SOIL HEALTH & FERTILITY

GLOBAL GARDEN REFUGEE TRAINING FARM, CHICAGO IL

Summary

This module contains six mini-lessons on practices and knowledge related to soil health and fertility. These lessons can be chosen and combined in whatever way makes sense for your program. The lessons address soil texture, fertilizers, soil organisms, legume crops and nitrogen, cover crops, and nutrient problems.

The need: Farmers with limited literacy and/or limited formal education are unlikely to be familiar with concepts and vocabulary needed to make informed choices about soil management and fertility options in the U.S., or to understand information and advice provided by agricultural professionals.

Global Garden
Refugee Training Farm

ISED SOLUTIONS
INSTITUTE FOR SOCIAL AND ECONOMIC DEVELOPMENT

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Who made this guide?

Collaboration and Testing

ACKNOWLEDGMENTS: This teaching resource was developed by Linda Seyler of Global Garden Refugee Training Farm in Chicago Illinois, in partnership with the Institute for Social and Economic Development (ISED Solutions). Refugee farmer training programs across the country provided feedback on this lesson, which is now integrated throughout the guide. From 2015 to 2017, ISED partnered with twelve refugee farmer training programs through a USDA BFRDP educational enhancement grant, to support the design and testing of new and shareable teaching resources for culturally and linguistically diverse farmers. To learn more about this project, or to access the whole list of newly developed teaching resources for refugee farmer training programs, see the New American Resource Library https://nesfp.org/new-american-resources. For more in-depth explanations of the teaching approaches and activities used in these materials, please see the 'Refugee Farmer Teaching Handbook'. While these resources were designed with refugee audiences in mind, they can be adapted and used in any farmer training or incubator setting.

VARIATION:

Throughout this guide, boxes (like this one) contain variations and adaptations that serve varying programs and farmers. They are suggestions and reflections from other programs based on how they made this workshop work for them.

TEACHING TIP:

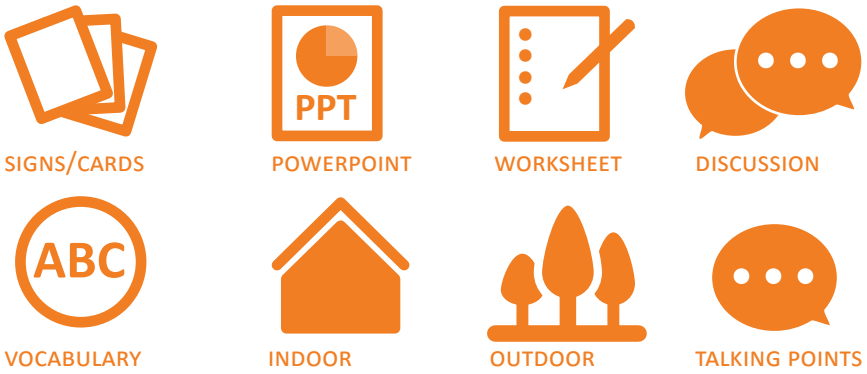
Throughout this guide, boxes (like this one) contain teaching tips to help you better facilitate farmer learning. Most come from other programs who have tested and reflected on using this lesson.

DEVELOPER'S NOTE:

Throughout this guide, boxes (like this one) contain notes from this guide's developer that provide insight into how a lesson is typically taught at the developer's program.

Reviews and core skills

ICONS: You will find the icons below throughout this guidebook. They are there so you are prepared for the activity and can get an idea of what it will bring at a glance.



WHAT TESTERS SAY: "Very comprehensive - it covers all the techniques organic farmers can use to manage soil fertility and would be a great tool to cover a lot of ground."

-The International Rescue Committee in Sacrameto CA

"I think the way it is broken down is great. There is new vocab in every section and it is not all at the start of the class. This helps people to compartmentalize new words with new topics. It does not give them too much to think about at once, but gives them a list of what they need to think about for the next section."

