process.
    c.   Neither a sexual nor an asexual process.
    d.   A sexual or an asexual process.

Complete the following short answer questions.

4.   What are two disadvantages of selective breeding?

5.   Why is selective breeding done?

6.   What is natural crossbreeding?

7.   What is a hybrid plant?

Lesson 1:   Traditional Plant Breeding   Name _____

Hybrids and Their Offspring

Objective: Design an experiment that will test the idea that hybrids produce inferior offspring.

For this activity, work in groups assigned by your instructor and design and perform an experiment that will accurately test your hypothesis about the performance of hybrids (F_1) and their offspring (F_2). Use seed collected from a field of hybrid corn and seed from a bag of the same hybrid seed. Whether the offspring of hybrids is "inferior" will be measured by the growth rate of the two groups of plants from emergence to a specified height or length of time as well as the diameter of the stalk, germination rate, and rate of nutrient uptake. The questions below will help guide you through the design of the experiment. Data should be collected periodically until the experiment is completed.

1.   What is the problem statement, or what information is desired?

2.   List any information that can be collected about the problem.   (Hint: check textbooks and the Internet, call a seed salesperson, etc.)

3.   State your hypothesis.

4.   Define your control and experimental groups. You must consider the size of the groups carefully.

        Experimental group:

        Control group:

5.   How will the observations be measured?

6.   What environmental controls will be used to ensure that the seed is the only variable in this experiment? (Hint: list the factors that affect the growth rate, and then explain how each factor will be kept the same for the control and experimental group.)

7.   What will be the schedule for conducting the experiment? When will observations be made and data be collected?