Sustainable Agriculture:
Feeding People Feeding the Soil

Unit Overview

Currently human actions are threatening some of the world's resources and ecosystems that could be essential to a sustainable society. As world population continues to grow and countries further their development, measures must be taken to ensure our current actions are not jeopardizing the well being of future generations.

Agriculture is key to development not only in that it feeds a population, but it also provides domestic capital, foreign exchange opportunities, opens additional labor markets, and provides rural welfare to a country (Norton and Alwang). Sustainable agricultural practices will allow current food needs to be met without damaging the ability of future generations to meet their food needs. Sustainable methods are environmentally friendly and must be able to produce adequate food supplies.

"Most industrialized, Western agriculture fails to exhibit the ecological integrity of an ideal agroecological system… (therefore) The most important element of sustainable agriculture is a change of mind set among farmers…(Thompson).

The background information will provide reasons as to why adopting sustainable methods in agriculture is critical for today's less developed countries and for developed countries such as the United States.

Unit Background

Many believe that to achieve sustainable agriculture all that needs to be done is protect the environment for future use while producing food for today's population. However, since agriculture is a business, not just a means of feeding the public, other factors must also be considered. Dr. Charles Benbrook, an agricultural policy analyst, has formulated conditions to follow in developing a system of sustainable agriculture:

- Meet food needs;
- Provide a rate of return to farmers to sustain their family and agricultural infrastructure;
- Provide a rate of return to public and private providers of inputs, information, and service providers;
- Preserve and regenerate soil, water, biological resources upon which production depends;
- Avoid adverse environmental impacts;
- Increase productivity and yields at least at the rate of increasing demand;
- Adhere to social norms and expectations with regulation and food safety (Benbrook).

The central message to these conditions is that farmers and secondary markets associated with farming, like seed producers and equipment suppliers, must be compensated enough to be profitable and wish to continue in the agriculture industry. Sustainable agriculture not only needs to maintain or improve environmental conditions, it must also maintain its workforce through proper wages and working conditions.

Sustainable agriculture was thought to be an impossible feat in years past. In a 1798 essay, Thomas Malthus postulated that human population growth would outstrip the earth's food producing capabilities (Postel). Malthus claimed that human population expands exponentially, while food production increases linearly only by bringing new land into

production. He believed populations would grow to the point where there would not be enough land to produce food for everyone. Malthus was basically proven wrong; he failed to consider two things in his essay. First, as a society develops, people attain more wealth, become healthier, and tend to have smaller families. The growth rate of the human population peaked in the 1960's, at a rate of more than 2% a year (Lomborg). The rate of increase in population has been declining ever since, and the United Nations estimates the world's population growth will cease in 2100 with a stable population of 11 billion. The second issue Malthus did not consider in his dismal forecast was technological innovation. Agricultural technology has made it possible to harvest more and more food out of each given area of land, proving food production increases are non-linear and do not depend solely on the amount of land taken into production (Lomborg).

In the past 100 years, the production of major crops has more than doubled, and the production of cereals has tripled (Hawken et al). Over the past 30 years, even with population increasing, worldwide food calories available per person have increased by thirteen percent (Hawken et al). These increases result from intensification in the farming industry, and using faster growing and maturing plants that have higher yields, not by an increase in the area of land farmed. However, the intensification of farming is not the only reason yields have increased so drastically throughout the years. U.S. farmers have increasingly used large amounts of fossil fuel energy - as much as ten times as they return in food energy (Hawken et al). Further, farmers began to use large amounts of fertilizers and pesticides to increase crop yield, unaware of the adverse effects. Today, the major threat to reaching sustainable agriculture practices is not population growth rate or the amount of land farmed, but rather how we take care of the farmland and the limited resources used in farming.