- Alex, Cultivating Community, Portland ME

CORE SKILLS:

- Soil amendment vocabulary
- Identify fertility issues & amendments
- Comparing organic and inorganic fertilizer
- Soil texture types
- Identify crops that add nitrogen
- Define N-P-K
- Fertilizer usage
- Green manure and compost usage

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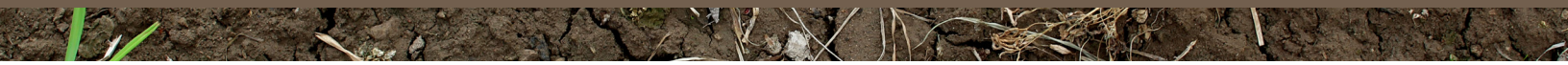
Adaptable except where noted.



Audience and Objectives

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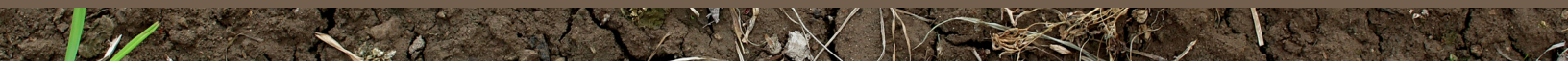


OBJECTIVES: **At the end of this module, growers will be able to:**

- Name/differentiate between sandy, silty, and clay soils by sight and/or touch
- Describe effect of sand, silt, clay, and organic matter on water drainage
- Know what organic matter (OM) is and name at least two sources
- Say what management practices harm or benefit soil organisms
- Understand that most soil organisms are beneficial to crops
- Name the three crops (beans, peas, and clovers) that add N (Nitrogen) fertilizer to the soil
- Identify root nodules in a picture (or real life) when the legume-bacteria partnership is working
- Identify a clover
- Know why and how green manures maintain and/or improve soils
- Identify common, above-ground symptoms of nutrient deficiencies and excesses
- Know where to find advice when they see symptoms they do not recognize

WHO: **1-15 refugee farmers and growers**

LANGUAGE / LITERACY: **Appropriate for all levels, with interpreter**

FARMING EXPERIENCE: **Farmers should have...**

- Some experience or knowledge of farming or gardening (experience does not have to be in the U.S.).
- Some familiarity with different soil textures from real life experience.
- Some knowledge about the difference between standard and organic farming practices.
- Some familiarity with the concept of Organic Certification.
- Ability to indentify and read a label.

REGION / CLIMATE: **Midwest Zone 5b**

Adaptable to other climates

PROGRAM STRUCTURE: **Adaptable to most programs**

SEASON: **Any time**

Resources needed

Adaptable except where noted.

TIME: **Approximately 3 hours**
6 lessons, each requiring 30-45 minutes.

STAFF / INTERPRETERS: **One instructor and language interpreters for the group**

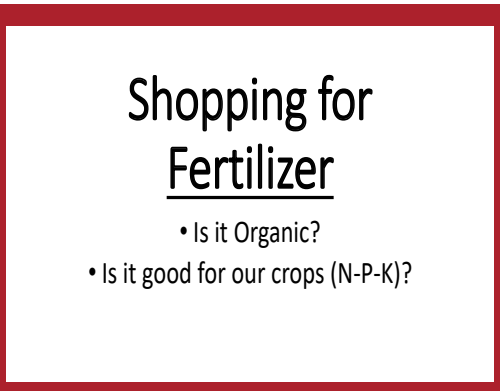
LOCATION: **Classroom with projector and computer**
Adaptable by printing slides as handouts

SUPPLIES: **For classroom session:**

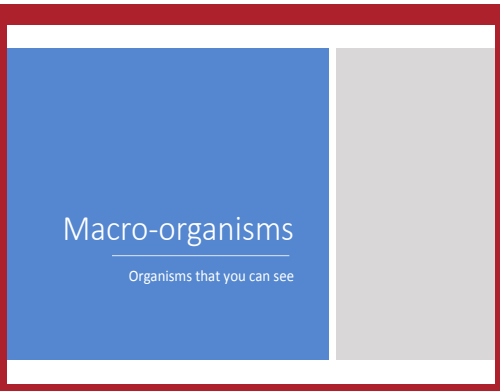
- Samples of sand, silt, and clay soils and soil samples from participants' farm(s)
- Samples of soils with high and low organic matter content
- Three of each: drip coffee filter cone, coffee filter paper, and clear glass cylinder or jar
- 4-cup measuring cup and water
- PowerPoints: **Shopping for Fertilizer**, **Soil Organisms**, **Legumes for Green Manure**
- Fertilizer packaging, both synthetic and organic: empty, full, or photographs
- OPTIONAL: Live specimens of earthworms, insects, mushrooms, sow bugs, and any other soil organisms which may be routinely encountered by participants
- OPTIONAL: Live specimens of legumes for green manure

