Texas Ag in the Classroom STEM Lessons

PLANT SCIENCE | THE QUEST TO FEED 9.7 BILLION: CONVENTIONAL VS. ORGANIC PRODUCTION

AT A GLANCE

Grade Level/Subject
10th grade biology

Overview
In their quest to determine how agriculture is going to feed a growing population, students will evaluate the differences in conventional and organic production. This evaluation and comparison will include the use of pesticides and herbicides, modern agriculture practices and technologies, and genetic modification. Students will discuss the costs, safety, and reliability associated with both conventional and organic production. This lesson should follow the "Soybeans and Genetic Modification" lesson. *(Note: this lesson uses the term 'conventional' to also include biotech crops).*

Phenomena Focus
The world population continues to grow, and agricultural production continues to increase to meet this growing need for food and fiber.

Major Concepts
- Enhanced/updated technology and agricultural practices have increased agricultural outputs.
- Organic production is a system that relies more on ecosystem management rather than external agricultural inputs (FAO).
    - Organically produced food is grown without the aid of synthetic pesticides or chemical fertilizers and was produced without the use of genetically modified organisms or chemical food additives (Monsanto).
- Conventional production varies from farm to farm; however, they share many characteristics: rapid technological innovation; large capital investments in order

to apply production and management technology; large-scale farms; single crops/row crops grown continuously over many seasons; uniform high-yield hybrid crops; extensive use of pesticides, fertilizers, and external energy inputs; high labor efficiency; and dependency on agribusiness (USDA).

- Both conventional and organic production use pesticides and herbicides, they just vary across the production types.
- Production costs and yields vary between conventional and organic production.
- There are 11 genetically modified products on the market today: alfalfa, canola, corn (field and sweet), cotton, papaya, potatoes, soybeans, squash, sugar beets, arctic apple, and AquAdvantage Salmon.

Objectives

At the end of this lesson, students will be able to:

- Explain the difference in organic and conventional production, including practices, costs, yield, environmental impacts, and reliability.
- Compare the costs of both production types.
- Identify three modern agricultural practices that have helped increase food production.
- Identify the 11 genetically modified products on the market today.

TEKS Alignment

Science

- 112.34.c.2.G: Scientific processes. The student uses scientific practices and equipment during laboratory and field investigations. The student is expected to: analyze, evaluate, make inferences, and predict trends from data.
- 112.34.c.3.B: Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: communicate and apply scientific information extracted from various sources such as current events, published journal articles, and marketing materials.
- 112.37.c.2.K: Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to: communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.
- 112.37.c.9.G: Science concepts. The student knows the impact of human activities on the environment. The student is expected to: analyze how ethical beliefs can be used to influence scientific practices such as methods for increasing food production.
- 112.37.c.9.J: Science concepts. The student knows the impact of human activities on the environment. The student is expected to: research the advantages and disadvantages of "going green" such as organic gardening and farming, natural methods of pest control, hydroponics, xeriscaping, energy-efficient homes and appliances, and hybrid cars.

English Language Arts

- 110.36.c.1.A: Developing and sustaining foundational language skills: listening, speaking, discussion, and thinking—oral language. The student develops oral language through listening, speaking, and discussion. The student is expected to: engage in meaningful and respectful discourse by listening actively, responding appropriately, and adjusting communication to audiences and purposes.
- 110.36.c.1.C: Developing and sustaining foundational language skills: listening, speaking, discussion, and thinking—oral language. The student develops oral language through listening, speaking, and discussion. The student is expected to: give a presentation using informal, formal, and technical language effectively to meet the needs of audience, purpose, and occasion, employing eye contact, speaking rate such as pauses for effect, volume, enunciation, purposeful gestures, and conventions of language to communicate ideas effectively.
- 110.36.c.1.D: Developing and sustaining foundational language skills: listening, speaking, discussion, and thinking—oral language. The student develops oral language through listening, speaking, and discussion. The student is expected to: participate collaboratively, building on the ideas of others, contributing relevant information, developing a plan for consensus building, and setting ground rules for decision making.
- 110.36.c.4.G: Comprehension skills: listening, speaking, reading, writing, and thinking using multiple texts. The student uses metacognitive skills to both develop and deepen comprehension of increasingly complex texts. The student is expected to: evaluate details read to determine key ideas.
- 110.36.c.5.D: Response skills: listening, speaking, reading, writing, and thinking using multiple texts. The student responds to an increasingly challenging variety of sources that are read, heard, or viewed. The student is expected to: paraphrase and summarize texts in ways that maintain meaning and logical order.

Agricultural, Food, and Natural Resources

- 130.2.c.13.B: The student describes the principles of food products and processing systems. The student is expected to: determine trends in world food production.
- 130.2.c.13.C: The student describes the principles of food products and processing systems. The student is expected to: discuss current issues in food production.

