What practices can farmers use to minimize crop damage from harmful insects?

PROJECT PUMPKIN (gr 3-5)

Integrated Pest Management

(ILS 12A and 12B, 13A and B)

Overview

This curriculum explores the relationship between people and the food they eat. By growing pumpkins in a garden plot, the curriculum takes teachers and students through six features of sustainable agriculture that separate it from conventional farming. If the entire curriculum is completed, students will gain an understanding of sustainability and people's place in the food chain.

Sustainable Agriculture, for the purpose of this curriculum, shall be defined as "a system of food production, supported by consumers, where farming operations, practices and technologies work in harmony with the natural systems that sustain life on earth."

Suggested Grade Level

This curriculum is designed for 3rd through 5th grade levels. The topics covered can be built upon in complexity throughout that age range.

Approximate Time

The time required to complete this activity will vary greatly depending on the students' prior knowledge and their involvement in the project. Allot at least 45 minutes.

Objectives

1. The students will learn about various options available to farmers to reduce crop damage by harmful insects.
2. The students will learn that beneficial insects can be used to control harmful insects.
3. Students will learn some results from heavy use of synthetic pesticides.

Activity Abstract

In this activity, students are introduced to IPM. They use their knowledge to "create" harmful and beneficial insects, which they will present to the class.

Background Information

There are 32 orders, or groups, of insects. The largest order is the beetles (Coleoptera) with 125 different families and around 500,000 different species. Scientists estimate that 10% of the animal biomass of the world is ants, and another 10% is termites. This means that "social insects" are probably 20% of the total animal biomass of the earth. (Social insects are those that live in groups in which cooperation and specific "tasks" are necessary for the survival of the group, i.e., ants, bees, wasps, termites.)

Scientists believe that insects are so successful because their lightweight exoskeleton is a protective shell; they are small; most of them can fly.

Farmers and gardeners have had to deal with the effects of harmful insects for as long as people have been raising plants for food. As a result of research prompted by insect casualties during World War II, the early 1950's saw the development of synthetic pesticides, such as DDT that farmers started to depend on to get rid of various insects that were damaging or destroying their crops. Before this, they had used other forms of pest management, but they were looking for an easier, cheaper, more time efficient way to do this.

Development of synthetic pesticides revolutionized farming and led to a high dependence on chemicals for agricultural production. Formerly farmers had tolerated a minimal pest population but with chemicals they were able to aim for complete eradication. They abandoned former techniques such as rotating crops, encouraging natural enemies, selecting resistant varieties, and removing diseased plants. They planted only one crop on large acreage, leading to the evolution of pests that were resistant to the pesticides… and this led to the need for more pesticides. The chemicals had unintended consequences. These included poisoning the workers that handled the chemicals, harming the very insects that farmers depended for plant pollination, contaminating the air, food and water supply for humans and other animals, numerous health problems, evolution of pest resistance, reduction of natural control insects, and harming wetland food chains through run off water containing the pesticides.

Despite the statistical evidence supporting these negative results and the perceived need to reduce pesticide use, heavy pesticide use continues today. According to Mark L. Winston's <u>Nature Wars: People vs Pests,</u> "in 1993, 1.1 billion pounds of active pesticides were used in the United States, and 4.5 billion pounds world-wide…with the U.S. figure translating to about 4 pounds of pesticides for every man, woman, and child in America." (p. 11) Numbers are increasing annually.

Scientists have been researching alternatives to the use of the synthetic pesticides, which has lead to the development of a program called Integrated Pest Management (IPM), or alternative technologies. It has become identified as a least-toxic pest management scheme. The approach is not to eradicate pests but to use a "law of least intervention" that will tolerate a pest below a level where it will cause economic damage. Rather than follow one management strategy, multiple techniques are followed. It recognizes the complicated nature of biotic interactions and relies on extensive training for an effective IPM program. Winston calls for a "new pest ethic… to direct future pest management decisions away from chemicals and toward biological methods. Chemical pesticides should be the last method used for pest control, not the first. Pest control should aim to manage pests, not eradicate them. Only pests doing substantial damage should be managed, and only when their damage approaches an economically significant threshold." (p. 176)

Appendix B contains a list of IPM methods.

