Edition 4 (2020)

AGsploration
The Science of Maryland Agriculture

UNIVERSITY OF MARYLAND EXTENSION

Persistent Pests

GOAL STATEMENT:

Students will explain how repeated pesticide exposure can cause an insect population to develop resistance over time due to natural selection.

OBJECTIVES:

- Students will collect, graph, and analyze data.
- Students will simulate the effects of repeated pesticide application to an insect population.
- Students will explain how pesticide resistance can change the makeup of an insect population over time.

REQUIRED MATERIALS:

- Photographs of insect damage to agricultural plants ((available at https://extension.umd.edu/agsploration/download-curriculum)
- Copies of 3-page activity sheet packet (1 per student)
- Light-colored beads (1 cup per group)
- Dark-colored beads (1 cup per group)
- Small plastic container or paper lunch bag (1 per group - To make the simulation more visual/ realistic, you may want to print out aerial photos of a cornfield and tape them into the bottom of the plastic containers or to the sides of the paper bags.)
- Colored pencils (optional) and straight edges for creating bar graphs

AMOUNT OF TIME TO ALLOW:

60 minutes. Extension activities will take additional time.

Background Information

Many things can affect **crop yield**, the amount of a crop that is produced in a growing season. Weather conditions, pests, and diseases are the primary factors that can negatively affect crop yield. **Pests** are plants and animals that negatively affect plant health, quality, and yield. Farmers strive to reduce pest damage to crops, often using pesticides to control weeds, insects, and plant diseases. **Pesticides** are specially-formulated chemicals that suppress or kill plant pests that damage crops. **Insecticides** are pesticides that kill insects and **herbicides** are pesticides that kill weeds.

There are many kinds of pesticide products available, and pesticides have been widely used by farmers over the past several decades. However, some pesticides have become less effective over time due to the development of resistance to the pesticide within pest populations. Pesticide resistance develops in response to repeated exposure to the same pesticide chemical. Many pest species develop pesticide resistance. (The same type of resistance develops in bacterial populations, causing the development of antibiotic-resistant bacteria.) The following example will illustrate this concept using insects as an example. Most insects are naturally susceptible to pesticides, but due to natural genetic variation a small number of individuals in an insect population may naturally possess genetic resistance. When a pesticide is applied, the susceptible insects are killed but the resistant insects are not. These resistant insects reproduce and pass down the resistance genes to their offspring. Over time, as susceptible insects are killed and only resistant insects are left to reproduce, the insect population becomes entirely resistant. Pesticides (insecticides) that were once effective have no further action on the insect population.

Because pesticide resistance can become a problem, farmers do not rely solely on chemical pesticides to control pests. Instead, many farmers use an approach called **Integrated Pest Management (IPM)**. Pesticides are only one tool within an IPM program; other techniques include use of non-chemical practices such as tilling, rotating crops, and releasing natural predators of the pest. The IPM approach is more effective than the use of chemical pesticides alone and also reduces the likelihood that pesticide resistance will develop.

Engagement

10 minutes

Show several photographs of crops with insect damage to the class. the students what words come to mind as they look at the photographs. Allow them to share ideas. You may want to show a video to emphasize how insects can damage crops. The Northeast IPM channel on YouTube has several short clips in a series called “Tracking the Brown Marmorated Stink Bug.”

Lead the discussion to the concept that insects can reduce the amount and quality of food harvested by farmers. Because farming is a business, farmers try to harvest and sell the maximum amount of food per acre. As a result, modern farming in the United States usually relies on pesticides.

Ask the students if there could be any drawbacks to using pesticides. Allow them to share ideas. Explain that pesticides kill insect pests such as stink bugs that damage crops like tomatoes and squash. However, pesticides can also harm beneficial insects such as ladybugs and beetles that are predators and eat pest nsects. Modern farming uses integrated pest management (IPM) which relies on a numerous techniques that help to reduce the quantities of pesticides applied to farm fields.