Materials/Preparation

- PowerPoint Presentation (prepared by teacher)
    - Information from Explain section
- Copies of GMO issues, results, and solution cards (provided)
- Copies of GMO foods cards (provided)
- Copies of worksheet (provided)

PROCEDURE

ENGAGE – Gets the students' minds focused on the topic

- *Describe how the teacher will capture students' interest.*
- *What kind of questions should the students ask themselves after the engagement?*

1. Play 'High-Low' with students. Put a number on the board (8 billion) and ask students to guess if that number is higher or lower than what the world population is going to be in 2050. Have students vote by raising their hands if they think the answer is higher or lower. Reveal the answer to be higher...it's 9.7 billion.
   - Discuss how the population continues to grow, but the land to produce food and fiber is not.
   - 35% of the world's land area is used for agricultural land (this includes crops and open land for grazing).

2. This lesson is going to utilize the same Bloom's Taxonomy questioning strategy used in the 'Soybeans & Genetic Modification' lesson. After presenting students with the facts above, begin asking questions at the end of each section to encourage deeper thinking of the problem at hand and how it has been/could be solved. Present the question to the students, give them one minute to write down their answer (one minute per question) and then solicit a few volunteers to share their answers to encourage discussion. By writing them down, students can refer back to their answers throughout the lesson to gauge how their answers and thoughts have changed as a result of the content learned. Throughout the lesson, questions will become increasingly harder to encourage deeper thinking and evaluation of the problem (based off Bloom's taxonomy). Early on in the questioning, students may or may not have the correct answers. However, the goal of these questions is to encourage them to think about the problem and potential solutions before the material and solution are taught.
   - KNOWLEDGE: Describe how you think the agriculture industry is responding to this problem.
     - *Teacher note:* Solicit a few answers and use them to help segue to the next section where you'll define conventional and organic production.

EXPLORE – Provides students with a common experience; real world connection/personalization

- *Describe what hands-on/minds-on activities students will be doing.*
- *List "big idea" conceptual questions the teacher will use to encourage and/or focus students' exploration.*

3. Tell students we are going to be focusing on how agricultural production has, and will continue to, keep up with a growing population while exploring conventional and

organic production practices. Ask students to write down their definitions of conventional production and organic production. Solicit a few answers and then show students the following definitions of each:

- Conventional production varies from farm to farm; however, they share many characteristics: rapid technological innovation; large capital investments in order to apply production and management technology; large-scale farms; single crops/row crops grown continuously over many seasons; uniform high-yield hybrid crops; extensive use of pesticides, fertilizers, and external energy inputs; high labor efficiency; and dependency on agribusiness (USDA).
- Organic production is a system that relies more on ecosystem management rather than external agricultural inputs (FAO).
- Organically produced food is grown without the aid of most synthetic pesticides or chemical fertilizers and was produced without the use of genetically modified organisms or chemical food additives (Monsanto).

4. Ask more questions to continue moving up Bloom's scale. Give students one minute to write down their answers (one minute per question). Solicit a few volunteers to share their answers to encourage a brief discussion.
    - COMPREHENSION: Knowing what you do about conventional and organic production, write three to five sentences comparing the two types of production and how they differ.
    - Consider your answers to your questions from earlier and revise as needed based off any new knowledge.

EXPLAIN – Teaches the concept with interaction between the teacher and students

- *Student explanations should precede introduction of terms or explanations by the teacher. What questions or techniques will the teacher use to help students connect their exploration to the concept under examination?*
- *List higher order thinking questions which teachers will use to solicit student explanations and help them to justify their explanations.*

6. Pass out worksheet (provided). Explain that they will fill in the blanks as the lesson progresses. There is a second part to the worksheet that will be filled out during student presentations and a Q&A section at the end. Worksheets will be collected by teacher at the end for grading and/or participation points and to evaluate if students understand the concepts from the lesson.

7. Output Efficiencies
    - Agricultural output has more than doubled in the last 60 years. Between 1948 and 2011, soybean yields per acre more than doubled, corn yields grew more than fourfold, and labor productivity increased by nearly 16 times.

- Currently, 35% of the earth's ice-free land is used for agriculture; if the entire industry were to switch to organic practices, it would take 20% more land to produce the same amount of food.
- Without biotechnology, we would need more acreage to meet the growing demand:
    - 17 million more acres of corn
    - 12.1 million more acres of soybeans
    - 7.6 million more acres of cotton
    - 49 million more acres of canola

7. Pesticides & Herbicides
    - Since becoming commercially available in 1996, the use of genetically modified organisms has reduced pesticide application by almost 10%.
    - Corn varieties produced through biotechnology have reduced pesticide use by eight percent in the U.S.
    - Since its introduction in 1996, biotechnology has reduced the impact of herbicides and insecticides on the environment by 18.7%.
    - 'Organic' does NOT mean 'no pesticides'
        - Organic production can use approved pesticides, fertilizers, and herbicides.
        - Some are natural, and some are synthetic.
        - More than 50 pesticides have been approved by USDA for organic produce.
        - Organic farmers will sometimes use compost or manure. Manure has to compost for months, and if it doesn't reach a certain temperature, it could be unsafe to use. Improper compost management can result in harmful bacteria such as E. Coli.
        - Often time, conventional production uses less pesticides than their organic counterparts.