Additional Materials:

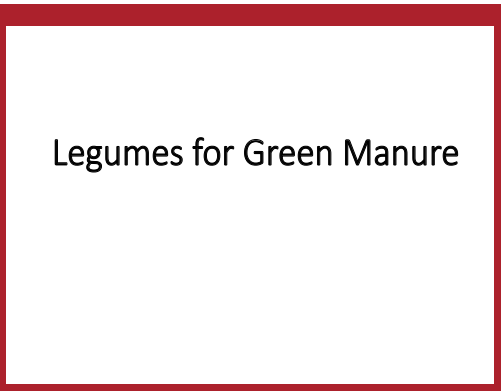
- Computer, projector, and other equipment necessary for slideshows
- Phones with camera capabilities for Activities 2 and 3



Shopping for Fertilizer PowerPoint



Soil Organisms PowerPoint



Legumes for Green Manure PPT

Soil Texture

1

TIME: 30 Minutes

OVERVIEW:

Farmers will learn how to differentiate and name three different soil textures and organic matter by feel, and understand how these four soil components affect water infiltration and drainage through hands-on activity, demonstrations, and discussion. This activity allows you to tap into farmers' experiential knowledge of soil texture and soil properties.

MATERIALS NEEDED:

- Samples of sand, silt, and clay soils
- Sample of soil from participants' farm(s)
- Samples of soils with high and low organic matter content
- Three of each: drip coffee filter cone, coffee filter paper, and clear glass cylinder or jar
- 4-cup measuring cup and water

OBJECTIVES / LEARNING:

By the end of this activity, participants can:

- Name/differentiate between sand, silt, and clay soils by sight and/or touch.
- Know what organic matter is and name at least two sources.
- Describe effect of sand, silt, clay, and organic matter on water drainage properties.

VOCABULARY:

Soil	Sand
Silt	Clay
Drainage	Organic Matter (OM)

TEACHING TIP:

One reviewer suggested having a pre-lesson discussion about why soil fertility matters and address the state that their soil is in now.

STEP 1: DEMONSTRATION AND DISCUSSION

a. Bring in samples of major soil types for students to handle and discuss: a heavy clay soil, sand, and a good loam with high organic matter content.

b. Ask them to identify the best soil for farming.
   - What soil type would they prefer and why?
   - List their responses on the board or in your notes so you can refer to them later. Examples:
     - Clay is heavy and difficult to cultivate/plow.
     - Sand doesn't hold water.

STEP 2: FEELING SOIL TEXTURE

Have students handle different soils and describe how they feel. Show them that:

- Sand runs through their fingers
- A sandy soil feels gritty
- A clay soil smears when squeezed between fingers
- A high OM soil smells nice, and is springy when squeezed

STEP 3: VOCABULARY

After farmers have handled the soil samples and discussed their preferences, introduce four English vocabulary words: SAND, SILT, CLAY, and ORGANIC MATTER

- If students ask, remember: sand, silt, and clay are all just rock ground up to different sizes.
- Particle size is what determines almost all soil properties: size of spaces between particles, capacity to bond with and hold water and nutrients, tendency to compact, etc.

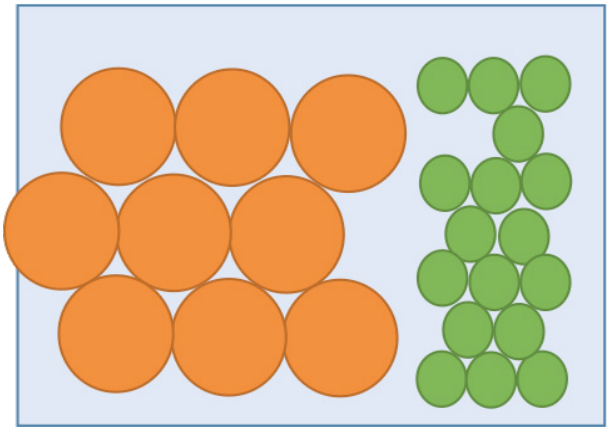
STEP 4: WATER INFILTRATION DEMONSTRATION

a. **Demo 1:** For this demonstration, use two or three drip coffee filter cones, filter paper, and two or three glass jars/cylinders.