High use of fossil fuel and fertilizer, i.e., chemically-based agriculture, are not practices that generally promote sustainable agriculture. One-third of U.S. topsoil is already gone from excessive fertilizer and pesticide use, and currently degraded topsoil is eroding much faster than it is being formed. Loss of the soil's organic richness prevents it from cycling nutrients, fighting disease, and retaining water (Hawken et al). Healthy soil has been proven to produce healthier crops with more vigor and less susceptibility to pests (SARE program, California). The health of soil is critical to food production yields and to sustaining them in the future. Crop systems that impair soil quality often result in greater inputs of water, nutrients, and pesticides, or need tillage, which can further damage the soil. Sustaining the soil and improving its health for future generations calls for a reduction of inputs like fertilizers and pesticides, and for a reduction of tillage. It is critical to understand that without healthy, viable soil agriculture cannot be sustained. With fossil fuels at limited supply, excessive use by farmers could also be detrimental to future generations. Sustainable practices should also include alternatives to using high levels of non-renewable resources.

The United States, like other developed countries of the world, has the means to supply food to its own people either by domestic production or by import. Thus the main focus of sustainable agriculture in developed countries is in the environmental dimension. Developed countries must adopt practices that maintain or improve their soil's fertility in

order to be able to sustain its production for future generations. Less developed countries, with weak agricultural infrastructure, have a greater struggle to achieve sustainability.

Currently there is more than enough food being produced to feed the world's population, yet there is still a world hunger problem. In the United States one percent of Americans grow food for the entire country (Hawken et al). This one percent farming sector is not evenly distributed throughout the United States, so the food is processed and transported from intense farming regions to all parts of the country. It is important to note that because of such large spatial and temporal gaps between farmers and consumers, problems with crops, environmental issues, and general dissatisfaction, farmers require a lengthier response time and consumers a lengthier wait time to see results. In less developed countries, starvation results from food distribution problems, lack of infrastructure, and government corruption, seldom by a lack of food supply.

Lower income countries have weaker policies and institutions in place. To improve development, stronger economic policies and institutions that enforce contracts and protect property rights need to be established (Norton and Alwang). Typically, in developing countries subsistence farming is a normal way of life. Each family tries to grow the food it needs to live. This is usually because inadequate government regulations set prices too low for a farmer to make profit by selling crop; instead everyone farms for their own family. This greatly hinders the development of industries because nearly the entire labor market is in farming. In addition, some countries' governments are corrupted, selling food aid to the highest bidder and not delivering it to the most needy areas. These less developed countries must adopt new policies to induce agricultural development. Norton and Alwang outline policies that should include:

- Developing governmental policies with a long-term planning horizon with conservation incentives;
- Establishing markets to regulate prices at profitable levels;
- Protection for the domestic producer by increased prices;
- Protection for infant industries so they can expand and compete;
- Offset unfair competition through the enforcement against foreign "dumping" of products at low prices;
- Developing agriculture lending establishments (agribusiness banking institutions) to help farmers with seasonal financial needs;
- Developing marketing organizations (like the Chicago Board of Trade's futures contracts) to help farmers deal with production and market uncertainty;
- Improve terms of trade.

Policies setting higher prices will encourage farming for income. Higher consumer prices will also encourage less skilled farmers, who would not make much profit from farming, to look for other means of employment and buy food for their family's consumption. This will, in turn, promote the growth of the agriculture market and industry within the country. Once an agricultural infrastructure is in place a country can develop a plan for sustainable agriculture, protecting the soil's ability to produce and provide for future generations, and protecting those providing the food.

There is general agreement that sustainable practices must be developed and established in the agriculture industry. It is widely agreed upon that in order for agriculture to provide for the growing population we must act now to protect the soil, resources, and farmers themselves to ensure a healthy farming sector in the future. However, there is a wide range of opinion as

to how sustainable agriculture should be pursued. This unit addresses methods such as biotechnology and various practices associated with organic farming including crop rotation, cover crops, predatory insects, mulching and multi-cropping.

