Lesson 4 | Elaborate

Plant Nutrient Deficiencies

At a Glance

Overview

Students discuss the definition of "fertilizer" and relate it to plant nutrition and the need to restore nutrient balance in agricultural soils. They discuss how people and plants can suffer from nutrient deficiencies. Students assume the roles of plant doctors and diagnose nutrient deficiencies in corn plants.

Major Concepts

- Plants, like people, require essential elements to be present in certain quantities in order to be healthy.
- Plants extract nutrients from the soil. In the case of crops, a large portion of these nutrients are removed from the ecosystem when crops are harvested.
- Plants with nutrient deficiencies show specific symptoms.
- Commercial and organic fertilizers provide essential nutrients for plants.
- The soil is a "nutrient bank" that can hold a limited amount of nutrients. Commercial and organic fertilizers put more "money" in the bank by restoring nutrient balance to an agricultural soil.

Objectives

After completing this lesson, students will be able to

- recognize that plants, like people, require essential nutrients to be present in the right amounts in order to be healthy,
- use reference materials to diagnose plant nutrient deficiencies,
- define fertilizer as a type of "food" for plants, and
- appreciate that fertilizers are used to replenish nutrients in agricultural soils.

Teacher Background

Consult the following sections in *Teacher Background:*

6.0 Nutrient Deficiencies of Plants

7.0 Nourishing Plants with Fertilizers

In Advance

Photocopies

Activity 1	Master 4.1, *Alfalfa with Calcium Deficiency* (Prepare an overhead transparency.)
Activity 2	The following Masters are needed for the print version of the activity. Master 4.2, *Humanity Against Hunger* (Prepare an overhead transparency.) Masters 4.3a–c, *Corn Case Studies* (Make enough copies so that each student group works with 3 case studies.) Master 4.4, *Plant Doctor Evaluation Form* (Make 1 copy for each student.) Masters 4.5a–d, *Plant Doctor Reference Manual* (Make 1 copy for each student group.)

Materials

Activity 1	No materials except an overhead transparency
Activity 2	No materials except photocopies and transparencies

Preparation

Activity 1. No preparations are needed except for making photocopies and transparencies.

Activity 2. Students will be working in teams for this activity. Divide the class into groups of 3 students. Use scissors to cut Masters 4.3a–c, *Corn Case Studies* along the dotted lines separating *Primary Information* from *Secondary Information* in each case study.

Teacher note

During Activity 2: Humanity Against Hunger, you have the option of dividing the students into small groups or conducting the activity with the whole class. If you downloaded the supplement from the Web, you can request that a CD be sent to you by e-mailing the Nutrients for Life Foundation (info@nutrientsforlife.ca).

You are encouraged to use the interactive Web version http://www.nutrientsforlife.ca/for-students/games/humanity/ of this activity either in the classroom or as a take-home assignment.

Procedure

Activity 1: Take a Plant to Dinner

1. **Begin the activity by reminding students that in the previous lessons they explored how plants obtained nutrients from the soil and transported them through the xylem tissue. Explain that in this lesson they will investigate how to identify crop plants that are lacking an essential nutrient. Ask students, "What is fertilizer?"**

   Student responses will vary. Some will mention plant food.

2. **Mention that plants make their own "food" through photosynthesis. Ask, "Why do we need to give them additional food through plant nutrients?"**

   Student responses will vary. Notice that in the case of photosynthesis, "food" refers both to the element carbon, which accounts for about half the weight of the plant, and the light energy that is trapped and used to support plant metabolism. There are two important points that need to come out of this discussion. First, as discussed in Lesson 1, plants require essential elements (building blocks) that are not supplied by photosynthesis. Second, students should recall from Lessons 2 and 3 that most essential elements are found in soils and absorbed by the plant through its root system.

By the end of Grade 8, students will:

- identify unicellular organisms (*e.g., amoebae*) and multicellular organisms (*e.g., invertebrates [worms], vertebrates [frogs*]), and compare ways in which they meet their basic needs (*e.g., nutrition, movement, gas exchange*).

