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

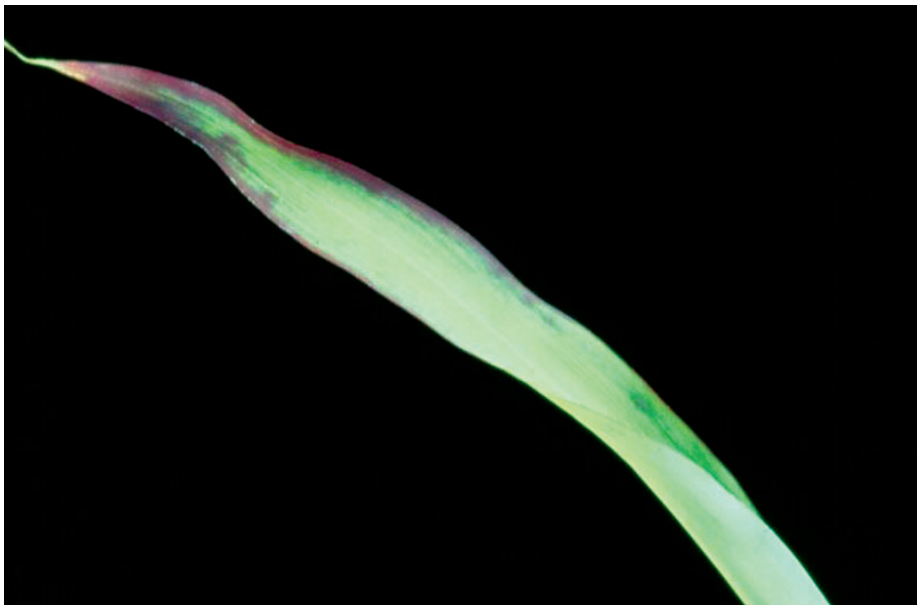
DATE

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.

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).

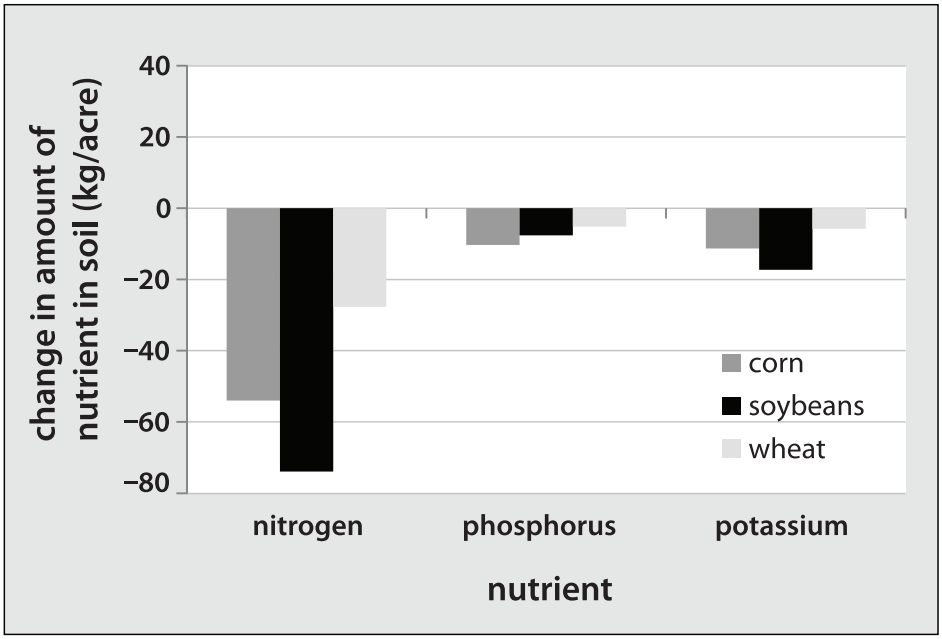
US Environmental Protection Agency. (2013). Major Crops Grown in the United States. http://www.epa.gov/oecaagct/ag101/cropmajor.html

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