Curriculum development was supported by the USDA National Institute of Food and Agriculture.	Kansas Foundation for AGRICULTURE IN THE CLASSROOM (KFAC)	Curriculum Development Team Chelsea McCall Emily Duello Katie Hutchison Celsey Crabtree

Course:	Biology 9-12	**Unit:**	Vertical Gardening - Agriculture Careers
Lesson Title:	Healthy Plants for Healthy Humans: Addressing Nutrient Deficiencies and Crop Yield		
Estimated Time:	4 class periods of 40 minutes		

Objectives:

1) Evaluate plant growth data
2) Describe the causes and identify the symptoms of nutrient deficiencies
3) Identify careers in the field of agriculture

Equipment Needed:

Projector or device to present Lesson 8 slides
Projector or device for Kahoot Game
Individual devices for students to play Kahoot!

Supplies Needed:

Paper copies of National Ag in the Classroom Handout (1 per student)
Interview with Dr. Tesso (Audio file)

Accessibility Options

Students can access information visually through online videos with subtitles and auto-translations.
Utilize Speech-to-Text and text-to-speech add-ons for reading/listening/writing support (Updated 7/17/23)

For more suggestions, please visit:
https://www.washington.edu/doit/equal-access-science-and-students-sensory-impairment

Instructor Directions & Estimated Time	Procedures
Day 1 40 minute period	Analyze plants and document observations.
Day 2 40 minute period	Communicate with a professional.

Day 3 40 minute period	Humanity Against Hunger
Day 4 40 minute period	Career Bingo/Kahoot

No.	9-12 Next Generation Science Standards		
HS-LS 2-3	Matter and Energy in Organisms and Ecosystems: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.		
	Disciplinary Core Ideas	Science and Engineering Practices	Cross-Cutting Concepts
	LS2.B: Cycles of Matter and Energy Transfer in Ecosystems	Constructing Explanations and Designing Solutions	Energy and Matter

No.	9-12 National Agriculture Literacy Outcomes
T1. 9-12 h	h. Understand the natural cycles that govern the flow of nutrients as well as the way various nutrients (organic and inorganic) move through and affect farming and natural systems
T2. 9-12 b&d	b. Compare similarities and differences between organic and inorganic nutrients (i.e., fertilizer) on plant growth and development; determine how their application affects plant and animal life d. Evaluate evidence for differing points of view on topics related to agricultural production, processing, and marketing (e.g., grazing; genetic variation and crop production; use of fertilizers and pesticides; open space; farmland preservation; animal welfare practices; world hunger)

Vocabulary	
Commercial fertilizer:	Commercially prepared mixtures with precisely measured plant nutrients that include nitrogen, phosphorus, and potassium are applied to the soil to restore fertility and increase crop yields
Inorganic fertilizer:	Commercially prepared mixtures of plant nutrients containing nitrogen, phosphorus, and potassium that were obtained by mining from the earth
Macronutrient:	A nutrient that must be present in a relatively large amount to ensure the health of the organism; building blocks used to make essential

	biomolecules
Micronutrient:	A nutrient required in small quantities to ensure the health of the organism; often used as cofactors for enzymatic reactions
Organic fertilizer:	A fertilizer that undergoes little or no processing and includes plant, animal, and/or mineral materials

Careers Mentioned	
Entomologist	Responsible for researching growth, nutrition, behavior, and how insects interact with plants.

Day 1

Day 1 Essential question: How do we know our plants are healthy?
1) Bellringer on Lesson 8 slides: What are the signs of a nutrient deficiency in humans?

2) Students examine their plants and make notes in their plant journals - are we noticing anything different about them? Nutrient deficiencies? Growth differences? Better root or leaf structure? Color differences? Yellow/brown/wilted?

Evaluate: Do our plants have what they need to grow? Did we select the right plants based on environmental conditions?
*Add to plant journal

Essential Question: What careers are connected to agriculture? Which careers are you most suited for based on your skills and interests?

1) Ask students to draw a mind map with Food Production in the center. Give them 3 minutes to list the careers they have learned about in this lesson. Discuss the answers as a class.

2) Matching activity - Read/listen to the career description and choose which **Career Poster** matches the description.
*This activity is useful to have students move around. You can post career descriptions around the room, make a set of career cards for each small group, or have students play individually.

Day 2

Day 2 Essential Question: What types of research are scientists doing in the field of crop production?

Meet the scientist- Dr. Tesfaye Tesso, Crop Scientist at Kansas State University.