3. **Ask students, "If farmers have fertile soil, then why would they need to use fertilizers?"**

   Student responses will vary. Students should recall that as plants extract nutrients from the soil, and people remove crops from the fields, the soil becomes depleted of nutrients. Fertilizers are used to restore nutrient balance to agricultural soils in order to sustain plant growth.

4. **Remind students that plants and people are both made of cells and that cells need nutrients to be healthy. Ask, "What happens to us if we don't get enough of an essential nutrient?"**

   Student responses will vary. Students will recognize that when we have a nutrient deficiency, we get sick.

5. **Ask students to consider calcium. Explain that it is an essential nutrient for both plants and people. When people do not get enough calcium in their diets, it is removed from their bones, weakening their skeletal system.**

6. **Display a transparency of Master 4.1, *Alfalfa with Calcium Deficiency*. Explain that the photograph shows alfalfa growing in soil lacking calcium. Point out that plants also become ill when their "diet" lacks calcium. Explain that, just like people, plants must have each of their essential elements present in the proper amounts in order to be healthy. In the next activity, students will investigate plants with nutrient deficiencies.**

For classes using the Web-based version of this activity

Activity 2: Humanity Against Hunger

Teacher notes

Introduce this activity with a brief discussion about Africa and farming. Use guided questions to bring out that sub-Saharan African farmers have traditionally cleared land, grown food 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 hoping that it would eventually regain its fertility. Increasing population growth has limited this traditional farming practice that worked so well in the past. Today, many African farmers grow crop after crop on the same land, "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 and/or the money needed to do so.

Critical thinking is important to this activity. Not all of the information provided to students is helpful in identifying nutrient deficiencies. For example, the presence or absence of weeds in the fields is not a useful piece of information.

The Web version of this activity can be accessed at http://www.nutrientsforlife.ca/for-students/games/humanity/". The activity has an audio narration. If headphones are available, then students can work at their own pace. Students working in groups can hear the narration through the computer's speakers. In the event that neither headphones nor speakers are available, read the narration (provided in Step 5) out loud to the class while the image of the jeep is driving along the horizon.

The Web version allows students to type their initial observations into an online page that is identical to Master 4.4. However, the Web program will not save this information. If you would like students to complete Master 4.4 as an assignment to turn in for a grade, you will need to provide them with a copy of Master 4.4 and ask that they record their answers on pen and paper while conducting the simulation.

If the students' computers are linked to a printer, then they can print an Award of Merit at the conclusion of the activity, which indicates that they completed all of the required steps correctly.

1. **For this activity, divide the class into groups of 3 students. Each group will evaluate 3 case studies.**

   If sufficient computers are available, allow each student to work alone.

2. **Instruct the students to access the "Humanity Against Hunger" activity at http://www.nutrientsforlife.ca/for-students/games/humanity/.**
3. **At the home page, instruct the students to begin by clicking on "Step 1: The Food Crisis in Africa." Ask for a volunteer to begin reading the article.**
4. **Pause for a moment after reading for a brainstorming session with the students. Ask, "Can you think of ways to solve Africa's food shortage problem?"**
5. **Instruct students to click on the car keys icon to access their "Humanity Against Hunger Assignment." At this point, the students will complete the Web activity on their own, following the directions from the Web site.**

If your computers do not have audio, read to students the following introduction while the jeep is driving across the horizon:

Welcome to Africa. As a volunteer with Humanity Against Hunger, it will be your mission to help alleviate the food shortage on this continent. To begin your briefing, click on the remote control for the slide projector.

When the slide show begins, read the following:

Africa.

A continent full of mystery.

A land of exotic animals.

A land that is literally a geography lesson with vast deserts, rugged mountains, broad savannas and dense jungles.

Although Africa may be rich with diversity of plant and animal species, it is also rife with hunger and poverty.

Starvation and malnutrition abound, despite the fact that nearly two-thirds of Africans depend on agriculture for their livelihoods.

How can this be? How can so many people involved in agriculture be so undernourished?

One of the major reasons is a serious depletion of nutrients in the soil. African farmers have traditionally cleared land, grown a few crops, and then moved on to new land, leaving their old land depleted of nutrients.