<u>Materials</u>

- Nature magazines to cut (optional)
- Paper
- Crayons, colored pencils, etc.

- Computer with internet access (optional) for further research

Procedure (Session 1)

1. **Tap prior knowledge.** Ask students what they know about insects and other "bugs." Keep a list on the board. Remind them to think about what they've learned in school, but also what they know from their outside experiences.
2. The list should be rather large – help students to organize their knowledge into categories, such as "insect body parts" "what insects eat" "what eats insects" "spiders" "bugs and people," "life cycles," etc. The class could use notecards to help them manipulate what they know. Appendix A contains a list of things that students may know, or that the teacher might want to add to the list – although the students may generate a much longer list.
3. Optional: have class cut pictures of insects and other bugs from nature magazines. Use them to glean more information about insects.

> **Teacher note:**
> If the students have little or no prior knowledge about insects, it may be necessary to complete a background lesson about basic insect characteristics. The My Own Food Chain (K-2) sustainable agriculture curriculum contains such an activity, "Introduction to Insects," or there are many available in the Internet or in books at the library.

4. **Share with a neighbor.** Ask students how insects help and hurt farmers. How might they help and hurt the class pumpkin patch?
5. **Introduce scientific principle.** Explain that farmers have long had to deal with the problems of controlling insects. Chemicals that first became available in the 1950s made killing bugs easy – but they had negative effects on birds and other creatures, humans, and the environment as well. As a result, people came up with methods of controlling insects that were more friendly to the environment. One method called Integrated Pest Management (IPM).
6. Appendix B lists several methods of IPM. Share as many of the examples with the students as desired.
7. Option: Share some IPM methods with the students and have them try to figure out why they work and what some downfalls might be.

> **Teacher note:**
> The game Farm-opoly, in the Crop Diversity activity from this curriculum, also addresses IPM! Relate if the class has already played!

8. **Hands-on activity.** Explain that students will work in teams to design a set of imaginary insects, one that is a pest for a crop, the other its opponent -- a beneficial insect for the crop. They will make up a crop that is threatened by pests and explain how the insect threatens the crop. Use the following questions to guide discussion and to help students plan the features of their particular insects: Does it chew, suck, bite and burrow, cause disease? What special adaptations does it have to live in its habitat? How does it move and defend itself? How does the beneficial insect control the pest? Does it lie in wait and ambush the pest? Is it camouflaged for this purpose? Does it capture the pest in flight as the robber fly does? What stage of metamorphosis is it in when it controls the pest? What part of its body does the job and how has it adapted to this?
9. Students may want to research real insects and the ways they ravage crops to get ideas for this activity.
10. Have students draw all stages of the life cycle as they imagine them to be for each insect they design.

11. NOTE: If this is too advanced for the students, an alternative is to design an imaginary insect , describing ways that it is adapted to its environment, whether it lives in water, in soil, wood, a cave, dry sand, etc. Describe what it eats and what might want to eat it; how it moves; how it defends itself; special adaptations it has for living in its habitat. Draw a picture of the insect in each stage of its life cycle, showing the metamorphosis to adulthood, whether complete or incomplete.
12. **Conclusion/Wrap-up.** Conduct a whole-class discussion that involves the various groups. First, have each team choose a spokesperson who will describe the rationale of the insect design, including answers to the questions generated in Session 3. Allow time for team input to each spokesperson. Once all teams have been heard from, have students group their invented insects into categories that would include various features named earlier. For example, group pictures of all insects with camouflage; those that fly; those that parasitize the harmful insect, etc. Have class draw conclusions about the importance of using beneficial insects instead of using pesticides for control.