8. Biotechnology
    - In a study conducted by the National Academies of Sciences, Engineering, and Medicine, it was found that GMO crops are no greater threat to human health or the environment that organically grown crops.
        - A comprehensive review conducted by the USDA found no differences between the health benefits of organic and conventional foods.
    - Genetically modified foods have been in the marketplace since the 1990s. To ensure the safety and well-being of consumers, agencies of all different types perform extensive testing on GMOs before they ever reach the store. Testing can take as long as 13 years and cost as much as $136 million for one product.
    - Organizations that test GMOs are the American Medical Association, United Nations Food and Agriculture Organization, Food and Drug Administration, and World Health Organization.
    - Not only have GMOs reduced pesticide needs, but they have also reduced prices on many commodities.

- Corn prices would be 5.8% higher without GMOs. Everyday products like cereal, fuel ethanol, and corn syrup would be more expensive.
- Soybean prices would be 9.6% higher, resulting in more expensive cooking oils, biodiesel, and printing ink.
- Canola prices would be 3.8% higher, increasing the prices of cooking oil and animal feed.

8.. The last part of this lecture is the Corn Showdown, GMO vs. Organic. The worksheet has a table that students will fill out as you go through the content. As you, the teacher, are working through each comparison, conduct a poll to see who students think will win the showdown, GMO corn or organic corn. Students will vote in the poll by raising their hand. Questions will include the following:

- Who will have higher yields, GMO corn or organic corn?
  - GMO: 161 bushels/acre
  - Organic: 118 bushels/acre
- Who will have higher seed costs, GMO corn or organic corn?
  - GMO: $85/acre
  - Organic: $60/acre
- Who will have lower labor costs, GMO corn or organic corn?
  - GMO: $26/acre
  - Organic: $71/acre
- Who will have lower fertilizer and chemical costs, GMO corn or organic corn?
  - GMO: $143/acre
  - Organic: $58/acre
- Who will have lower fuel costs, GMO corn or organic corn?
  - GMO: $25/acre
  - Organic: $37/acre
- Who will have lower overall production costs, GMO corn or organic corn?
  - GMO: $1.73/bushel
  - Organic: $1.92/bushel

9. Ask more questions to continue moving up Bloom's scale. Give students one minute to write down their answers (one minute per question). Solicit a few volunteers to share their answers to encourage a brief discussion.

- APPLICATION: Predict how you see that both conventional and organic production can coexist.
- ANALYSIS: Considering what you know about both types of production in regard to output, costs, environmental impact, etc., draw a conclusion on the type of production you believe to be the most efficient in feeding 9.7 billion by 2050.
- Consider your answers to your questions from earlier and revise as needed based off any new knowledge.

ELABORATE – Provides opportunity for students to apply the concept in a new situation

- *Describe how students will develop a more sophisticated understanding of the concept.*
- *What vocabulary will be introduced and how will it connect to students' observations?*
- *How is this knowledge applied in our daily lives?*

10. Students will first be handed a stack of cards with pictures of foods. Instruct students to get into groups of three and hand each group a stack of cards. Each card has a picture of a food. As a group, they need to separate the stack into two piles, GMO and non-GMO. Give them three to five minutes to complete this.
    - After students complete the activity, begin discussion about what they got right and what they got wrong. In regard to those they got wrong by labeling as a GMO, ask why they thought it was a GMO. Ask if any of the answers surprised them and if so, why.

11. In that same group, students will then work through the GMO issues cards (source: Iowa Ag Literacy Foundation)
    - Instruct students to stay in their groups of three. Hand each group a stack of issues cards. Students will read the cards aloud, lay them out flat on the table, and discuss the issues. (1) Why is it important? Who is affected? (2) Brainstorm possible solutions based on content learned and prior knowledge.
    - The teacher will then pass out a stack of solutions cards to each group. The students will match the solution to the issue and discuss (1) Does the solution address the issue? And (2) What types of technology are involved in the solution? What types of science are involved in the solution? Give students five minutes to complete this.
    - Finally, the teacher will pass out a stack of results cards to each group. The students will match the results to the other cards and discuss (1) Is the result safe? Why or why not? (2) Could this technology be applied to other foods? If so, what? Give students another four to five minutes to complete. Once complete, teacher will lead a discussion about each scenario and provide the correct answers. Discussions can include student reasoning, pros and cons of solutions, and the importance of these solutions to both the farmer and consumer. Below are the correct answers:

Issue	Solution	Result
1	A	Arctic apples won't…
2	H	Golden Rice could…
3	F	Rice is the primary…
4	G	Norman Borlaug…
5	B	Innate potatoes reduce…
6	D	Bt Corn has revolutionized…
7	C	The Rainbow Papaya…
8	E	RoundUp Ready…

EVALUATE – Allows students to demonstrate understanding of the concepts and facts

- *How will students demonstrate that they have achieved the lesson objective?*
- *This should be embedded throughout the lesson as well as at the end of the lesson*