Students will complete this activity to learn more about Dr. Tesso, who has firsthand experience researching ways to address hunger in Ethiopia.

Part 1: Background Information- Give students 5-10 minutes to answer questions about Dr. Tesso's website

Part 2: Interview with Dr. Tesso- Listen to the interview and record the answers to the students' questions. (30 minutes) Students can divide the interview into 5-7-minute sections and report their information back to small groups or the whole class..

Part 3: 3-2-1 Summary (5 minutes) Students describe what they learned from the interview and share with their groups.

Optional Extension: Students write their questions and email Dr. Tesso as a class.

Day 3

Day 3 Essential Questions: How do nutrient deficiencies affect plant growth and food production? Who is responsible for addressing these issues?

Begin National Ag in the Classroom activity: Humanity against hunger (web or print version)- Estimated time for activity is 1 hour.
https://agclassroom.org/matrix/lesson/237/

Day 4

Day 4 Essential Questions: How do nutrient deficiencies affect plant growth and food production? Who is responsible for addressing these issues?

Options:

1) Complete the Humanity against Hunger activity from Day 3
2) Play a game to review agricultural careers

   Review game links: Career Bingo or Kahoot.
   (Kahoot link - You will need to create a free account to access this game -https://create.kahoot.it/share/ag-careers/4f6dec5d-7708-4e70-a81c-8686508a896b

3) Exit ticket:
a) Which of the careers that we discussed today would you be most interested in? Why?
b) Which of the careers that we discussed today would you be most prepared for based on your current skills? Why?
c) Are the careers in questions A and B the same or different? What conclusion can you draw from this?
Additional topics students could explore:
Kansas food insecurity data and Kansas crop production data
Kansas Department of Agriculture statistics
What are the top crops that we produce in Kansas?

Main topics teachers should know:

Understanding plant health and science is vital to food production and agriculture. Ensuring plants receive the right nutrients and grow optimally impacts everything from gardens to the global food supply. Commercial fertilizers and manufactured products are used to provide plants with essential nutrients for plant growth. These fertilizers are made to supply plants with specific nutrients that might be lacking in the soil, ensuring that the crops grow well and produce high yields. Commercial fertilizers can be tailored to meet the specific needs of the crop and are highly useful in large-scale farming. Inorganic fertilizers are chemically synthesized and often contain high concentrations of nutrients. Common examples of these fertilizers include Nitrogen (N), phosphorus (P), and potassium (K) in specific formulations. These fast-acting fertilizers provide immediate nutrients to plants, which is useful in large-scale farming. Overuse of these fertilizers can harm the environment so proper application is essential. Organic fertilizers come from natural resources like compost, manure, or bone meal. These resources release nutrients more slowly than inorganic fertilizers but improve soil health over time by increasing organic matter. These fertilizers are often favored in sustainable farming and gardening because they promote long-term soil fertility and reduce the risk of pollution. Macronutrients are the nutrients that plants need in a much higher quantity. The three primary macronutrients are nitrogen, phosphorus, and potassium (N-P-K). Nitrogen promotes leafy growth and is crucial for photosynthesis. Phosphorus is important to root development and flowering. Potassium helps regulate water and improve overall plant health. Micronutrients are the nutrients that are required in smaller amounts. These include elements like iron, manganese, zinc, and copper. These nutrients play an important role in enzyme function and photosynthesis. Without these nutrients, plants suffer from deficiencies that impact growth and yield.

Entomologists also play a crucial role in agriculture by studying insects that impact plant health. Insects can harm or benefit crop production which makes entomologists vital in pest management and pollination research. Harmful pests can reduce the effectiveness of certain fertilizers and eventually harm the plant roots and leaves. Integrated Pest Management strategies will help reduce challenges with fertilizers and chemical pesticides which can also disrupt soil health and nutrient balance. They also study beneficial insects like pollinators which can improve crop yield and plant vitality.

- https://sustainablemacleod.org.au/the-difference-between-organic-and-inorganic-fertiliser/#:~:text=The%20fundamental%20difference%20between%20organic,plus%20minerals%20from%20the%20earth.
- https://fertilizerboosters.com/commercial-fertilizer-boosters/#:~:text=Like%20agricultural%20fertilizers%2C%20commercial%20fertilizers,are%20depleted%20through%20plant%20harvesting.
- https://kellogggarden.com/blog/gardening/macronutrients-vs-micronutrients-in-plants/#:~:text=Great%20gardens%20start%20with%20good,make%20nutrients%20available%20to%20plants.