- Fill each cone with sand, silt, or clay soil.
- Pour measured volume of water into each cone.
- Observe relative speed of water drainage through each soil type.
- Ask students for ideas about why this happens.

b. **Optional Demo 2:**

- Explain relative soil particle sizes: use spherical objects of two or three different sizes to show how a given volume of larger spheres have more air space than the same volume of small spheres. Ask the farmer to think about how this would affect the speed by which water would move through each volume.
- Ideally, sand would be represented by something very large - like a large beach ball - in relation to silt (e.g.: ping pong balls, marbles, or beads) and clay (e.g..: smaller marbles, small beads or seeds). Use whatever you have at hand, or is most convenient to store and carry to class (e.g..: beach balls can be deflated when not in use).
- If actual spheres are not available, a 2-dimensional graphic, like the one below, will suffice (or can help clarify the point for students).



STEP 5: REVIEW VOCABULARY

a. Hold up or pass around soil samples used previously and ask students to name each one: clay, silt, sand, organic matter.

b. Pass around a soil sample from soil that participants are farming in and ask them to describe it using this vocabulary.

STEP 6: OPTIONAL DISCUSSION - RELATIVE PARTICLE SIZE

a. Particle size is the main defining difference between sand, silt, and clay.

b. Size matters: most soil properties are determined by particle size,e.g. water movement, nutrient holding capacity, energy needed for tillage, and root penetration.

VARIATION:

One reviewer suggested mentioning water holding capacity of soils. “This is a big deal with my farmers and they will listen to anything if it means learning to use water more efficiently. Talk about how water drains through various soil types, and how to combat erosion with cover.”

Fertilizers

2

TIME: 30 Minutes

OVERVIEW:

In this activity, farmers will discuss the importance of using fertilizers, and will compare the advantages and disadvantages of chemical and organic fertilizer.

MATERIALS NEEDED:

- PowerPoint: **Shopping for Fertilizer**
- Actual fertilizer packaging, both synthetic and organic: empty, full, or photographs. It may be helpful to print and distribute enlarged photocopies

OBJECTIVES / LEARNING:

By the end of this activity, participants will:

- Know what organic matter (OM) is and name at least two sources.

VOCABULARY:

Animal manure
Fallow
Rotation
Green manure
Chemical fertilizer
N-P-K

DEVELOPER'S NOTE:

Language interpreters may not be prepared to distinguish between different types of fertilizers and/or manures. Be sure to explain the purpose of this lesson to them beforehand and have them agree to make careful distinctions. For languages that use a single word for all types of fertilizer, adjectives can be used to separate animal manure, plant/green manures, and chemical fertilizers if those adjectives are used in a consistent manner. Without this preparation, this lesson may be useless.

STEP 1: DISCUSSION

Ask students to describe what they did to keep soils healthy/productive on their farms. Allow significant time for this discussion, especially if the class includes farmers from different regions who may have used different practices. If students are reticent, prompt them with questions about animal manures, use of chemical fertilizers, fallow periods, rotations that may have included legumes, etc.

STEP 2: N, P, AND K ARE LIKE VITAMINS FOR PLANTS

Explain that these letters - N, P, and K - stand for the fertilizer ingredients that plants need the most. (If it is helpful, call them Vitamin N, Vitamin P, etc.)