Extensions

1. Play the game "Buggo" as a whole class review or as an informal assessment. You will need the "Buggo" Game Card, Vocabulary List, and Questions and Answers found in Appendix C (or make up your own!), along with paper chips made of construction paper, etc., to cover the "Buggo" squares. The game is similar to Bingo. Instead of numbers, students randomly fill in the provided vocabulary words in the blank spaces on the playing card. Stress that they should mix up the words or terms to make the game more fun. Decide in advance what constitutes Buggo---vertical lines, horizontal rows, four corners, "postage stamp" or other conventions from the game Bingo. Decide in advance the rules for winning, i.e., no chips to be added once a student calls "Buggo," whether to clear the card with every new Buggo winner or continue the game, etc. Use paper chips to cover over the answer spaces. Teacher will read the incomplete statement or question twice, observing as students think about and select answers. Names of winners can be listed on the board with simple prizes offered such as first dismissed from class, stickers, etc.
2. Students do research either in books (see references below) or the Internet to find out more about insects' compound eyes, then build a model of such an eye.(See Make It Work! Insects listed in the References).
3. For those really interested in insects, find out more about insect structure and build a model of one that illustrates that structure, such as a grasshopper.
4. Working with Fantasy Insects in Sessions 3 and 4, compile data with the class on the number of insects chosen for a variety of features. Have students work with the data to show mean, medium, mode, average, maximum and minimum.
5. Be prepared! Do specific research on pumpkin pest management.

References

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Eyewitness Books: Insect Laurence Mound. Ålfred A Knopf, New York 1990. (See for background information on insects).

Incredible Insects: Ranger Rick's NatureScope. National Wildlife Federation, McGraw-Hill, New York, 1998

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http://yahooligans.yahoo.com/content/animals/insects/
http://www.ivyhall.district96.k12.il.us/4th/kkhp/1insects/buginfo.html
www.sic.ucdavis.edu

"Insect Pest Management for Organic Crops." Calvin Fouche, Mark Gaskell, Steve T. Koike, Jeff Mitchell, Richard Smith.
http://www.ext.vt.edu/departments/entomology/ornamentals/beneficials.html

http://www.insectworld.com/user/itm/itm_display.asp?action=display_item&ItemID=60030010
(good selection of photos if you know the scientific name)

http://www.comnet.ca/%7Edefayette/newinsects/intro.htm facts about honeybees

http://tqjunior.thinkquest.org/3715/polin5.html

http://www.ent.iastate.edu/imagegallery/ good insect identification site

http://www.uen.org/utahlink/activities/view_activity.

http://www.howe.k12.ok.us/~jimaskew/binsect.htm#twopair insect order identifier, if you're curious about true bugs versus the common term bug.

http://animaldiversity.ummz.umich.edu/site/accounts/information/Arthropoda. Info on insect classification

http://www.pa.msu.edu/~sciencet/ask_073097.html How bees make honey

http://library.thinkquest.org/27968 detail about different body parts, predators, and life cycles of butterflies and moths.

http://www.enchantedlearning.com/subjects/butterflies/allabout/ All about butterflies and moths

http://www.insects.org/ insect appreciation

Appendix A: Insect Background.

- Between 75 and 95% of all animal species on the planet are insects. Millions of them can exist in a single acre of land. Over one million species have been discovered by scientists, and it is thought that there might be ten times more as yet unnamed. If weighed together, all insects would weigh more than all other animals together.
- Insects inhabited the earth 150 million years before dinosaurs and are impossible to eradicate. Humans must learn to live with them.
- All insects have three main body parts - a head, thorax, and abdomen.
- Insects have six jointed legs, two antennae to sense the world around them by feel, smell, or taste, and an exoskeleton ("outside skeleton" or hard outer shell).
- Insect mouthparts have evolved for chewing (beetles, caterpillars), piercing-sucking (aphids, true bugs), sponging (flies), sucking (moths), rasping-sucking (thrips), cutting-sponging (biting flies), and chewing-lapping (wasps).
- Their muscles and organs are on the inside. This multi-layered exoskeleton protects the insect from the environment and natural enemies. The exoskeleton also has many sense organs for sensing light, pressure, sound, temperature, wind, and smells. Sense organs may be located almost anywhere on the insect body, not just on the head.
- The inside of an insect's body has an open circulatory system. That means its body fluids just sort of flow around inside the exoskeleton. It also has many breathing tubes, and a digestive system. It has a heart, a few blood vessels, and insect blood simply flows around inside the body cavity. Air enters the insect through a few openings in the exoskeleton called spiracles. From there oxygen gets to all areas of the insect's body through the breathing tubes, which go everywhere in the body. The insect "stomach", or digestive system, is long and tube-like, and is usually divided into three sections.
- The insect nervous system sends messages from the sense organs (sight, smell, taste, hearing, and touch) to and from the brain. The brain is located in the head and processes information, but some information is also processed at nerve centers at different places in the body.
- Most insects have two types of eyes: simple and compound. Compound are usually bigger than simple and are made up of thousands of tiny lenses that fit closely together. All together the lenses form a mosaic composite view of the world around it. More lenses mean better eyesight, although insects do not have detailed sharp vision. Simple eyes sense light and dark, but entomologists don't know exactly how they are used.
- Most insects have one or two pairs of wings, but wings aren't necessary to be classified as an insect.
- Insects are cold-blooded, so the rate at which they grow and develop depends on the temperature of their environment. Cooler temperatures cause slow growth; higher temperatures speed up the growing process. If a season is hot, more generations, or life cycles, might happen than during a cool season.
- Most species of insects have males and females that mate and reproduce sexually. Sometimes there aren't many males or they are only around at certain times of the year. When there aren't any males, females of some species may still reproduce!