As a soil scientist – or agronomist – for Humanity Against Hunger, your task will be to help farmers identify nutrient deficiencies in their crops and provide them recommendations on how to improve their existing soil with nutrients to increase their crop yields.

In the village where you will work, the main crop is mealies, or maize, very similar to what you call corn. As this is an older farming community, much of the farmland has been overused and the soil has been depleted of many essential nutrients, resulting in small crop yields and crops that are more susceptible to disease. During your stay in the village, local farmers will show you samples of their maize and describe their growing conditions.

You will then be asked to make an initial analysis of what might be wrong with the farmer's soil. To assist you in your analysis, click on your field manual for reference. Consult it often.

After your initial evaluation, you will then need to make a diagnosis by answering a multiple-choice question.

Ready to start?

6. **When the students have completed the assignment, ensure that they print out their certificates to turn in to you.**
7. **After the assignment portion of the activity, encourage students to explore the "Additional Resources/Links" section.**

For classes using the print-based version of this activity

Activity 2: Humanity Against Hunger

1. **For this activity, divide the class into groups of 3 students. Each group will receive 3 case studies to evaluate.**
2. **Display a transparency of Master 4.2, *Humanity Against Hunger* and ask for a volunteer to read it aloud.**
3. **Explain to the students that they will review information sent in by local farmers who suspect that their crops suffer from a nutrient deficiency. Students will be provided with photographs and brief descriptions of 4 different nutrient deficiencies. Using this information, they will be challenged to diagnose the specific nutrient deficiency affecting each of their crop plants.**

By the end of Grade 8, students will:

- identify unicellular organisms (*e.g., amoebae*) and multicellular organisms (*e.g., invertebrates [worms], vertebrates [frogs]*), and compare ways in which they meet their basic needs (*e.g., nutrition, movement, gas exchange*).

4. **Pass out to each group 1 copy of *Primary Information* for each case study that they are to evaluate. *Primary Information* is found on the top portions of Masters 4.3a–c, *Corn Case Studies*. Ask students to read *Primary Information* for their case studies.**

   Each group receives the top portions of Masters 4.3a, 4.3b, and 4.3c, *Corn Case Studies*. Each student is responsible for 1 of the case studies.

5. **Pass out to each student 1 copy of Master 4.4, *Plant Doctor Evaluation Form*. Instruct students to write down in the appropriate space what they consider to be the important information related to their case study.**
6. **Pass out to each group 1 copy of Masters 4.5a–d, *Plant Doctor Reference Manual*. Instruct students to make a preliminary diagnosis for their case studies by using the information contained in the reference manual. Have students enter their initial diagnoses in the appropriate spaces on their evaluation forms.**

   Remember, each student in the group is responsible for 1 of the 3 case studies. Students should list symptoms of the nutrient deficiencies that match the important information of their case studies.

7. **Ask students if they are certain of their diagnoses.**

   Some students may indicate that they have correctly diagnosed their case studies. Ask them what additional information would help them confirm or refute their diagnoses.

8. **Explain to the class that some additional information about their case studies has come to light. Give each group the bottom portions of Masters 4.3a–c, *Corn Case Studies*, which contain *Secondary Information*.**
9. **Ask students to read *Secondary Information* for their case studies and use this information to re-evaluate their diagnoses. They should indicate on the evaluation form whether they want to confirm their initial diagnoses.**

10. **If students have changed the diagnosis, they should enter the new diagnosis, together with the reason for the change, in the appropriate spaces on the evaluation form.**

11. **Reconvene the class and discuss each case study in turn, asking students how they arrived at their diagnoses.**

    Write the students' diagnoses on the board or an overhead transparency.

12. **Ask students how they could correct these nutrient deficiencies.**

    Students should mention adding plant nutrients to the soil. Some students may specify commercial or organic fertilizers. Explain that they will explore the advantages and disadvantages of these plant nutrients in the next lesson.