Suggestions for instruction:

If students are noticing strange symptoms on their plants, you can have them research possible causes as an extension. Have students create a list of possible solutions for their plants and present to the class on their findings.

Agribusiness Commodity Flow Studies

Commodity flow studies were conducted for four of the major crops in Kansas (corn, grain sorghum, soybeans and wheat), the major livestock species produced in Kansas (cows, fed cattle, market hogs, sheep, broilers, and turkeys), four major feed ingredients (dried distillers' grains (DDGs), soybean meal, wheat midds, and meat and bone meal), and two biofuels (ethanol and biodiesel). In 2020, Kansas produced more than 44 million tons of these crop and livestock products. An estimated 19.3 million tons of these commodities are transported from production points within Kansas for first-level processing, use as feed, fuel, or other intermediate uses such as ingredients in pet foods. Local use, defined as within the same USDA Agricultural Statistics District (ASD), accounts for 72% of the commodity movement that stays inside the State of Kansas.

An estimated 4.9 million tons of these agricultural commodity products are brought into Kansas for use as feed, fuel, and first level processing from 315 counties outside of Kansas. Kansas ships an estimated 30.5 million tons of grains, feed ingredients, biofuels and livestock to an estimated 617 counties (including international export ports). The seven most-used feed ingredients in Kansas and the 11-state region1 are corn, grain sorghum, wheat, soybean meal, DDGs, and meat & bone meal, and wheat midds. Estimated total use of these ingredients in 2020 was 11.8 million tons in Kansas. Corn is by far the leading feed ingredient at 7.4 million tons in Kansas and 75.8 million tons in the region. For Kansas, the next most used ingredient is DDGs (2.4 million tons) followed by grain sorghum (986,000 tons), wheat midds (394,000 tons), soybean meal (331,000 tons), meat & bone meal (157,000 tons), and wheat (139,000 tons).

Takeaways:

1. Kansas grain and oilseed production is increasing with the greatest increases in corn and soybean production.

2. Even with robust ethanol production, Kansas has net inflows of DDGs. Kansas has net outflows of corn, grain sorghum, wheat, soybean meal, meat & bone meal, and wheat midds.

3. The bulk of these outflows are to demand points within the 11-state region identified as our study area. The exception is HRW wheat for which 51% of outflows are outside the region.

4. Finding ways to add more value to Kansas grains within Kansas is a way to increase revenues, decrease transportation costs, and reduce associated greenhouse gas emissions. Pathways for adding value to grains can include expanded livestock feeding and processing, increased biofuels production, and valueadded grain processing such as protein extraction, synthetic amino acid production, and production of other grain-based nutritional derivatives.

5. Kansas has net outflows of biofuels with approximately 20% of biofuels moving outside the 11-state region. This implies that rail transport is an essential component of competitive biofuels production in Kansas. On a similar note, rail infrastructure is an essential part of moving the Kansas wheat crop to markets outside of Kansas and outside the 11-state region.

6. Kansas fed cattle processing facilities draw a significant share of their slaughter supply from outside the 11-state region. This suggests there may be an opportunity for more fed cattle feedlot production in Kansas; however, the Kansas-based supply shortage of DDGs would need to be addressed for more fed cattle feedlot production to be strongly competitive.

7. While Kansas ships most of their hogs out of state for processing, there is substantial processing capacity just beyond the Kansas borders to the north, east, and southwest. Expansion of hog production needs to consider the needs and flows of the individual processing plants just outside of Kansas.

8. Kansas ships a substantial amount of soybean meal to poultry producing areas in Oklahoma and Texas. Additionally, when the announced soybean processing facility in Montgomery County, Kansas begins operation, there will be more soybean meal available that could be the basis for more value-added production via broiler production in southeastern Kansas.

9. Kansas has a substantial amount of on-farm storage and a strong country elevator and terminal elevator network. In addition, Kansas is well positioned with rail shuttle loading facilities within reasonable distances of the major crop growing areas (especially wheat).

10. Farm to market and other rural road infrastructure have become even more important to the viability of Kansas farms as farm-to-first-market transport of commodities has become reliant on 5, 6 and 7-axle semi-truck/trailer combinations.

11. Kansas produces 6 million tons of livestock and poultry products that move from the farm. All of this production moves from the farm to the first point of purchase, collection or processing by truck. While some of this movement is on state and/or federal highways, a significant portion of this movement occurs on county roads and farm-to-market roads.