To achieve sustainable agricultural practices a society must not only meet the food needs of today without compromising the future's ability to meet those needs, but also provide financial support and input providers to the farmers in order for them to adequately sustain their business and family. Sustainable agriculture must preserve and improve the environment on which future production depends. The level of a country's development determines what actions need to be taken in order for sustainable practices to be implemented. A developed country with sound agricultural infrastructure, institutions, and policies must focus on avoiding further environmental damage through their production processes, while being able to increase yields to meet future demands. A less developed country must create institutions and policies to coincide with development of its agricultural infrastructure. They need to create markets in which prices are at a level where good farmers can make a profit and marginal farmers will exit the business to other industries allowing overall economic development to occur. Once those advances have been made in less developed countries, the environmental aspects of sustainability can be addressed.

Unit Context

In the context of our Hard vs Soft Green Framework (see Chapter 2), Hard Green advocates see great promise in using biotechnology to enhance food production and pharmaceutical applications of agricultural products. Soft Green supporters adhere to the Precautionary Principle – unless the severity of potential impacts (human and environmental) of a new technology is known in advance with some degree of certainty, do not adopt the technology, especially if the decision would be irreversible.

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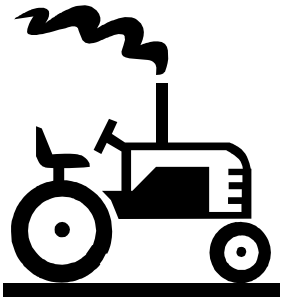

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Combating Pests: The War Against WIF

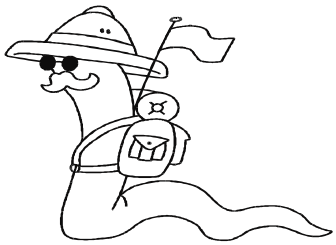
(Weeds, Insects and Fungus)

Grade Levels: High School (9-12)

Skills Taught: comparing, concluding, evaluating disadvantages and benefits

SOL's: Life Science 7, 9, 12; Biology 9, English 10.10, 12.7

Key Terms/Concepts: pesticide, herbicide, fungicide, insecticide, cover crops, crop rotation, predatory insects, mulching, multi-cropping, organic farming



Learning Objectives

The student will be able to explain and understand the benefits and disadvantages of using pesticides on farm crops; discuss alternatives to pesticide usage, highlighting the benefits and disadvantages of the given practice.

Background For Teachers

This lesson addresses the benefits and disadvantages of pesticide use and its alternatives. Pesticide use is just one aspect of sustainable agriculture and is often discussed in the context of organic farming. Awareness about organic farming has increased and many consider it a way in which sustainable agriculture can be achieved, especially in poorer countries. Organic farming uses no synthetic fertilizers or pesticides, but instead uses compost from household waste or confined livestock as fertilizer (Ikerd) along with natural methods of pest control. According to the Organic Farming Research Foundation, organic methods prevent pest infestation by building healthy soils rich with organic matter through the use of cover crops, compost, and other methods. Many times the food we consume is grown great distances from us, so it is necessary to use chemicals to keep them fresh during transport. In contrast, food from organic farming is consumed in local areas, relying solely on local resources and avoiding the need for preservatives. In large scale organic operations, efficiency is increased by satellite imaging and remote sensing used to determine what specific nutrients are needed, how moist the soil is, how fast growth is, and what pests are present to a particular crop (Hawken et al). This decreases unnecessary water and fertilizer usage, reduces water pollution, preserves soil quality, and imposes less harm on wildlife (Lockeretz).

Currently, many of the fruits and vegetables Americans buy at supermarkets are treated with some sort of pesticide. The National Agricultural Statistics Service conducted a survey on pesticide use in the 2000 crop year. The survey was conducted in 21 major crop-producing states. The survey found high levels of usage:

% Acreage Treated By Pesticides

	Carrots		Sweet Corn		Tomatoes		
	Fresh	Processing	Fresh	Processing	Fresh	Processing*	
Herbicides	58%	77%	79%	90%	63%	78%	
Insecticides	13%	54%	84%	75%	87%	64%	
Fungicides	49%	65%	38%	22%	86%	73%	

* Data from CA, MI, and PA only.