Answers to the case studies:

Corn Case Study 1

From *Primary Information*	
Important information	Stunted, yellow leaves; sandy soil
Diagnosis	These symptoms are consistent with either nitrogen or potassium deficiency. The yellowed leaves seem to have the V-shaped pattern associated with nitrogen deficiency.
Matching symptoms	Stunted, yellowing leaves; sandy soil
After reading *Secondary Information*	
Is your initial diagnosis confirmed?	Answers will vary.
If not, what is your new diagnosis?	Answers will vary.
If not, what caused you to change your diagnosis?	The second photograph shows a leaf with the V-shaped pattern of yellowing that is consistent with nitrogen deficiency. The fact that the fields have been exposed to heavy rains further supports the nitrogen-deficiency diagnosis.

Corn Case Study 2

From *Primary Information*	
Important information	Stunted, yellow leaves; sandy soil
Diagnosis	These symptoms are consistent with either nitrogen or potassium deficiency.
Matching symptoms	Stunted, yellowing leaves; sandy soil
After reading *Secondary Information*	
Is your initial diagnosis confirmed?	Answers will vary.
If not, what is your new diagnosis?	Answers will vary.
If not, what caused you to change your diagnosis?	The second photograph shows a yellowed leaf with dried edges that are consistent with potassium deficiency. The fact that the plants have weak stems further supports the potassium-deficiency diagnosis.

Corn Case Study 3

From *Primary Information*	
Important information	Stunted, compacted (dense) purple color on some leaves
Diagnosis	The symptoms are consistent with phosphorus deficiency.
Matching symptoms	Stunted, compacted (dense) soil; purple color on leaves
After reading *Secondary Information*	
Is your initial diagnosis confirmed?	Answers will vary.
If not, what is your new diagnosis?	Answers will vary.
If not, what caused you to change your diagnosis?	Plants mature later than normal. The second photograph of a leaf shows distinct purple coloration, which is characteristic of phosphorus deficiency.

Optional Homework Assignment

This lesson stressed diagnosing nutrient deficiencies in crop plants. Such nutrient deficiencies can be remedied through the use of fertilizers. Instruct students to research and write a short paper that describes how to interpret fertilizer labels and correctly apply fertilizers to ensure economic, social and environmental sustainability.

You can provide students with information from the Teacher Background section or have students perform their research using the Web. Students' papers should explain the NPK ratio and describe the importance of applying fertilizers

- in the right amounts,
- at the right times, and
- in the right places.

M = Involves copying a master

T = Involves making a transparency

= Involves using the Internet.

P = Print version.