12. Off-farm commercial and terminal storage for grains and oilseeds plays an integral role in the marketing flows of Kansas crops. Wheat moves very rapidly from farms and farm storage to commercial storage with only 9% in on-farm storage one quarter after harvest and 58% of the current harvest in commercial and terminal storage. Soybeans stay on farm a bit longer with about 17% on-farm after 90 days and 43% of the harvest in commercial storage. Corn moves a bit slower with 20% still on-farm after 90 days and 33% in off-farm storage.

Careers:

Entomologist

Description: Entomologists are responsible for researching the growth, nutrition, behavior, and how insects interact with plants. They are considered scientists and their main focus lies on the study and research of insects. An entomologist may have the following responsibilities: monitor insect feeding behavior, insect physiology, plant-insect interactions, insect feeding biology, visit farm and other research trial plots to collect insect samples, weigh, formulate, and apply experimental and commercial insecticides to pest targets and their habitats, prepare and deliver documented proposals and reports for establish research trials, design and implementation of research plans to support the selection of new insecticide products, manage trial establishment and collection of data, and budget for research work and provide management reporting in regard to trial/research progress.

Education: A doctoral degree in entomology, biology, or zoology is required to become an entomologist.

Salary: The average Entomologist salary in Kansas is $76,214 as of July 25, 2023, but the range typically falls between $62,567 and $93,947. Salary ranges can vary widely depending on the city and many other important factors, including education, certifications, additional skills, and the number of years you have spent in your profession.

Links:
https://www.agcareers.com/career-profiles/entomologist.cfm

https://www.salary.com/research/salary/recruiting/entomologist-salary/ks

Take a look at the Career Glossary to find other related careers!

Augustine Obour
aobour@ksu.edu
Soil Science
Ghana
https://www.agronomy.k-state.edu/about/people/faculty/obour-augustine/
CV:
https://www.agronomy.k-state.edu/about/people/faculty/obour-augustine/documents/Obour-CV.pdf

Tesfaye Tesso
ttesso@ksu.edu
Sorghum Breeding and Genetics
Ethiopia
https://www.agronomy.k-state.edu/about/people/faculty/tesso-tesfaye/
CV:
https://www.agronomy.k-state.edu/about/people/faculty/tesso-tesfaye/documents/Tesso-Tesfaye-2014CV.pdf

Questions for African Professors/Researchers

Hello Professor____,

My name is ______ and I am a high school science teacher in _______. My students are studying food production, agriculture, and climate change. We read about your research and are interested in your opinion on several topics. Do you have a few minutes to answer our questions below?

We truly appreciate your time.

Regards,
____

1) What do you think all students should know about food production and ____?

2) What do you think all students should know about famine?

3) How are people in your home country addressing challenges with food production and climate change?

4) What do you enjoy about your job?

5) What is challenging about your job?

6) What skills do students need to be successful after graduating from high school?

7) What do you think all students should know about your home country?

8) Who is someone that has inspired you and why do you find them inspirational?

P.S. If you have time for a phone call or zoom in the next few weeks I would love to speak with you about a possible collaboration with Kansas Foundation for Agriculture in the Classroom, an affiliate of Kansas State University. I am part of a team of educators that is working to provide more opportunities for culturally and linguistically diverse students to see themselves in agricultural fields. Do you perhaps know someone who would be interested in discussing this? Thank you!

MASTER 4.1

HUMANITY AGAINST HUNGER

NAME

DATE

You have been selected to join **HUMANITY AGAINST HUNGER,** an international effort dedicated to fighting hunger around the world. Globally, it is estimated that 842 million people—12 percent of the global population—were unable to meet their dietary energy requirements in 2011–13. Thus, around one in eight people in the world are likely to have suffered from chronic hunger, not having enough food for an active and healthy life. The vast majority of hungry people—827 million—live in developing regions.

Your first assignment is to travel to sub-Saharan Africa and help farmers from a small village. Africa remains the region with the highest prevalence of undernourishment, with more than one in five people estimated to be undernourished.

Although some areas of Africa have rich soil and support plant growth, other areas do not. Growing food for the increasing human population is an important challenge. African farmers have traditionally cleared land, grown and harvested their crops, and then moved on to clear more land for the next planting. After harvesting their crops, the farmers left the land alone so that it would eventually regain its fertility.