- N = Nitrogen: promotes good leaf and foliar growth
- P = Phosphorus: promotes good seeds and root growth

- K = Potassium: aids photosynthesis to provide energy
- It is not necessary to use the words *Nitrogen*, *Phosphorus*, or *Potassium*. The symbols *N*, *P*, and *K* are sufficient.
- (RESOURCES: Back to Basics: The Roles of N, P, K and Their Sources. Jeff Ball, http://www.noble.org/ag/soils/back2basics/)

STEP 3: DEMONSTRATION OF FERTILIZER LABELS

a. Show fertilizer packaging and where the N-P-K is listed. This can be actual packages or photos/slides. Print size for this info is becoming smaller and harder to find on products for home gardeners.

b. Include labels from both chemical and organic fertilizer products that farmers are likely to encounter in local stores.

c. Explain difference between a 10-10-10 vs. 20-20-20 fertilizer (or other examples).

d. Minor nutrients: Copper, Zinc, Iron, etc.; point out that there are many.

e. Show where these are listed on container labels.

f. If necessary, review logos for OMRI and USDA Certified Organic Certification.

STEP 4: COMPARING CHEMICAL AND ORGANIC FERTILIZER

a. Besides the chemicals which have been identified as major and minor plant nutrients, there may be other soil ingredients which contribute to soil health that we don't know about (especially for interactions with soil organisms).
- Chemical vs. Organic Fertilizer: like vitamin pills vs. whole foods. Each has advantages and disadvantages:

	Advantages	**Disadvantages**
Chemical Fertilizer	• Easy to find and apply • Easy to control amount of major and minor nutrients applied	• Cash input that may be expensive • Harsh, concentrated chemicals require special handling • Does not contribute to long term soil health • Can harm or destroy soil organisms • More likely to leach off-site and cause pollution

	Advantages	Disadvantages
Organic Fertilizer (Includes organic manure, crop manure, and compost)	• Can be produced on a farm with no need to buy • Does not harm soil organisms • Less likely to leach into or pollute surface/ground water • Increases soil's long term health through buildup of organic matter	• Can be wet, heavy, and bulky to handle and apply • Animal manure can be smelly; complaints from neighbors • Unincorporated manure can leach off site and cause pollution • Animal manure can present health risks and requires careful processing/compost-ing before it is safe to apply to vegetable crops • Cover crops for green manure require careful planning to fit into vegetable production calendar

b. Many chemical fertilizers and fast acting organic fertilizers (pro-gro or chicken manure) are like a candy bar - a quick hit of energy but not enough to sustain a plant through its entire lifecycle.

c. Adding compost to plants is like a bowl of rice for people - not nutritious enough on its own, but can help fill you up (or sustain the plant) for a long time.

d. Using a balanced, slow-release organic fertilizer like soybean meal or alfalfa meal is like eating chicken and salad - a lot of different types of nutrition that provides a balanced diet.

e. Ask farmers what they would feed their kids to make them healthy and strong? Draw the connection between human health and plant health.

VARIATION:

One reviewer suggested doing a demo plot to show the difference fertilizer can make. Plant a bed of onions, fertilize half and don't fertilize the other half. Plant late season cabbage where you had spring peas, and some where you didn't. It takes prep time, space, and supplies, but it can be very convincing. Or, if staff have capacity to run trials and take photos, those can also be very convincing.

TEACHING TIP:

Peer-to-peer teaching has worked well if you can find a farmer-champion who effectively adds fertilizer and uses cover crops.

Soil Organisms

3

TIME: 25 Minutes

OVERVIEW:
This lesson is an overview of the types of organisms that live in soil and their role in soil and crop health. The goal is not to learn about specific soil organisms or even categories like insects, fungi, or bacteria, but to become aware of the existence and role of soil biology, and learn about management practices that harm or benefit soil organisms.

MATERIALS NEEDED:
- PowerPoint: **Soil Organisms**
- Optional live specimens: earthworms, insects, mushrooms, sow bugs, any other specimens routinely encountered by farmers

OBJECTIVES / LEARNING:
By the end of this activity, participants can:
- Say what management practices harm or benefit soil organisms.
- Understand that most of these organisms are beneficial to crops.

STEP 1: MACRO ORGANISMS

a. Macro organisms include earth worms, insects, sow bugs, mushrooms, etc.

b. Show lots of pictures (or bring live specimens, especially if you are at the farm). Ask students to identify each critter - in their own language if they don't have English names for each - and give them a few vocabulary words for soil animals which are common in your area: earthworm, insect, beetle, sow bug, centipede, mushroom, etc.