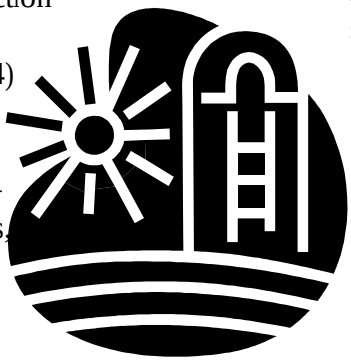
The use of pesticides often produces more aesthetically pleasing fruits and vegetables in a cost efficient and practical manner. But are these pesticides healthy and effective? Studies have found that some pesticides can cause cancer. In addition, the heavy reliance on pesticides has caused many insects to build up tolerance to insecticides, thus rendering them ineffective. Pesticide use remains an important and controversial aspect of sustainable agriculture.

Getting Ready

Make copies of:

- Pesticides: A Quick Introduction (SA 1)
- Alternative Practices (SA 2-4)
- Alternative Practices: Pros and Cons (SA 5)

Materials to make a brochure – construction paper, markers, glue, etc.



Procedure

1. Distribute Pesticides: An Introduction (SA 1) to students. Discuss the use of pesticides with students. What do they know about them? How often do they think pesticides are used? What are some of the benefits of using pesticides? What are some of the disadvantages? Have they ever used pesticides themselves on a home garden or farm? What are the alternatives to using pesticides or practices to use in conjunction with pesticides?

2. Introduce students to five alternatives to pesticides that can be used alone or in conjunction with pesticides (cover crops, crop rotation, predatory insects, mulching, and multi-cropping). Remind students that these are not the only alternatives, there are many more. Students will pick a "practice" and construct a brochure explaining the advantages and disadvantages to that particular practice. Students are not limited to the five practices introduced. If they wish to research one independently (including advocating the use of pesticides as the most effective method) they may do so. Students may work alone or in groups.

3. Distribute the short summaries of the particular practice accordingly to students (SA 2-4). Students will research their practice further to obtain more information for their brochure. Research may include library searches as well as contacting a local farmer or extension agent for an interview or requesting information from sustainable agriculture groups. Students may include information such as:
   - What type of soil and climate best suits this practice? What type of soil and climate does this practice not work for?
   - Is this practice economically sound for different kinds of farmers (small, medium and large farms)?
   - Does it take several years to recognize the benefits of this practice? If so, will the farmer first suffer losses or is there a way in which to implement the practice so this can be avoided?

4. Groups or individuals may present their brochures to the class. Students can fill out the "Alternative Practices Pros and Cons" chart (SA 5) as they listen to the presentations or read through the brochures. In summary, review advantages and disadvantages; reiterate that different practices are appropriate for different farmers and situations, all of which strive for the same goal – sustainable agriculture.

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Pesticides:
A Quick Introduction

Pesticides include:

- Herbicides - control/kill competitive weeds;
- Fungicides - kill fungal diseases;
- Insecticides - control/kill insects.

Herbicides and insecticides are more commonly used than fungicides, which are expensive to apply and mostly used on perennial plant and fruit crops.

The first mention of the use of an insecticide/chemical to control insects is in 1000 BC. Homer writes of using sulfur to keep insects away from crops. Modern synthetic insecticides as we know them today were brought to market in the 1930's. The purpose of insecticides is to keep away pests, which in turn increases yields, makes crops more aesthetically pleasing and lowers prices for consumers. By making crops aesthetically pleasing, consumers are more likely to buy them. Many times fruits and vegetables that "look" the best are the ones that received insecticide treatment. Insecticides are also cost effective; they are easy to apply and relatively inexpensive.

The benefits of pesticide (herbicides, fungicides, and insecticides) are usually quite obvious. Crops can produce higher yields at a lower cost with less manual labor from the farmer. Crops also "look" more inviting. However, the downsides of pesticides are usually not as obvious. Currently, of the pesticides available on the market, 10% are suspected of or known to be carcinogens, cancer-causing agents. Excess run-off can pollute water and land. In addition, the generous application of pesticides weakens their effectiveness. More than 200 insect species are known to be resistant to one or more insecticide. Are there alternatives to pesticides?