However, increasing population growth has limited this traditional farming practice which worked so well in the past. Today, farmers often grow crop after crop on the same land, thereby “mining,” or depleting, the soil of its nutrients. Most of them realize that they need to repair the soil, but often they lack the knowledge or the money needed to do so.

Your task is to help the local farmers diagnose nutrient deficiencies among their crops. Then you will make recommendations on how to restore nutrient balance to the soil and improve crop yields.

MASTER 4.2a

CORN CASE STUDY 1

NAME
DATE

PRIMARY INFORMATION

The farmer reports that his corn grows in sandy soil. The plants are stunted and have yellow leaves. They are free of pests, and the fields are free of weeds. The farmer provided the following photograph.

SECONDARY INFORMATION

The farmer sent this additional photograph of an affected leaf. He reports that his fields have been exposed to heavy rains and higher than normal temperatures.

MASTER 4.2b

CORN CASE STUDY 2

NAME

DATE

PRIMARY INFORMATION

The farmer reports that the plants are stunted. Her corn grows in sandy soil. Some weeds are present in the fields. She provided the following photograph, which shows some yellowing of leaves.

SECONDARY INFORMATION

The farmer sent this additional photograph of a leaf from an affected plant. She also reports that some of her plants have stems that are not strong enough to support the ears of corn.

MASTER 4.2c

CORN CASE STUDY 3

NAME

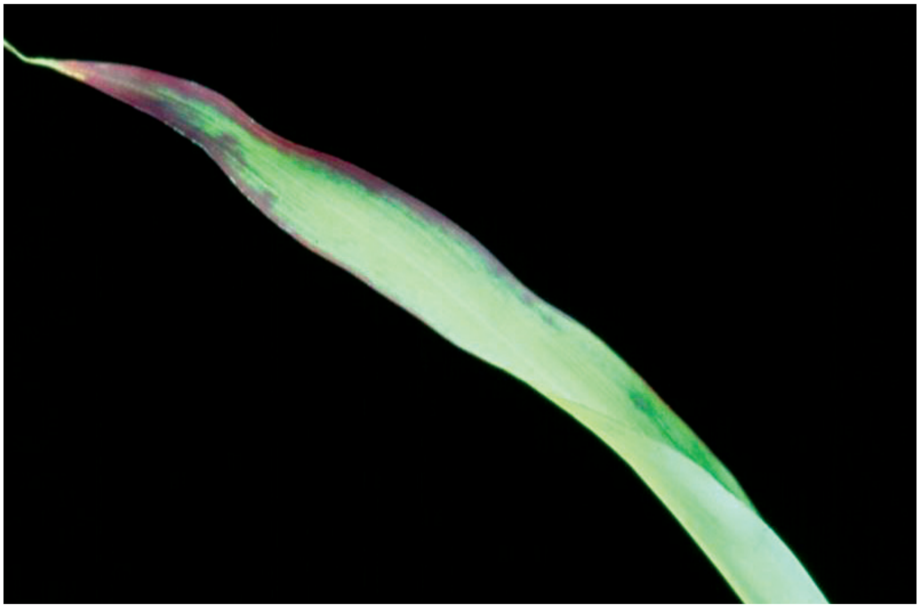
DATE

PRIMARY INFORMATION

The farmer reports that her plants are stunted. Her fields are composed of compacted (dense) soil and are free of weeds. She provided the following photograph of two affected plants.

SECONDARY INFORMATION

The farmer sent this additional photograph of a leaf from an affected plant. The discoloration seen near the tip of the leaf is purplish. She reports that her corn is maturing later than it should and that she is beginning to see some weeds growing in her fields.



MASTER 4.3

PLANT DOCTOR EVALUATION FORM

NAME	
DATE	
CASE STUDY NUMBER	

INSTRUCTIONS

STEP 1. Complete 1 evaluation form for each case study.

STEP 2. After reviewing Primary Information, record your responses in the following spaces:

IMPORTANT SYMPTOMS
INITIAL DIAGNOSIS
SYMPTOMS THAT MATCH THE NUTRIENT DEFICIENCY

STEP 3. After reviewing Secondary Information, record your responses in the following spaces.

IMPORTANT SYMPTOMS	
IS YOUR INITIAL DIAGNOSIS CONFIRMED?	**YES** OR **NO**
IF NOT, WHAT IS YOUR NEW DIAGNOSIS?	
IF NOT, WHAT CAUSED YOU TO CHANGE YOUR DIAGNOSIS?	