12. Staying in their group of three from the previous section, students will be assigned to research one modern agricultural technology or practice that is helping farmers and ranchers feed a growing population. Each group will present to the class using a visual of some sort (PowerPoint, poster, video of the technology or practice, etc.). Examples could include conservation tillage, drones, biotechnology, precision agriculture, GPS, cover crops, computer-controlled irrigation. Teachers could also consider assigning each group a topic to prevent any repeats. Presentations will be short, but should include the following information:
    - Name of technology or practice
    - What it does/how it works
    - What production type it can be used in (conventional and/or organic)
    - Costs
    - How it increases yield and/or cuts costs
    - Environmental benefits

    Provide groups with list of resources to aid with research:
    - American Farm Bureau Federation
    - Arkansas Farm Bureau
        - Eatology
        - 9,000,000 Changes Everything
        - Farming for the Future
    - GMO Answers
    - Genetic Literacy Project
    - USDA
    - Monsanto
    - University of Arkansas Division of Agriculture
    - Texas A&M AgriLife Extension Service
    - Precisionag.com
    - U.S. Farmers & Ranchers Alliance
    - Findourcommonground.com

During presentations, students will be taking notes on their worksheets. Following the presentations, allow students some time to answer the questions at the end of the worksheet and then turn in.

SOURCES

- USDA
- USDA Economic Research Service
- Food and Agriculture Organization of the United Nations
- Monsanto
- National Academies of Science
- GMOanswers.com
- Iowa Ag Literacy Foundation
- Arkansas Farm Bureau
    - Eatology
    - Farming for the Future
    - 9,000,000 Changes Everything

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____

Name

VARIATION & PROBABLITY OF EXPRESSED TRAITS

Output Efficiencies

1. Agricultural output has more than doubled in the last ______ years.

2. Between 1948 and 2011…
    a. ________________ yields more than doubled.

    b. Corn yields grew more than ____________________.

    c. ____________________________ increased by nearly 16 times.

3. Currently, _______ percent of the earth's ice-free land is used for agriculture.
    a. If the entire industry were to switch to organic practices, it would take _____ percent more land to produce the same amount of food.

4. Without ______________________, we would need more acreage to meet the growing demand.
    a. _________________ more acres of corn

    b. _________________ more acres of soybeans

    c. _________________ more acres of cotton

    d. _________________ more acres of canola

Pesticides & Herbicides

5. Since 1996, the use of _____________________________ has reduced pesticide application by almost _________ percent.

6. Corn varieties produced through biotechnology has reduced pesticide use by ______ percent in the U.S.

7. There has been a ___________ percent decrease in environmental impact caused by herbicides and insecticides since the introduction of biotechnology in 1996.

8. Organic production can not use pesticides or herbicides.
   TRUE FALSE
   a. More than __________ pesticides have been approved by the USDA for organic produce

   b. Organic farmers will sometimes use ___________ or ____________.

   c. Manure has to compost for months, and if it doesn't reach a certain temperature, it could be unsafe to use. Improper compost management can result in harmful bacteria such as _________________.

   d. Often time, conventional production uses ____________ pesticides than their organic counterparts

Biotechnology

9. In a study conducted by the ____, it was found that GMO crops are ________________ to human health or the environment that organically grown crops.
   a. A comprehensive review conducted by the __________ found ______ differences between the health benefits of organic and conventional foods.