Alternative Practices

Predatory Insects

Predatory (or "beneficial) insects are insects that eat pest or "bad" insects. Predatory insects are effective in combating pest insects and can sometimes eliminate the need for insecticides entirely. Predatory insects do no harm to humans or pets/animals, nor do they cause water or soil pollution as some pesticides can. One challenge to using predatory insects in place of insecticides is that release of the beneficial insect at the correct time is critical. If released too early or too late, they can fail to effectively ward off pests. This method also requires more time input from farmers as it is necessary to routinely check the fields to be certain that predatory insects have established themselves. Commonly used predatory insects include:

- Lady Bugs – eat aphids, mealy bugs, mites, and insect eggs;
- Solider Beetles – eat aphids, larvae eat maggots, grasshopper eggs, and small caterpillars;
- Green Lacewings – eat aphids, mites, and other soft-bodied insects;
- Big Eyed Bugs – eat aphids, mites, leafhoppers, and other small insects;
- Various types of Nematodes – eat grubs, maggots, cutworms, weevils, beetles (e.g. Japanese and May), flea larvae, and other soil and boring insects.

Multi-Cropping

Multi-Cropping involves planting more than one species of crop in a field. There are several benefits to multi-cropping:

- Helps eliminate insects and other parasites. One crop repels the pests that are attracted to the other crop – may reduce the need for insecticides. For example, a field will contain tomatoes, onions and marigolds; the marigolds repel tomato pests. This decreases the possibility of crop failure.
- Promotes healthy soil. The crops are paired such that they can "feed" off each other, a nutrient that one crop uses is replenished by the other crop and vice-versa.
- Increases crop yields.
- When used in conjunction with mulching, it is a useful way of controlling weeds – may reduce the need for herbicides.

The major downside to multi-cropping is that it is very labor intensive. It requires a substantial amount of labor/effort to plant, tend and harvest the crops. In addition it necessitates significant planning coordinating crops.

Alternative Practices

Mulching

Mulching involves applying a layer of organic (or inorganic) material on the ground around plants. Mulch can be made up of a variety of materials; organic mulches include everything from grass clippings, compost, straw, shredded leaves, sawdust and pine needles just to name a few. Mulching provides several advantages:·

- Smothers out competitive weeds – may reduce the need for herbicides;
- Conserves soil moisture – promotes healthier soil and heartier plants which can reduce the need for pesticides;
- Keeps the ground cooler in the summer and warmer in the winter – promotes heartier plants which can reduce the need for pesticides;
- Prevents erosion – promotes healthier soil and heartier plants which can reduce the need for pesticides;
- Keeps fruits, vegetables and plants cleaner, in particular decreases fruit/vegetable rot because the products are not directly touching the soil – a more attractive looking product is yielded.

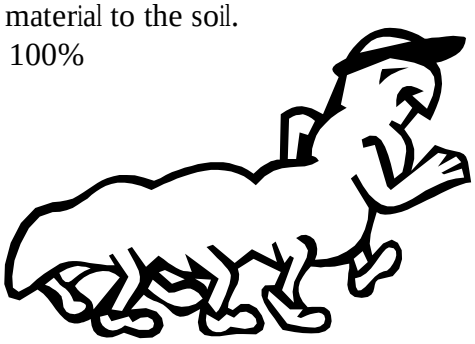
The benefits of mulching are numerous; keep in mind, however, that mulching requires more time and labor from farmers. Timing is key to the application mulch; if it is applied to early it can stunt the growth of plants, if too late, weeds may all ready have established themselves and won't be detoured by the cover. The amount of mulch is critical as well - over mulching can suffocate plant roots, denying them oxygen, harbor diseases and attract rodents.