STEP 2: MICRO ORGANISMS

a. Micro organisms include micro-fungi, bacteria, nematodes, etc.

b. Explain that these organisms are too small to see, but are present in healthy soil.

c. Perhaps provide amazing factoids abuot the number of nematodes in a teaspoon of healthy soil, etc.:
- A single teaspoon (1 gram) of rich garden soil can hold up to one billion bacteria, several yards of fungal filaments, several thousand protozoa, and scores of nematodes, according to Kathy Merrifield, a retired nematologist at

Oregon State University.
- "Agricultural soils generally support less than 100 nematodes in each teaspoon (dry gram) of soil. Grasslands may contain 50 to 500 nematodes, and forest soils generally hold several hundred per teaspoon." - Elaine Ingham, Oregon State University
- "A teaspoon of productive soil generally contains between 100 million and 1 billion bacteria." - Elaine Ingham, Oregon State University

d. The nice smell of healthy soil comes from these organisms, especially soil fungi.

e. Possible graphic: vertical cross view of a mushroom with mycelia in soil.

STEP 3: ROOTS

Show video clips of time-lapse roots growth:
- Radish (46 seconds): https://www.youtube.com/watch?v=d26AhcKeEbE
- Corn (1 minute): https://www.youtube.com/watch?v=ev9I6dXr6Iw
- Corn (35 seconds): https://www.youtube.com/watch?v=iFCdAgeMGOA
- Corn (58 seconds): https://www.youtube.com/watch?v=eoQsKOtsOoo
  - If these links don't work, google 'root growth time lapse'

STEP 4: ORGANIC MATTER

Soil biology is a major source of organic matter (OM).
- When these organisms die they become organic matter. Each one is small, but together they are a big part of healthy soil.
- Soils high in OM are easier for plant roots and for farmers to work with.
- Organic matter helps soil hold nutrients and water until plants need them (and prevents leaching, pollution, flooding, and soil erosion).
- Soil organisms are harmed or destroyed by harsh or excessive use of chemical fertilizers and pesticides.

STEP 5: REFLECT AND ASSESS

Discussion questions:
- Ask farmers to name/describe soil organisms they have seen in their farm soil. Use photos or live specimens to review the names of these organisms.
- Why do we want soil organisms? How do they contribute to healthy, rich soil that is good for crops?
- What practices are good for soil organisms?
- What practices are harmful to soil organisms?

STEP 6: OPTIONAL DISCUSSION QUESTIONS

a. Do we use human manure as fertilizer? Why or why not?

b. Do we need to be careful about where animal manure comes from?
   - Manure should come from healthy animals only
   - Manures from animals being treated with medicine should not be used.
   - Why do we use manure from vegetarian animals (herbivores), but not manure from carnivores?
     - Smell
     - Carnivores are more likely to carry diseases that can make humans sick
     - Carnivore manure has much less organic matter

Legume Crops & Nitrogen Fixation

4

TIME: 15 minutes

OVERVIEW:
This is a quick introduction or review of the role legume crops can play in improving soil fertility.

MATERIALS NEEDED:
- If in classroom, PowerPoint: **Legumes for Green Manure**
- If in field, live specimens

OBJECTIVES / LEARNING:
By the end of this activity, participants can:
- Name the three crops (beans, peas, and clovers) that add N (Nitrogen) to the soil
- Identify root nodules in a picture (or real life) when the legume-bacteria partnership is working.
- Identify a clover.

VOCABULARY:

Bean (peas)	Clover
Root	N (Nitrogen)

STEP 1: DISCUSSION

Ask the group if there are crops/vegetables they plant to improve their soil or make soil stronger. If yes, what are they?
- Whatever they name, mention the other legumes included in this lesson and show pictures or specimens (if they name something other than a legume, take good notes because this might be important information).
- Review concepts and vocabulary by asking farmers to name live specimens or pictures.

STEP 2: VISUAL

Show pictures or live material of bean, pea, and clover plants.
- If using pictures, have one that clearly shows the three leaflets and round flower heads typical of clovers.
- Optional to bring in pictures or live specimens showing bacterial nodules on legume roots.

STEP 3: REFLECT AND ASSESS

Discussion questions:

- What are three ways to tell that a plant is a legume?
- What can legume crops do to make soil more fertile?
- How can you tell whether or not a legume crop is fixing N into the soil?