10. Genetically modified foods have been in the marketplace since the __________.

11. Testing on GMOs can take as long as ______________ and cost as much as ______________ for one product.

12. List the organizations that test GMOs:
    a. ____

    b. ____

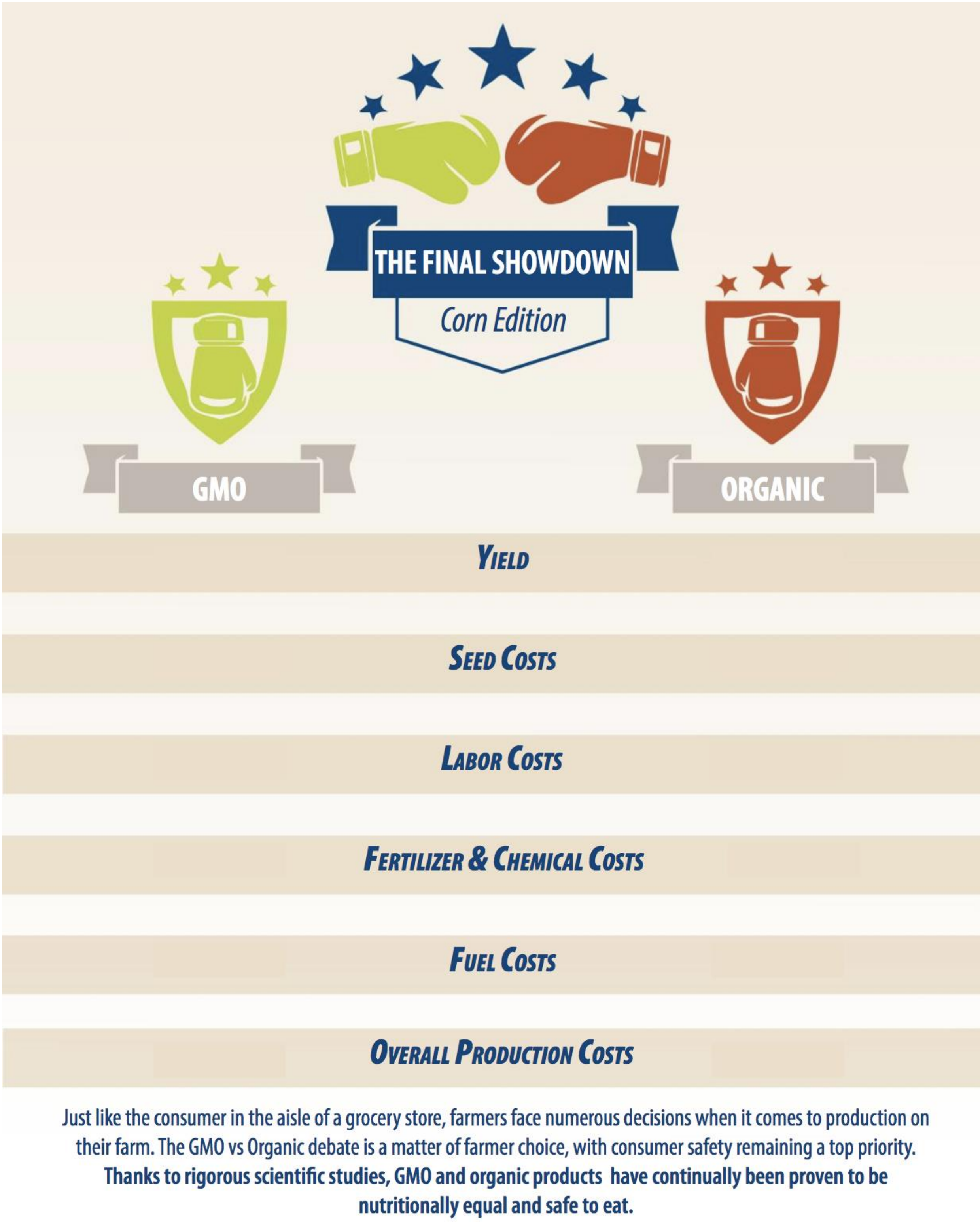
    c. ____

    d. ____

13. Corn prices would be _________ percent higher without GMOs. Everyday products like ____________, ____________________, and __________________ would be more expensive.

14. Soybean prices would be ___________ percent higher, resulting in more expensive ________________________, ____________________, and ____________________.

15. Canola prices would be __________ percent higher, increasing the prices of ________________________ and ____________________________.



Modern Agriculture Technology/Practice Presentations

Group:

Name of technology or practice:

What it does/how it works:

Where it can be used (what production type):

Costs:

How much it increases yield and/or cuts costs:

Environmental Impact:

Group:

Name of technology or practice:

What it does/how it works:

Where it can be used (what production type):

Costs:

How much it increases yield and/or cuts costs:

Environmental Impact:

Group:

Name of technology or practice:

What it does/how it works:

Where it can be used (what production type):

Costs:

How much it increases yield and/or cuts costs:

Environmental Impact:

Group:

Name of technology or practice:

What it does/how it works:

Where it can be used (what production type):

Costs:

How much it increases yield and/or cuts costs:

Environmental Impact:

Group:

Name of technology or practice:

What it does/how it works:

Where it can be used (what production type):

Costs:

How much it increases yield and/or cuts costs:

Environmental Impact:

Group:

Name of technology or practice:

What it does/how it works:

Where it can be used (what production type):

Costs:

How much it increases yield and/or cuts costs:

Environmental Impact:

1. Select three practices/technologies you believe to be the most effective for feeding 9.7 billion people by 2050 and discuss why.

2. Imagine you have a farm of your own. What would you grow and what technologies/practices would you implement to help that commodity have a high/profitable yield? Explain your answer.

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ANSWER KEY

THE QUEST TO FEED 9 BILLION PEOPLE BY 2050: CONVENTIONAL VS. ORGANIC PRODUCTION

Output Efficiencies

1. Agricultural output has more than doubled in the last 60 years.

2. Between 1948 and 2011…
   a. SOYBEAN yields more than doubled.

   b. Corn yields grew more than CORN

   c. LABOR PRODUCTIVITY increased by nearly 16 times.

3. Currently, 35 percent of the earth's ice-free land is used for agriculture.
   a. If the entire industry were to switch to organic practices, it would take 20 percent more land to produce the same amount of food.

4. Without BIOTECHNOLOGY, we would need more acreage to meet the growing demand.
   a. 17.1 MILLION more acres of corn

   b. 12.1 MILLION more acres of soybeans

   c. 7.6 MILLION more acres of cotton

   d. 49 MILLION more acres of canola

Pesticides & Herbicides

5. Since 1996, the use of GENETICALLY MODIFIED ORGANISMS has reduced pesticide application by almost 10 percent.

6. Corn varieties produced through biotechnology has reduced pesticide use by 8 percent in the U.S.

7. There has been a 18.7 percent decrease in environmental impact caused by herbicides and insecticides since the introduction of biotechnology in 1996.