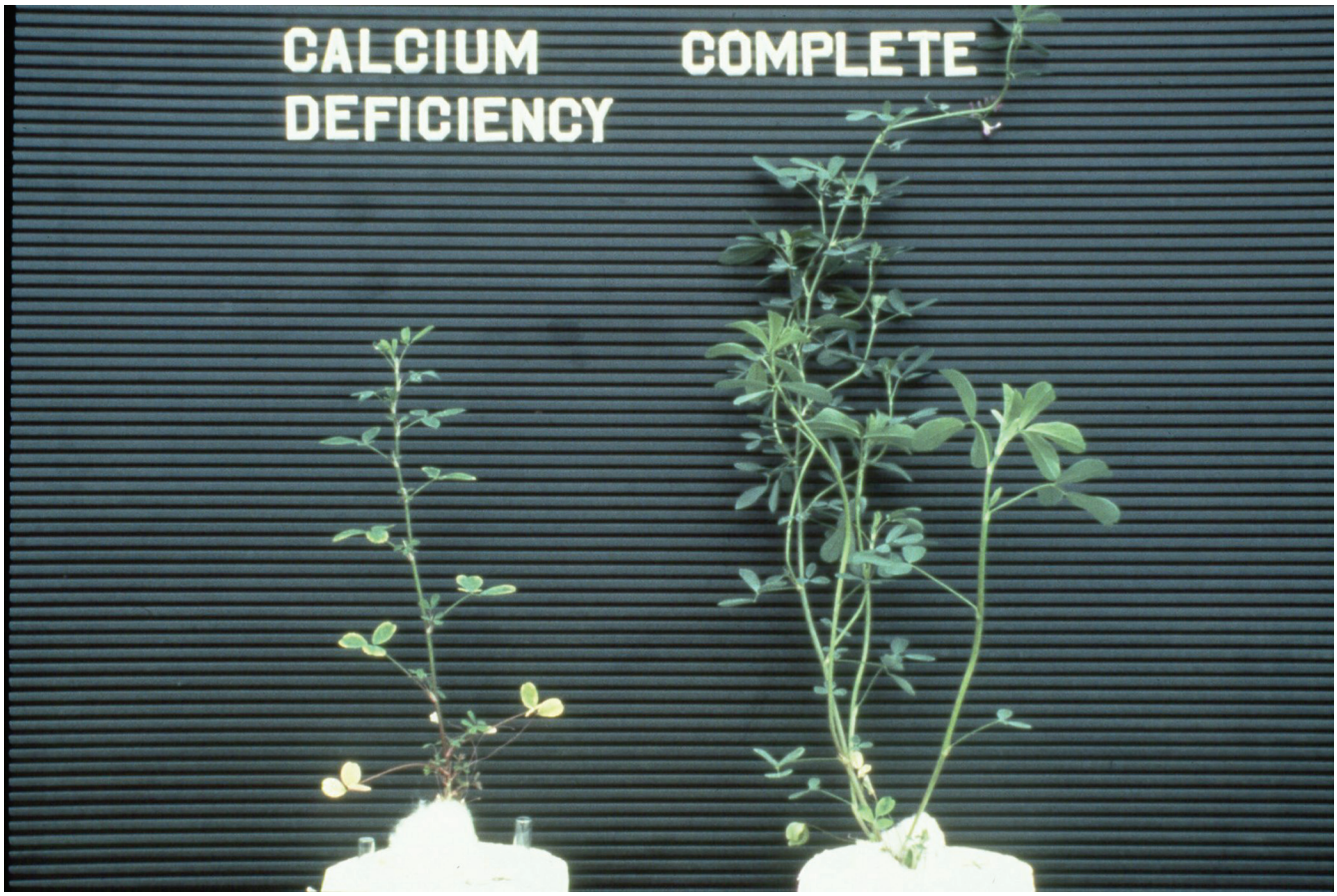
Lesson 4 Organizer

Activity 1: *Take a Plant to Dinner* What the Teacher Does	Procedure Reference
Begin by asking students, "What is fertilizer?" [Note the term is used to refer to organic and commercial sources of plant nutrients.]	Page 99 Step 1
Mention that plants make their own 'food' through photosynthesis. Ask: ■ "Why do we need to give them additional food through fertilizer?" ■ "If farmers have fertile soil, then why would they need to use fertilizers?"	Page 99 Steps 2 and 3
Remind students that people and plants are both made of cells and that cells need nutrients for structure and for processes such as growing. Ask: ■ "What happens to us if we don't get enough of an essential nutrient?"	Page 99 Step 4
Explain that calcium is an essential nutrient for both plants and people. Remind students that if people lack calcium in their diets, it is removed from their bones, weakening their skeletal system.	Page 99 Step 5
Display a transparency of Master 4.1, *Alfalfa with Calcium Deficiency*. ■ Explain that these plants were grown in soil lacking calcium. ■ Point out that plants also become ill when they don't get adequate amounts of their essential elements.	Page 99 Step 6
Activity 2: *Humanity Against Hunger* (Web Version) **What the Teacher Does**	**Procedure Reference**
Divide class into groups of 3 students or, if there are enough computers, have students work alone.	Page 100 Step 1
Instruct student to access the "Humanity Against Hunger" activity at http://www.nutrientsforlife.ca/for-students/games/humanity/ ■ Click on "The Africa Situation/Discussion." ■ Ask a volunteer to read the article.	Page 100 Steps 2 and 3
Ask students if they can think of ways to solve Africa's food shortage problem.	Page 100 Step 4
Instruct students to return to the home page and click on "Humanity Against Hunger Assignment." ■ Instruct students to complete the activity by following the instructions given on the Web site and to print out the evaluation report at the end of the activity.	Pages 100-101 Steps 5 and 6
Encourage students to explore the "Additional Resources/Links" section.	Page 101 Step 7

continued on page 102

Lesson 4 Organizer *continued*	
Activity 2: *Humanity Against Hunger (Print Version)* **What the Teacher Does** P	**Procedure Reference**
Divide the class into groups of 3 students.	Page 102 Step 1
Display a transparency of Master 4.2, *Humanity Against Hunger* and ask for a volunteer to read it aloud.	Page 102 Step 2 T
Explain to students that they will review information sent in by farmers from an African village who suspect that their crops suffer from a nutrient deficiency. ■ They will receive photographs and information that will enable them to diagnose the nutrient deficiency.	Page 102 Step 3
Give each group 1 copy of *Primary Information*, found on the top portions of Masters 4.3a–c, *Corn Case Studies*. ■ Instruct students to read *Primary Information*.	Page 102 Step 4 M
Give each student 1 copy of Master 4.4, *Plant Doctor Evaluation Form.* ■ Instruct students to record on the form what they consider to be the important information about their case studies.	Page 102 Step 5 M
Give each group 1 copy of Masters 4.5a–d *Plant Doctor Reference Manual*. ■ Instruct students to use the information in the manual to make a preliminary diagnosis for their case studies.	Page 102 Step 6 M
Ask students if they are sure of their diagnoses.	Page 102 Step 7
Explain that new information about the case studies has come to light. ■ Give each group 1 copy of the bottom portions of Masters 4.3a–c, *Corn Case Studies*, containing *Secondary Information.*	Page 102 Step 8 M
Instruct students to read the information and to reevaluate their diagnoses. ■ If they changed the diagnosis, they should enter the new one on the form and write down the reason for the change.	Page 102-103 Steps 9 and 10
Reconvene the class and discuss each case study, asking students how they arrived at their diagnoses.	Page 103 Step 11
Ask students how they could correct these nutrient deficiencies.	Page 103 Step 12

Master 4.1, *Alfalfa with Calcium Deficiency*



Master 4.2, *Humanity Against Hunger*

You have been selected to join Humanity Against Hunger, an international effort dedicated to fighting hunger around the world. Your first assignment is to travel to Africa and help farmers from a small village.

In sub-Saharan Africa, nearly one-third of the population, almost 200 million people, lacks enough food to lead healthy, productive lives. 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, "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. If this trend continues, by the year 2010 Africa will have almost two-thirds of the world's undernourished people.

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.

Corn Case Study 1

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.

Corn Case Study 1

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.

Corn Case Study 2

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.

Corn Case Study 2

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 aren't strong enough to support the ears of corn.

Corn Case Study 3

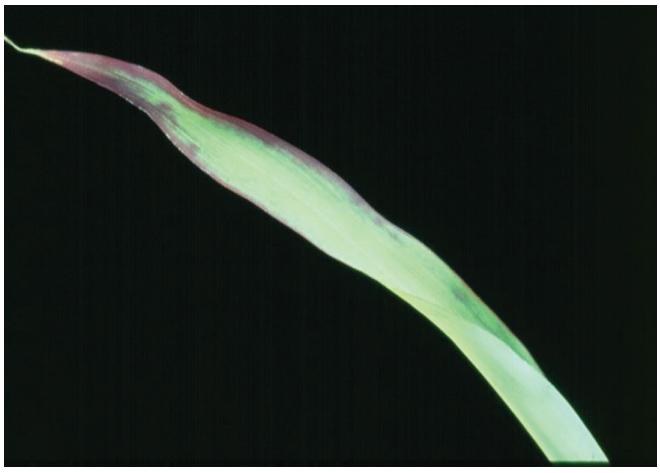
Primary Information

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.

Corn Case Study 3

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 4.4, *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?

Introduction

Like humans, plants need a proper a diet to be healthy. Unlike humans 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 it's 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 seen on the right. Leaves from increasingly nitrogen-deficient plants are on the left.

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 the 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.

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.

a   b

The older leaves of potassium-deficient corn plants yellow and die around the edges (a), while areas of cell death on leaves may appear as dark spots (b).

Nutrient Deficiencies of Corn

Zinc Deficiency

Plants lacking zinc show pale- to whitish-coloured 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.