MASTER 4.4a

PLANT DOCTOR
REFERENCE MANUAL

NAME

DATE

INTRODUCTION

Like humans, plants need a proper diet to be healthy. Unlike humans, however, plants cannot move to find food. They can only take up nutrients available in the soil or, in the case of legumes, from the atmosphere. Different species of wild plants are adapted to different levels of nutrients, and many thrive in low-nutrient soils. However, when growing most crop plants, if a nutrient is missing, or present in a lesser amount than is needed, then the crop plant cannot reach its maximum growth potential. The consequences of nutrient deficiencies can be moderate or severe, depending on the extent of the deficiency. The symptoms displayed vary depending on the type of plant and which nutrient is lacking. Sometimes, a nutrient deficiency causes the plant to become more susceptible to disease, similar to a person who has a weak immune system. A plant doctor (called an agronomist) determines which nutrient is deficient and recommends using a fertilizer that contains enough of the nutrient to restore the plant to good health. This manual describes the symptoms associated with nitrogen, phosphorus, potassium, and zinc deficiencies for corn plants. Photographs are supplied to help diagnose the deficiencies.

NUTRIENT DEFICIENCIES OF CORN

NITROGEN DEFICIENCY

The major symptom of this problem is a general yellowing of the plant. The yellowing begins at the leaf tip and gradually works its way down to the base of the leaf. Older leaves show a V-shaped yellowing of the inner leaves, with the leaf edges remaining green in a V pattern. The plants may appear stunted and spindly. Symptoms of nitrogen deficiency are most noticeable in plants growing in lower, poorly drained parts of the field. Nitrogen deficiency also can result after heavy rains remove nitrogen from sandy soils. Nitrogen is an important building block used by plants for many aspects of growth. Restoring nitrogen to the soil will improve crop yields.

A NORMAL LEAF IS ON THE RIGHT. LEAVES FROM INCREASINGLY NITROGEN-DEFICIENT PLANTS ARE ON THE LEFT.

MASTER 4.4b

PLANT DOCTOR
REFERENCE MANUAL

NAME

DATE

NUTRIENT DEFICIENCIES OF CORN

PHOSPHORUS DEFICIENCY

Plants that lack phosphorus show stunted growth and mature later than healthy plants. Late-maturing crop plants are more susceptible to frost, harvest damage, disease infection, and summer drought. The leaves and stems often show purpling or reddening.

Phosphorus deficiency can result when soil phosphorus levels have declined due to nutrient removal. It can also occur in cool conditions that reduce diffusion to the root. As a result, many farmers apply some phosphorus with the seed to support early growth when the soil is cool. Restoring phosphorus to the soil allows crop plants to mature properly and be better protected from disease, drought, and frost.

THESE PHOSPHORUS-DEFICIENT CORN PLANTS SHOW THE CHARACTERISTIC DARKENING OF THE LEAVES.

MASTER 4.4c
PLANT DOCTOR
REFERENCE MANUAL

NAME

DATE

NUTRIENT DEFICIENCIES OF CORN

POTASSIUM DEFICIENCY

Plants that lack potassium show stunted growth and mature later than normal plants. Potassium deficiency results in yellowing and drying of the leaf edges, especially on older leaves. The death of cells in the leaves may be visible as a dark discoloration. The stems of potassium-deficient plants are weak and often break below the ears.

Potassium deficiencies happen most often in soils that are sandy, wet, or compacted (dense) or when potassium has been removed through repeated cropping and natural levels are low. Restoring potassium to the soil will help the plants better absorb water and prevent wilting and dry leaves.


THE OLDER LEAVES OF POTASSIUM-DEFICIENT CORN PLANTS YELLOW AND DIE AROUND THE EDGES (LEFT), WHILE AREAS OF CELL DEATH ON LEAVES MAY APPEAR AS DARK SPOTS (RIGHT).

MASTER 4.4d

PLANT DOCTOR
REFERENCE MANUAL

NAME

DATE

NUTRIENT DEFICIENCIES OF CORN

ZINC DEFICIENCY

Plants lacking zinc show pale- to whitish-colored bands located between the veins of the leaves. The plants may be stunted. Zinc deficiency is associated with soils that are alkaline and contain little organic material.

LEAVES FROM ZINC-DEFICIENT PLANTS SHOW PALE STRIPES ON THEIR LEAVES.

MASTER 4.5

CROPS, SOIL, AND NUTRIENTS

NAME

DATE

Agriculture is a major industry in the United States. Approximately 20 percent (408 million acres) of our land area is used for crop production. The top field crops grown in the US are corn, soybeans, and wheat.