8. Organic production can not use pesticides or herbicides.

   TRUE FALSE

   a. More than 50 pesticides have been approved by the USDA for organic produce

   b. Organic farmers will sometimes use COMPOST or MANURE.

   c. Manure has to compost for months, and if it doesn't reach a certain temperature, it could be unsafe to use. Improper compost management can result in harmful bacteria such as E.COLI.

   d. Often time, conventional production uses LESS pesticides than their organic counterparts

Biotechnology

9. In a study conducted by the NATIONAL ACADEMIES OF SCIENCIES, ENGINEERING, AND MEDICINE, it was found that GMO crops are NO GREATER to human health or the environment that organically grown crops.
   a. A comprehensive review conducted by the USDA found NO differences between the health benefits of organic and conventional foods.

10. Genetically modified foods have been in the marketplace since the 1990s.

11. Testing on GMOs can take as long as 13 YEARS and cost as much as $136 MILLION for one product.

12. List the organizations that test GMOs:
    a. AMERICAN MEDICAL ASSOCIATION

    b. UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION

    c. FOOD AND DRUG ADMINISTRATION

    d. WORLD HEALTH ORGANIZATION

13. Corn prices would be 5.8 percent higher without GMOs. Everyday products like CEREAL, FUEL ETHANOL, and CORN SYRUP would be more expensive.

14. Soybean prices would be 9.6 percent higher, resulting in more expensive COOKING OILS, BIODIESEL, and PRINTING INK.

15. Canola prices would be 3.8 percent higher, increasing the prices of COOKING OIL and ANIMAL FEED.

THE FINAL SHOWDOWN

Corn Edition

GMO		ORGANIC
161 bushels/acre	**Yield**	118 bushels/acre
$85/acre	**Seed Costs**	$60/acre
$26/acre	**Labor Costs**	$71/acre
$143/acre	**Fertilizer & Chemical Costs**	$58/acre
$25/acre	**Fuel Costs**	$37/acre
$1.73/bushel	**Overall Production Costs**	$1.92/bushel

Just like the consumer in the aisle of a grocery store, farmers face numerous decisions when it comes to production on their farm. The GMO vs Organic debate is a matter of farmer choice, with consumer safety remaining a top priority. **Thanks to rigorous scientific studies, GMO and organic products have continually been proven to be nutritionally equal and safe to eat.**

Alfalfa

Canola

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Corn (Field + Sweet)

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ANIMAL SCIENCE | VARIATION & PROBABILITY OF EXPRESSED TRAITS

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Cotton

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ANIMAL SCIENCE | VARIATION & PROBABILITY OF EXPRESSED TRAITS

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Hawaiian Papaya

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Innate Potatoes

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ANIMAL SCIENCE | VARIATION & PROBABILITY OF EXPRESSED TRAITS

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Soybeans

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ANIMAL SCIENCE | VARIATION & PROBABILITY OF EXPRESSED TRAITS

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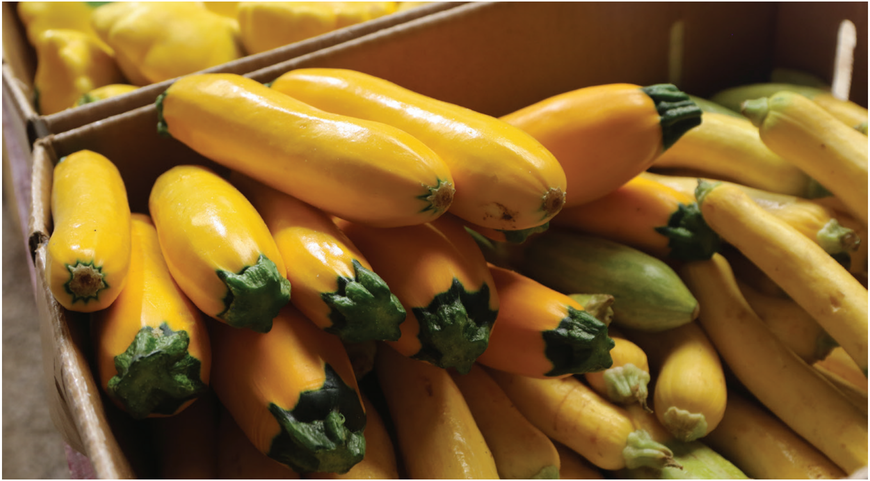
Squash



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Sugar Beets

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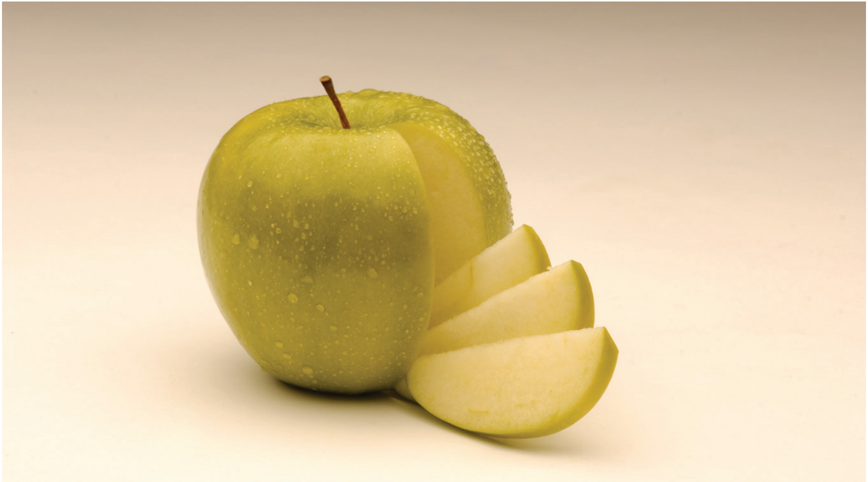
Arctic Apple