This is common, particularly among aphids. In many species of wasps, unfertilized eggs become males, while fertilized eggs become females. In a few species, females produce only females. Insects may reproduce by laying eggs, or in some species, the eggs hatch inside the female and are born a short time later. Sometimes in aphids, the eggs hatch inside the female and the young aphids remain inside the female for quite a while before birth.

- Spiders are not insects because they have eight legs and don't have three body parts. They are generally considered to be beneficial because they destroy harmful insects.
- There are two types of metamorphosis typical of insects. They are incomplete metamorphosis (egg --> nymph --> adult) and complete metamorphosis (egg --> larva --> pupa --> adult).
- With **incomplete metamorphosis**, the nymphs look like the adult. However, they don't have wings, and may be colored differently than the adults. Nymphs and adults usually live in the same kind of habitats. Incomplete metamorphosis is typical of true bugs and grasshoppers.
- **Complete metamorphosis** is typical of butterflies, beetles, flies, moths, and wasps. The young insects that go through complete metamorphosis do not look at all like the adults, often live in different habitats, and feed on different things. Some moth and wasp larvae weave a silken shell (cocoon) to protect the pupa
- Insects are considered to be pests by farmers when they interfere with successful, economical crop production.
- They are considered beneficials when they help in some way, either by pollinating crops or by controlling pests. The honeybee is the best known pollinator. Besides pollinating plants, it provides us with honey and beeswax, which we use in making candles, polishes, inks, and cosmetics
- Humans have tried to control pests in various ways that include the use of primitive forms of chemicals over the millennia.

Appendix B: IPM methods.

- Buildup of the pest population can be avoided by planting different crops in fields over time. Proper rotation of pest-susceptible cash crops with non-susceptible varieties and cover crops can keep population under control.
- Avoid monoculture, farming which is the planting of just one kind of crop over a large area. Instead, plant many different kinds of crops at the same time in adjacent fields.
- Correct identification of pests and beneficial insects present is most important. This includes recognition of the various immature life stages which can help avoid potential losses.
- Certain crops cannot be grown in a particular area and should be avoided. Knowledge of the appropriate varieties or crops to grow and their optimal planting time will help avoid serious pest problems.
- Good record keeping regarding when pests problems occur and which controls are most effective will help farmers build a foundation for the next year's pest control strategy.
- Understanding of pests' and beneficials' life cycles can be a guide for scheduling planting to avoid the stage at which the pest would attack the plants and/or when the beneficial would control the pest. Farmers must make careful weekly checks for insect activity with a hand lens to determine which insects may be developing.
- Related to this is coordination of planting and harvest dates to avoid pests that would build up on some crops. Early planting and avoidance of successive plantings can help avoid this.
- If plants are growing in healthy soil with sufficient water, they can often compensate for some foliage and root tissue loss. If cover crops are planted prior to the main cash crop, soil fertility and organic matter content will be improved.
- Farmers must decide what levels of damage they can economically tolerate for their particular pest and crop.
- Habitat for beneficial arthropods can be provided by planting field borders or strips within the field with species or varieties that differ from the main crops. Beneficial insects can get habitat from borders and edges of fields that have flowering plants.
- Growers can till soil to destroy insects and expose them to birds and other predators. Tilling can help break down plant residues that harbor insects and plant pathogens. Allowing complete decomposition or a fallow period before planting crops can help in controlling cutworms, root maggots, and bulb mites.
- Planting crops at different seasons may help them avoid pests that might thrive at a different time.
- Such mechanical controls as vacuums can destroy certain bugs on plants if timed to take place during critical periods. This is similar to hand picking in a backyard garden.
- There are several kinds of pest barriers that can be used with valuable vegetable and small fruit crops. Floating row covers and plastic tunnels reduce pest access. Reflective mulches can help prevent early aphid infestations in such row crops as tomatoes, squash, and eggplant.

- There are some chemical controls that are considered to be organically acceptable. In other words they will help control pests but will not have the adverse effects of toxic products. They do degrade rapidly and need repeated applications. Insect adaptation is not as common because they do no have long residual effects;oils and soaps use physical actions such as suffocation or physically displacing the crop to control pests.
- Organic chemicals for controlling pests: oils, soaps, pyrethrum/rotenone (aphids); soaps and oils (whiteflies); pyrethrins and rotenone (leafminer nymphs); oils, soaps, pyrethrum/rotenone combinations (flea beetle adults); Bacillus thuringiensis (B.t.) (worm pests).
- Using little or no pesticides can conserve and help build up large numbers of beneficial parasites and predators that help control pests. Acquiring and releasing biological control agents can bring pests to very low levels. Aphids can be controlled by ladybird beetles (ladybugs), lacewings, syrphid flies, or wasp parasites. Some wasps and flies can control caterpillar pests, parasitizing the eggs of pest species and killing them before they cause feeding injury.

Appendix C. BUGGO game materials.

B	U	G	G	O
		Free Space		

Sample BUGGO Questions and Answers

DIRECTIONS TO TEACHER: Direct students to randomly arrange the Buggo List on their Buggo cards; mix them up so the game is interesting. Read the following statements or questions leaving out the underlined words. Students will mark these on their Buggo Cards.

1. An insect goes through many changes to become an adult.
2. What do you call the changes an insect goes through as it grows? Metamorphosis
3. The first stage of an insect's life cycle is called the egg
4. An insect that changes in four states (egg, larva, pupa, adult) goes through complete metamorphosis.
5. The young of an insect that goes through complete metamorphosis is the larva.
6. A scientist that studies insects is called an entomologist.
7. What do aphids eat? Plant juices
8. A means of blending in with the environment is called camouflage.
9. One kind of insect, a word often mistakenly used to name all insects. Bug
10. A beneficial insect ladybug beetle
11. A new way of controlling insects pests by combining many methods. Integrated Pest Management
12. Used by insects for feeling, smelling, hearing, tasting. Antennae
13. What is a compound eye made of? many tiny lenses
14. What is the hard outer shell of an insect? Exoskeleton
15. Insects that interfere with successful, economical crop production. pests
16. A harmful pesticide that poisoned the environment in many ways. DDT
17. The number of legs that most adult insects have. Six
18. How many main body parts does an insect have? Three
19. Planting just one kind of crop on a farm is called a monoculture
20. Number of legs a spider has. Eight
21. Not able to maintain a constant body temperature independent of the outside temperature—cold-blooded
22. Group of animals that have exoskeletons, jointed legs, and segmented bodies—arthropods
23. Insects that control insects pests--beneficials
24. Insects such as preying mantids, ladybug beetles, lacewings and wasp parasites are released to control insect pests. They are called biological control agents.

Sample BUGGO Word Knowledge List

complete	three
camouflage	larva
beneficials	plant juices
ladybug beetle	entomologist
biological control agents	pests
metamorphosis	bug
adult	exoskeleton
six	arthropod
cold-blooded	Integrated Pest Management
DDT	monoculture
antennae	compound eye
eight	egg