Exploration

30 minutes

1. Divide the students into small groups. Distribute copies of the activity sheet packet. Provide each group with a cup of dark-colored beads, a cup of light-colored beads, and a container (paper lunch bag or plastic dish).
2. Explain to the students that their group's container represents a farm field on which crops are being grown. The dark and light beads represent different-colored insects of the same species that eat the crop growing on their field. Have the students count out 100 light-colored beads and 100 dark-colored beads and mix them together in their field container. (You may reduce the number of beads to accommodate a younger audience or if time is limited.)
3. Explain that groups will simulate application of a pesticide to their field to control the insect pests. When a pesticide is applied, it comes into contact with some of the insects in the field. In this simulation, we assume that the pesticide reaches half of the insects in the field. Have one student in each group reach into the field container and remove about half of the group's "insects," the ones that came into contact with the pesticide. Have the students count these insects and record their results (numbers of light- and dark-colored beads) on their data charts.
4. Explain to the students that most insects that come in contact with the pesticide will be killed, but because of natural genetic variation in most populations a small number may be naturally resistant and will survive. In this simulation, the light-colored insects will die; have students return these to their original cup. The dark-colored insects survive because they have a thick, waxy coating over their bodies that helps them repel the chemical. Each survivor of the spraying reproduces by having one baby. Have the students double surviving dark-colored insects and add them back to the field container. For example, if 37 dark insects survived, 37 additional dark insects should be taken from the cup and added to the field container for a total of 74 put back into the container. *(Note: To simplify the counting required for the simulation, we are ignoring the fact that in real life all of the insects in the field would reproduce, not just the insects that survive coming into contact with the spray.)*
5. Have the groups repeat the procedure to simulate sprayings 2, 3, 4, and 5.
6. After the simulation is complete, have the students separate the beads by color and return them to their original cups.
7. Have the students use their data to plot bar graphs of the number of light and dark insects that came in contact with the pesticide following each spraying. They should also answer the questions on the final page of their worksheets.

Explanation

20 minutes

Use the questions on the student worksheet to guide a class discussion of why the insect population changed. Explain that the natural resistance in the dark-colored insects gave them a selective advantage, meaning that they survived and reproduced more than the light-colored insects. If pesticide applications were to continue, the proportion of dark-colored insects would continue to increase. Resistance is developed via natural selection, the process during which individuals that are best adapted to survive differentially pass on their adaptive traits to their offspring. This is an example of emodern-day evolution because the population's genetic makeup has changed over time as a result of natural selection.

Extension

Ask the students to suggest possible alternatives to repeated spraying of a pesticide. Suggestions might include switching pesticides, rotating crops, releasing pest predators, etc. Many farmers use an Integrated Pest Management (IPM) system which utilizes a variety of pest management techniques in conjunction with pesticide application.

Allow the students to research pests and pest management techniques using the University of Maryland Home and Garden Information website (extension.umd.edu/hgic). You might want to develop a list of agricultural pests that affect crops in your area and have individual students or groups research the pests and manangement techniques.

Career Connections

Pest management is an essential career field for the agricultural industry. Below are descriptions of careers related to pest management.

- **Entomologist** – This is a scientist who studies insects, recommends techniques for controlling insect pests, and suggests ways to attract beneficial insects such as predators that eat insect pests.
- **Integrated Pest Management Specialist** – This person studies and recommends a wide variety of techniques that can be used to control insect and plant pests. The goal is to minimize costs to farmers and quantities of pesticides applied.
- **Biotechnologist** – A biotechnologist may genetically engineer crops to make them resistant to pesticides or insect pests.
- **Soil Scientist** – Soil scientists study and specialize in soils. With regard to pest management, they often monitor pesticide residues in the soil. They may also provide recommendations that help farmers and homeowners enrich their soils and improve plant defenses against insect pests.

Evaluation

Student understanding can be evaluated through class discussion or assessment of completed activity data sheets. The following questions may also be used to evaluate student learning.

1. What is a pesticide? Why is it used?
2. Explain how pesticide resistance develops in a population.
3. What steps can farmers and homeowners take to prevent pesticide resistance from developing?

References

Maryland Agricultural Education Foundation, Inc., <www.maefonline.com>.

University of Maryland Home and Garden Information Center, <extension.umd.edu/hgic>.

Persistent Pests

Name: _____

Date: _____ Period: _____

Goal:

Simulate the effects of pesticides on an insect population and observe how the population changes over time.

Materials:

- cup of light-colored beads
- cup of dark-colored beads
- plastic container or paper lunch bag
- colored pencils and rulers

Background:

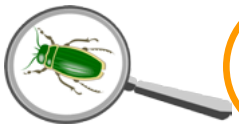
Agriculture is an important industry. Farmers work hard growing food for people and animals. Unfortunately, some insect pests eat many of the same crops. Large numbers of insects eating crops in a field can reduce the amount of food harvested by farmers. Plant pests also compete with crop plants. Because farming is a business, farmers try to harvest and sell the maximum amount of food per acre. As a result, modern farming in the United States usually relies on pesticides, chemicals that kill pests and increase crop harvests. (specifically, "insecticides" kill insects and "herbicides" kill plants.)

In the same way that people are genetically different from each other, insect populations also have natural genetic variation. In a given insect population, most insects may be killed by a pesticide but a small number may be naturally resistant and will not die. This activity will let you simulate how pesticides can affect an insect population. In the activity, dark-colored individuals have a gene for a waxy coating that helps them survive when exposed to the chemical.

Directions:

1. Get into your lab group and listen carefully as your teacher explains the activity.
2. Count 100 light-colored beads and 100 dark-colored beads (which represent insects of the same species that are different colors) and place them in the container which represents your farm field. Mix the beads together.
3. Have one member of your group reach into the field container without looking and remove about half of the insects. We are assuming that the pesticide comes into contact with half of the insects in the field. Count the number of light- and dark-colored insects removed and record your results on your data chart.
4. The light-colored insects die when they come into contact with pesticide; return these to their original cup.
5. The dark-colored insects are resistant to the pesticide; they survive and reproduce. Allow each dark survivor to have one baby by doubling the dark-colored insects: Add an equal number of dark insects from the supply cup. Put the dark insects and their offspring into the field container and mix them. (For example, if 37 dark insects survived place them and 37 more from the cup into your field container.)
6. Simulate the effects of sprayings 2, 3, 4, and 5 by repeating steps 3-5 above.
7. When the simulation is complete, separate the beads by color and place them in their original cups.
8. Use your data to make a bar graph of the number of light and dark insects taken from the field following sprayings 1-5. Be sure to label the axes on your graph.
9. Answer the questions on your data sheet.

Persistent Pests



Name: _____

Date: _____ Period: _____

Data Table

Pesticide Spraying Number	Number of Light Insects	Number of Dark Insects	Total Number of Insects Sprayed
1			
2			
3			
4			
5			

Graph: Effect of pesticide spraying on color distribution in an insect population.

Spray 1 **Spray 2** **Spray 3** **Spray 4** **Spray 5**

KEY

☐ Light-colored insects ☐ Dark-colored insects

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Name: _____

Date: _____ Period:_____

1. During the first pesticide application:

   A. How many light-colored insects came into contact with the pesticide? _____

   B. How many dark-colored insects came into contact with the pesticide? _____

2. During the final pesticide application:

   A. How many light-colored insects came in contact with the pesticide? _____

   B. How many dark-colored insects came in contact with the pesticide? _____

3. Describe how the populations of light and dark insects changed after repeated spraying of the same pesticide.

4. Explain *why* each color of insect increased or decreased over time.

5. Natural selection happens when there is genetic variation in a population. Some organisms are better able to survive than others and reproduce at a higher rate. How does this activity demonstrate natural selection?

6. Evolution is change in a population over time due to natural selection. Predict how the population will look if the farmer sprays the same pesticide five more times.

7. What other techniques could the farmer use to reduce insect pests without producing a pesticide-resistant population?