CORN

- The US is the largest producer of corn in the world.
- In 2011, the US produced over 12 billion bushels of corn.
- The US produces 32 percent of the world's corn crop.
- Corn grown for grain accounts for almost one quarter of the harvested crop acres in the US.
- On average, a farmer can harvest approximately 150 bushels of corn (for grain) on 1 acre of land.

SOYBEANS

- Soybeans rank second behind corn as a major crop in the US.
- The US accounts for 50 percent of the work's soybean production.
- In 2011, US farmers harvested 3.06 billion bushels of soybeans from 73.6 million acres of cropland.
- On average, a farmer can harvest approximately 46 bushels of soybeans (for grain) on 1 acre of land.

WHEAT

- Wheat ranks third as a major field crop in the US.
- The US produces over 2.2 billion bushels of wheat a year.
- The US produces approximately 10 percent of the world's wheat.
- On average, a farmer can harvest approximately 50 bushels of wheat (for grain) on 1 acre of land.

In previous lessons, you learned that plants get many of their nutrients from the soil. Earlier in this lesson, you observed how plants are affected if they do not get the nutrients they need. Consider the following scenario. Three farmers each have very good, nutrient-rich soil. One farmer plants corn, one plants soybeans, and one plants wheat. Each farmer's harvest matches the average in the US for each crop (150 bushels/acre for corn, 46 bushels per acre for soybeans, and 50 bushels per acre).

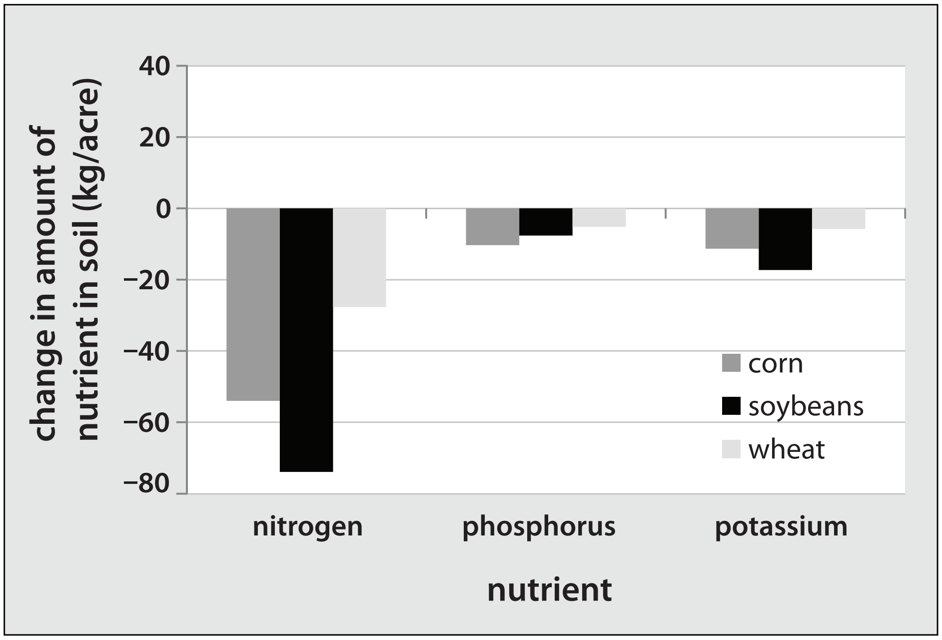
US Environmental Protection Agency. (2013). Major Crops Grown in the United States. http://www.epa.gov/oecaagct/ag101/cropmajor.html

MASTER 4.5

CROPS, SOIL, AND NUTRIENTS

NAME
DATE

How does growing those crops affect the soil? Look at the following graph that shows how nutrient levels are changed in just one acre of land after growing the crops.



Zero indicates the starting amount of the nutrient in one acre of soil (**before** the crops were grown).

The y-axis measures the change in amount of nutrient in the soil.

A positive number means that there is **more** of the nutrient in the soil after the crop has grown.

A negative number means that there is **less** of the nutrient in the soil after the crop has grown.

ANSWER THE FOLLOWING QUESTIONS:

What happened to the level of nutrients in the soil after growing the crops?

How would the levels of each major nutrient be changed if the farmer grew 100 acres of the crop? 1,000 acres of the crop?

What might happen to the crops if the farmers plant their crops in this soil again in future years?