Cover Crops

A cover crop is a crop grown in the off-season such as clover, winter peas, rye, vetch, rapeseed, and buckwheat. They can be planted at any time of the year depending upon the climate, need, and cash crop being planted. Cover crops have several benefits:

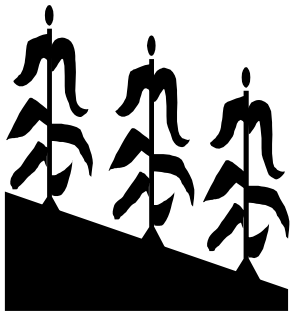
- Weed suppression – may reduce the need for herbicides;
- Can keep away "bad" insects because they do not like the cover crop – may reduce the need for insecticides;
- Provides a habitat for predatory and beneficial insects; these are insects that eat the "bad" insects which hurt crops – may reduce the need for insecticides;
- Provides erosion control – not as much soil is lost, thus sustaining healthier soil;
- Replenishes the soil nutrients – helps restore nitrogen and minerals in soil, also when turned over, they decompose and add more organic material to the soil.

There are many advantages to cover crops, but they are not 100% effective. In some cases, pesticides are still needed.



Alternative Practices

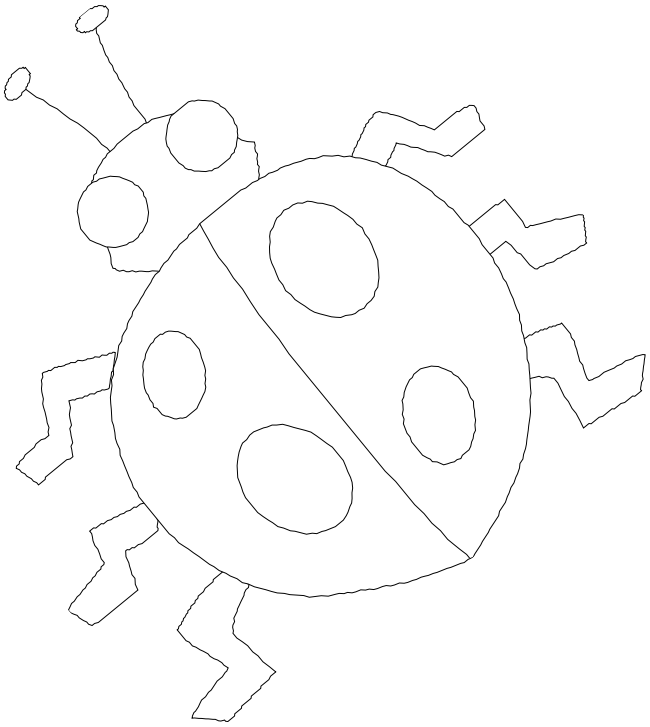
Crop Rotation



Crop rotation entails changing the crop grown in a field each year. Crops use certain nutrients from the soil, thus by rotating crops, the soil has a chance to replenish the nutrients that a particular crop used. A balanced crop rotation sequence can promote healthier soil. Other benefits of crop rotation include:

- Suppression of weeds, pathogens and insects – planting the same crop in a field allows pests and diseases that live in the soil to infect next year's harvest; since most insects and diseases tend to be plant specific, the insects and diseases will not affect the new crop planted and not accumulate in the soil – may reduce the need for insecticides, herbicides, and fungicides;
- Healthier soils mean heartier plants – which means plants are less susceptible to pests and disease – may reduce need for insecticides;
- Reduces erosion – promotes healthier soil, see above;
- Increases diversity of farm operation – farmer less likely to suffer a loss if a particular crop does not do well, can rely on other crops for profit.

A downside to crop rotation is that it requires significant planning; the sequence must be specific to the soil and climate types. It also must be developed in a way that is profitable for the farmer. In addition, crop rotation sometimes requires more labor input because of different planting and harvesting schedules, however, this can distribute labor demand more evenly and perhaps stabilize employment. Sometimes, herbicide residues applied to previous crops can damage the new crops when first beginning crop rotation.



Alternative Practices:

PROS & CONS

	ADVANTAGES	DISADVANTAGES
Cover Crops		
Crop Rotation		
Predatory Insects		
Mulching		
Multi-Cropping		
Other:		
Other:		
Other:		

Sustainable Agriculture:
High-Tech Foods

Learning Objectives

The student will be able to explain and understand the benefits and disadvantages of genetically modified organisms, discussing positive, negative, and unknown aspects of biotechnology.

Background for Teachers

Methods of achieving sustainable agriculture may vary depending on the country. Biotechnology is a prominent, and yet controversial, method of promoting sustainability. Use of biotechnology is mainly seen in developed countries because of its high research and testing costs. Biotechnology is used in agriculture through manual genetic manipulations of plant species. Scientists can insert genes into a plant that make it grow faster, produce higher yields, or be resistant to disease or insects (Ikerd). Crossing two different plant species can also create hybrids that may produce more yields or result in a higher quality crop when placed in a particular environment. Genetic engineering in agriculture can be used to achieve almost any objective for a particular crop.

Currently three-fourths of the world's food is produced from seven crop species (Hawken et al). Proponents of biotechnology in agriculture feel that using genetic technology is key to sustainable agriculture. Plants can be genetically engineered so that no fertilizer or pesticide is necessary for their growth. Crops can also be injected with genes that make them require less water. Supporters feel that the "super" crops that have been created will reduce environmental degradation, conserve resources, and at the same time produce higher yields for our growing population. This may sound like the perfect solution to achieve sustainability; there is, however, a large fraction of people in great opposition to biotechnology in agricultural production.

Opponents to the technology feel that it is too new and the long-term risks are unknown (Ikerd, Kaufman). They also feel that plant diversity is being threatened because genetically manipulated plants are replacing many native species (Hawken et al). Opponents feel more long-term research should be conducted before full-scale adoption of technology occurs (Ikerd). They feel less genetically diverse crops could be dangerous to our future. For example, climate changes worsen the pressure on overspecialized plants, and it is unknown how a drastic climate change may affect a crop. Genetically diverse, natural populations can cope with climate changes; however a climate change could potentially wipe out an entire engineered crop and be devastating to the food supply (Ikerd). Research is also needed for the possible effects engineered plants could have on their surrounding ecosystem. Opponents stress that so far the focus has been on how a gene might cause a beneficial trait, overlooking how

Grade Levels: High School (9-12)

SOL's: Life Science 13,14; Biology 2,9

Skills Taught: researching, comparing, concluding, evaluating disadvantages and benefits

Key Terms/Concepts: biotechnology, genetically modified organism, biodiversity

a new gene may cause a plant to interact with its environment (Kaufman). For reasons such as this and concern for human health, opponents to biotechnology in agriculture feel that it is still too new and under-researched to be considered a valid method of sustainable agriculture.

Getting Ready

Make copies of High-Tech Foods (SA 6)

Procedure

1. Distribute "High-Tech Foods" introduction sheet (SA 6). Discuss the information with students.

• What are the most common genetically modified (GM) crops? *corn, soybean, cotton and canola (rapeseed)*

• Are genetically modified organisms (GMOs) more likely to be sold as freshfruits and vegetables or as processed foods? *Processed Foods*

• Did the students realize that GMOs comprised such a significant portion of cropland?

• What countries grow the most GM crops in terms of % of cropland? *Argentina, Canada, China and the United States*

• Is there anything these countries have in common? *They are developed countries rather than undeveloped countries like those in Africa and parts of Asia*

• Generally, why do developed countries have the more GM crops than undeveloped countries?

• Why is the GMO industry growing?

2. Students will research an aspect of the GM foods controversy to present to the class (in groups or individually). Keep in mind that there is a lot of mixed opinions concerning these topics, there may be conflicting information depending upon sources. The goal is for students to practice critical thinking. Topics to address include:

• Is there a world food shortage? With the growing world population, will there be enough food in the future? If there is enough food produced to feed everyone, why are there millions of people starving or malnourished? What are some problems with food distribution systems? Where and how do GMOs fit into all of this?

• How can GM crops help the environment in terms of water, pesticide, fertilizer and land use? What are some of the latest developments?

• What are superweeds? Why are they dangerous? What are some concerns about GMOs and their inadvertent effects on insects and animals? What are some concerns about GMOs and their effect on pest resistance to pesticides?

• How do companies patent GMOs in the United States? (Currently, a company receives a patent for all forms of a certain fruit or vegetable for example Company A develops square tomatoes but receives patent for GM tomatoes. If Company B develops a new process to make tomatoes grow with less water, they must pay Company A royalties; they do not receive a new patent.) Is the U.S. patent policy fair? Does it encourage development of new products?

• How can GMOs fight disease?

• How can GMOs be harmful to people?

- How can GMOs affect biodiversity? Can GMOs help endangered or threatened species? Can GMOs reduce biodiversity by becoming too dominant?

- Have GMOs been "tested" enough to know that they are safe for humans? In the United States, what agencies must approve a new GMO before it is available on the market? (FDA, EPA, Dept. of Ag.) On average long is the review period for a new GMO? (10 years – according to the American Crop Association)

- How much money do companies spend in the development of GMOs? If the development process is so expensive, where will companies make their money?

- Should products containing GMOs or derivatives be labeled? If so, how should they be labeled? (GMO free, genetically engineered, etc.) What are the current methods of labeling required by the Food and Drug Administration? How are GM foods labeled in other countries?

- What is US public opinion concerning GM foods? Do Americans support, reject or not care about GM foods? What is public opinion about GM foods from people around the world? Is there a difference? If so, why?

3. After students have gathered their information, they will present their research to the class. Facilitate a class discussion where students debate the pros and cons of GM foods.

Enrichment

Ask students how many GM foods they think they consume. Print out the "True Food Shopping List" from the Greenpeace True Food Network website (www.truefoodnow.org/gmo_facts/product_list/pf-list.html). Share with the students foods on the list. After learning about GM crops, do they still feel comfortable eating these foods? Why or why not?

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High-Tech Foods

You probably already consume many Genetically Modified (GM) foods and don't realize it. Almost 70% of processed foods sold in the United States contain some sort of Genetically Modified Organism. GMOs are ingredients in all sorts of products ranging from cornflakes to dog food. So what exactly are Genetically Modified Organisms? GMOs are part of agricultural biotechnology, which involves the use of highly developed and complex engineering techniques to manipulate genes or gene sequences at a cellular or sub-cellular level (Thompson). GMOs are organisms that are the products of these manipulations. What is gained by manipulating genes? Scientists found ways to make organisms grow larger, faster, more nutritious, and more resistant to drought, disease, insects and herbicides (to name just a few of the things they can do). The four major GM crops grown include corn, soybean, cotton and canola (rapeseed).

Crop	*Products*	*Products and Derivatives can be found in:*
Corn	Corn flour, corn starch, corn oil, corn sweeteners and syrups	Breads, cereals, chips, cookies, ice cream, alcohol, tomato sauces, margarine, enriched flours and pastas
Soybean	Soy flour, soy oil, lecithin, soy isolates and concentrates	Breads, candies, chocolates, crackers, fried foods infant formula, veggie burgers and sausages, shampoo and bubble bath, cosmetics
Canola	Oil	Chips, cookies, fried foods, margarine, salad dressings soaps, detergents
Cotton	Oil, fabric	Clothes, linens, chips, cookies, crackers, peanut butter

Country	*% of crop area occupied by GM Crops*
United States	16.9%
Argentina	36.8%
Canada	6.6%
China	0.4%

GM crops are grown on six continents, but the majority of the crops are concentrated in four countries: Argentina, Canada, China and the United States. Between 1996 and 2000 the global crop area occupied by GM crops grew from .1% to 2.9%. As a three billion dollar a year industry, GM crops are growing each year.

Advocates of agricultural biotechnology claim that GMOs are a means to achieve important and necessary goals. GMOs can help fight disease and alleviate hunger and malnutrition, benefiting humans. Benefits to the environment include reducing the need for fertilizers and pesticides. Farmers will be able to grow crops using less water and reduce soil erosion and runoff. They also create more useful consumer products.

Opponents of agricultural biotechnology claim that there are too many risks associated with GMOs. GMOs can be harmful to people, causing allergies and other unknown human health issues because long-term testing has not been conducted. GMOs may hurt the environment. They can create "superweeds" increase pest resistance, affect "non-target organisms and reduce biodiversity. In essence, GMOs can change an eco-system.