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AquAdvantage Salmon

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Wheat

Tomatoes

Sweet Potatoes

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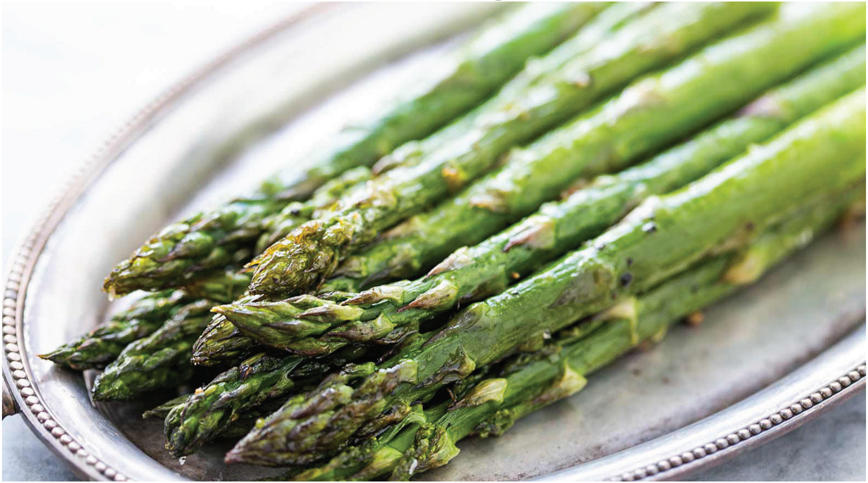
Asparagus



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ANIMAL SCIENCE | VARIATION & PROBABILITY OF EXPRESSED TRAITS

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Lettuce

Issue

1

Apples start to oxidize almost immediately after they have been sliced and exposed to air. This causes them to turn brown and a little mushy. The brown color is unappetizing, and consumers often throw away the apples rather than eat them. This results in wasted food.

Courtesy of Iowa Agriculture Literacy Foundation

Issue

2

Children in Africa can suffer from malnutrition and poor diets. They don't get enough fruits and vegetables in their diet that provide a wide range of nutrients. A deficiency of vitamin A can result in blindness. Rice is one of the staples of their diet, which is an excellent source of calories.

Courtesy of Iowa Agriculture Literacy Foundation

Issue

3

Global warming has caused rising sea levels. Lowlands of southeast Asia are experiencing an increase in the salinity of their soil from ocean water flooding and underground salt water seepage. Rice crops cannot grow in the salty soil, resulting in poor yields and crop failure. Rice is a staple crop and is essential to feeding the local population.

Courtesy of Iowa Agriculture Literacy Foundation

Issue

4

Wheat naturally grows on a tall shaft. But the taller the shaft, the weaker it is. A strong wind storm can easily blow down standing wheat which is heavy from the seeds on top. Once blown down, the wheat doesn't recover and cannot be harvested. The crop is lost.

Issue

5

Potatoes can be bruised by impact and pressure during harvest and storage. This results in black spots on the potato. Consumers will not purchase discolored potatoes, and potatoes with these black spots are thrown away. This results in a lot of food waste.

Courtesy of Iowa Agriculture Literacy Foundation

Issue

6

The corn borer is a moth that lays eggs on corn plants. When the eggs hatch, the larva that looks like a small worm eats the corn plants and can cause millions of dollars of damage to the corn field.

Courtesy of Iowa Agriculture Literacy Foundation

Issue

7

Papayas are susceptible to a disease called the papaya ring spot virus. This virus deforms fruit of young plants and can prevent the plant from producing fruit at all. The virus is spread by insects and cannot be contained. Papaya production was cut in half because of the virus.

Courtesy of Iowa Agriculture Literacy Foundation

Issue

8

Weeds in soybean and cotton fields compete for the water, nutrients, and sunlight that the soybeans and the cotton need to grow. Because they are broadleaf plants (same as the weeds) farmers can't spray herbicides while the plants are growing. This results is a significant reduction in crop yield.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in….

Arctic® apples won't brown after they've been bitten, sliced or bruised. Consumer research has shown that people prefer the eye-appeal of the new variety. Approximately 40% of apples are wasted because of browning. The new variety maintains a longer shelf life of the cut fruit so it won't be thrown away. There is no need to treat apples with ascorbic acid to try to prevent browning.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in….

Golden Rice could significantly reduce vitamin A deficiency syndrome. More than 1.1 million children die every year from vitamin A deficiency. Up to 500,000 more lose their eyesight and others become susceptible to diseases. This biofortification could improve the primary food source for billions of people.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in....

Rice is the primary source of calories for more than 3 billion people in the world—many in southeast Asia. The International Rice Research Institute has used a variety of techniques to change the genetic architecture of rice so that it can be grown in soil that has a higher salinity. This has led to increased harvests for poor farmers in salt affected areas.

The results are in….

Norman Borlaug initially worked with high producing varieties of wheat that had tall, thin stalks. In 1953, his semi-dwarf variety produced more stalks and more heads of grain per plant. Borlaug's semi-dwarf, disease resistant varieties changed the potential yield of spring wheat dramatically. This increased production by six-fold in Mexico.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in….

Innate™ potatoes reduce black spots from bruising. Previously, tons of bruised potatoes never made it to market, costing millions of dollars. The technology also resulted in the reduced production of the amino acid asparagine. Asparagine is a precursor to acrylamide, which is a suspected carcinogen when cooking potatoes. The new potato reduces the risk of getting cancer.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in….

Bt corn has revolutionized pest control in corn crops by providing protection from hungry corn borer larva. This means that growers will be handling and applying fewer chemical insecticides, which has health benefits for the growers and important environmental benefits. Bt corn reduces the use of insecticides, protects yields, and improves the quality of the grain.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in….

The Rainbow Papaya grown in Hawaii is resistant to the papaya ring spot virus and has been proven to be safe to eat and of commercial quality. This new variety yields up to 125,000 lbs. of fruit per acre—a 25x increase. The fruits are exactly the same nutrition and have been safely consumed for more than a decade.

Courtesy of Iowa Agriculture Literacy Foundation

The results are in….

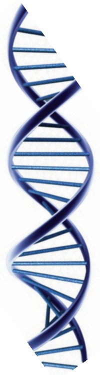
RoundUp Ready soybeans and cotton were first commercially produced in the mid-1990s. This transgenic variety can be sprayed with RoundUp (glyphosate) with no damage to the plant. The RoundUp will kill other plants (weeds) that compete with the soybeans and cotton. This can improve yields of the soybeans and cotton.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

A

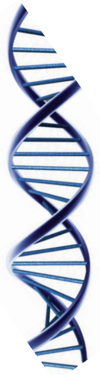
Scientists discovered a gene silencing technique to turn off the expression of polyphenol oxidase. This plant enzyme causes a chemical reaction when cells are damaged resulting in brown melanin. By suppressing this gene, no polyphenolics are produced and no browning occurs.



Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

B

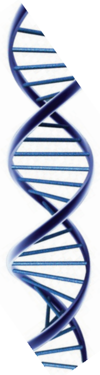


Scientists discovered a gene sequencing technique using similar wild plant species RNA to suppress natural enzymes. The gene sequence from wild plant species is so similar that the domesticated version easily recognizes it. This means that bruising can be reduced by up to 40%.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

C

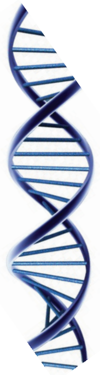


Scientists use a process called transformation to copy traits from one organism and insert them into another organism's cell. By copying a protein from a virus and inserting it into the seed of a fruit, the fruit becomes resistant to that virus.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

D



A naturally occurring soil bacterium—*Bacillus thuringiensis* (or Bt)—produces a protein that is toxic to caterpillars but safe for other insects and other animals like mammals, birds and fish. Scientists can insert the gene from the Bt into a plant's genetic code, and the plant can produce the protein that is toxic to the caterpillars.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

E

Many farmers spray glyphosate to control weeds. Glyphosate kills plants by interfering with their ability to produce essential amino acids. Using a gene gun, scientists can insert germplasm from a bacterium into seeds so they can still produce the amino acids. Then, when glyphosate is sprayed, it kills the weeds but leaves the desired crop.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

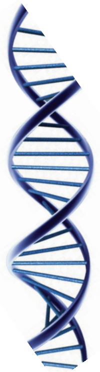
F

Some varieties of a plant are more salt tolerant than other varieties. But those salt tolerant varieties don't produce as much. Scientists are working on recombinant DNA that will inter-mate salt-tolerant plants with high-producing varieties. This will hopefully yield a high-producing, salt-tolerant variety.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

G

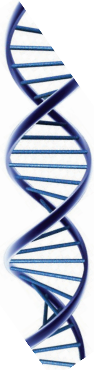


Scientists crossed a high-yielding American variety with a dwarf Japanese variety. This created a semi-dwarf variety that is half the height and can produce thick stems. The thick stems can hold more heads of grain per plant. The semi-dwarf variety was then crossed with disease-resistant varieties to add those traits.

Courtesy of Iowa Agriculture Literacy Foundation

Possible Solution

H



Many fruits and flowers that are orange produce beta-carotene and is necessary to produce vitamin A. Scientists added two genes (one from a grass and one from a bacterium) to turn on the production of carotenoids. The resulting grain was golden in color and produced beta-carotene.

Courtesy of Iowa Agriculture Literacy Foundation