TEACHING TIP:

If this lesson starts in the classroom, use opportunities in the field to review. Pull up plants to show root nodules. Quiz farmers about vocabulary and clover identification.

TEACHING TIP:

One reviewer suggested: "Sorting/categorizing/matching could be implemented in discussing which crops are heavy/light feeders, at what stage in crops' growth is it most important to fertilize at, etc."

Cover Crops as Green Manure

5

TIME: 30 minutes

OVERVIEW:
In this activity, farmers will discuss what green manure is, and how and why to use it.

MATERIALS NEEDED:
- Pictures or slides (put together yourself) and the equipment necessary to show them
- Live specimens
- Printed guide or pamphlet with pictures of field crops (Example: *Midwest Cover Crops Field Guide,* second edition, which can be obtained at https://ag.purdue.edu/agry/dtc/Pages/CCFG.aspx)

OBJECTIVES / LEARNING:
By the end of this activity, participants will:
- Know why and how green manures maintain or improve soils.

VOCABULARY:
Cover crop Green manure

STEP 1: DISCUSSION

Ask the group:
- Whether they have used animal manure to improve their soil.
- Does animal manure improve crops?
- Is it important to add animal manure to soil? Why?
- How did they mix animal manures into soil on their farms?

STEP 2: SHOW PHOTO

Show the photo of a cover crop being plowed under. Ask the farmers to explain what they think is happening and why it is being done here.
- If necessary, explain that the picture shows how plants are being used just like animal manure.
- Point out that we call this 'green manure.'
- Ask them if they have ever used green manures on their farms.
  - If yes, ask them to describe their methods: what crops? What season or part of the planting cycle?

Recognizing Nutrient Problems

6

TIME: 30 minutes

OVERVIEW:

Farmers will learn to identify common symptoms of deficiencies and excesses of N, P, and K in plants. Mid- to late summer is a good time for this lesson because live specimens will be available in the field.

MATERIALS NEEDED:

- Flash cards to review names of colors: Green, Red, Purple, Yellow, and Brown. Make your own with sheets of colored paper
- Full-color flashcards or photographs showing clear signs of N, P, or K deficiencies or excesses. (See Developer's Note below.)
- Slides and/or live specimens showing plant symptoms

OBJECTIVES / LEARNING:

By the end of this activity, participants can:

- Identify common, above-ground symptoms of nutrient deficiencies and excesses
- Know where to find advice when they see symptoms they do not recognize

VOCABULARY:

Yellow	Green	Too much
Purple	Red	Too little
Brown		

DEVELOPER'S NOTE:

Compendiums published by the American Phytopathological Society for specific crops have excellent photographs which show clear symptoms of nutrient deficiencies in soil. These are cost effective tools which can be passed around to students. We suggest using compendiums for two crops (ex. corn and tomatoes) so students can see the usual effect of N, P, or K deficiencies across species.

STEP 1: REVIEW COLORS

Review names of the colors with flashcards.

STEP 2: REVIEW SOIL NUTRIENTS

Briefly review the roles of N, P, and K in plant health:

- N = Nitrogen: promotes good leaf and foliar growth
- P = Phosphorus: promotes good seeds and root growth
- K = Potassium: aids photosynthesis to provide energy / is used biochemically as an ionic pump

STEP 3: SLIDESHOW

Use slideshow or photographs to show foliar symptoms.
- Use only obvious examples
- After several examples, start asking students to name the cause of symptoms

STEP 4: OTHER PROBLEMS

Towards the end, slip in pictures of plants stressed by something that is obviously not a deficiency of N, P, or K. Example: a plant collapsing from bacterial wilt, or leaves with big holes from insect feeding. Ask students to name the cause of this situation. You can guess what the cause might be, but the point is that this is not a symptom of N, P, or K deficiency.

STEP 5: LIVE SPECIMENS

Whenever possible, bring in examples from the field to share with the class. If you have the resources, you can purposely starve young plants of single nutrients to show deficiency symptoms.

VARIATION:

One reviewer said: "A soil map might be a fun demonstration to show what things grow best because of soil types. Why certain areas grow certain crops better than others, for example, due to sand or clay, etc. We could look at various places and look at soil to discuss what it needed and why."