What actions might the farmers need to take if they want to continue getting good harvests from their crops in the future?

MASTER 4.6

INVESTIGATING CALCIUM DEFICIENCIES

NAME

DATE

MATERIALS FOR EACH TEAM

- 6 paper or plastic cups
- Potting soil
- Tap water
- 6 pea seeds
- Permanent marker pen
- Ruler (after seeds have germinated)
- Stick or skewer (after plants have germinated to hold them upright)

PROCEDURE

1. Identify your team's cups with your initials or other identifying mark.
2. Poke small holes (2-3) in the bottom of each cup.
3. Fill each cup approximately 3/4 full with potting soil.
4. Moisten the potting soil with water. If the level of the potting soil goes down, add more so that the cup is approximately 3/4 full.
5. Place 1 pea seed on top of the potting soil.
6. Cover the seeds with additional potting soil and water thoroughly.
7. Record the date that the seeds were planted in the chart below.
8. Set cups in the designated place. Make sure they are watered regularly and that they do not dry out.
9. In your data chart, record observations, including when you first see signs of germination.
10. When the plants are approximately 5-7 cm tall, choose the three seedling plants that are closest to the same height. (This should be approximately 5-7 days after planting.) You will use these for your experiment.
11. Label each cup with the treatment that you will give
    - **Tap water**
    - **5 mM EDTA**
    - **25 mM EDTA**
12. Begin watering each plant according to its treatment. Record the date and the height of each plant in your data table when you begin the treatments.
13. Continue watering the plants regularly and do not let them dry out or over water. Observe the plants regularly. Record any observations in your data table. Make sure to measure the height of the plants in addition to visual observations.
14. Continue the experiment until your teacher asks you to collect final data. Record final data in your chart.
15. Add your data to the class chart.

MASTER 4.6

DATA CHART

NAME

DATE

DATE	ACTION TAKEN OR OBSERVATIONS

*IF YOU NEED ADDITIONAL SPACE FOR YOUR DATA CHART, YOU CAN DRAW A CHART ON PLAIN OR LINED PAPER.

MASTER 4.7

ADDITIONAL EXPERIMENTAL RESULTS

NAME

DATE

BEFORE EXPERIMENTAL TREATMENT
WATER

AFTER EXPERIMENTAL TREATMENT
25 mM EDTA

MASTER 4.8
CALCIUM AND PLANT GROWTH

NAME

DATE

You probably know some of the reasons why calcium is important in the human body. Calcium helps form and maintain healthy teeth and bones. You may be less familiar with some other roles for this important element. Calcium also plays a role in the clotting of blood, the sending and receiving of nerve signals, muscle contraction and relaxation, and regulating the release of certain hormones and other chemicals in the body.

In plants, calcium is a constituent of cell walls and is involved in the new growth of leaves and root tips. It provides elasticity and expansion of cell walls, which prevent the growing points from becoming rigid and brittle. As scientists continue to study the role of calcium in plants, they find that calcium is important in many plant functions ranging from nutrient uptake to coordinating changes in the cells that help the plant react to the impact of environmental changes and stresses.

Calcium deficiencies in plants generally appear in areas of new growth, such as leaves, stems, buds, and roots. Young leaves may be deformed. Areas around the edge of the leaf may die or the entire leaf may die. In older leaves, dead (necrotic) spots may develop.

In plants like tomatoes and peppers, calcium deficiency causes a disorder called blossom-end rot. In such cases, a black leathery spot appears on the blossom end of the fruit. The fruit then stops developing and eventually falls off. In peanuts, low calcium levels cause a condition that prevents nuts from developing.

Calcium deficiencies also affect roots. Roots may be short, stubby, and misshapen. In severe cases, root tips may die.

MASTER 4.9

EDTA EFFECTS ON PEA PLANTS

NAME
DATE

BEFORE TREATMENT

AFTER TREATMENT

Student Name:
Experiment Name:
Date:

Control Treatment:

	Quantitative Data			Qualitative Data		
Plant #	**Number of leaves**	**Plant Height**	**Plant Width**	**Color**	**Shape**	**Appearance**
Plant 1						
Plant 2						
Plant 3						
Plant 4						

Other Observations:

Experimental Treatment:

	Quantitative Data			Qualitative Data		
Plant #	**Number of leaves**	**Plant Height**	**Plant Width**	**Color**	**Shape**	**Appearance**
Plant 1						
Plant 2						
Plant 3						
Plant 4						

Other Observations: