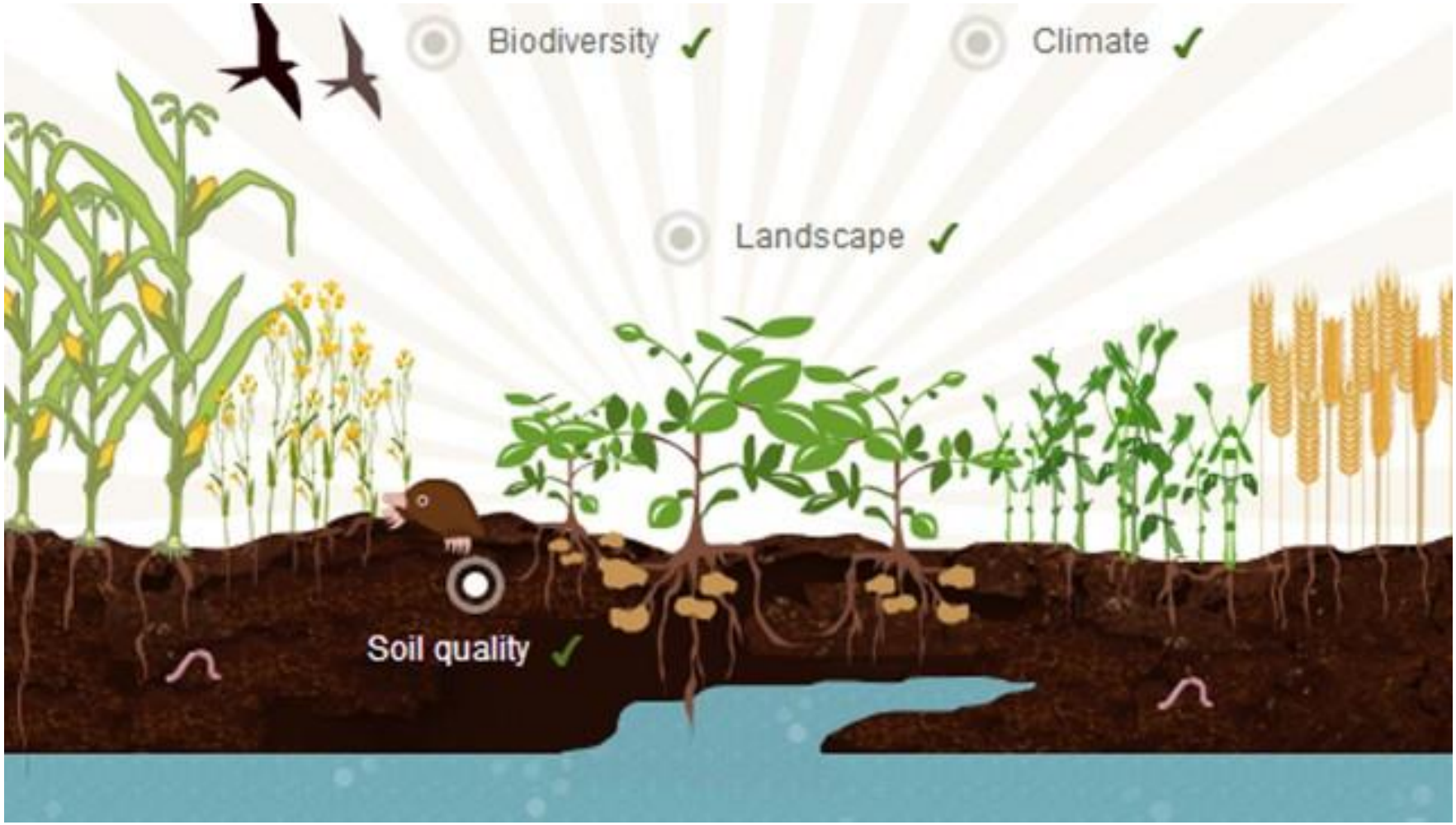
Crop Rotation

A smart way to build and maintain healthy soil

Crop Rotation: Step #1 for Soil Quality



How this crop rotation module is organized

A. Intro: Learning Objectives, Definitions, and History
B. Basic science behind crop rotation
C. The 6 major benefits and how they work:
    1. Naturally fertilizes
    2. Improves soil structure
    3. Controls weeds, diseases, and harmful insects
    4. Increases microbiology; bacteria and insects
    5. Preserves the environment
    6. Decreases costs; increases revenue of farming
D. Detailed science of plants' effects on soil and ecosystem
E. Models for crop rotation
F. Assessment/Review

Learning Objectives

- Understand various benefits of a system of crop rotation.
- Examine two popular rotational designs.

Definition of Crop Rotation

Crop rotation is a system of moving crops. The goal is not to grow the same thing in the same place in consecutive years.

Just as our diet needs variety, so does the soil.

Other terms to know for crop rotation

- Nitrogen Fixers- plants, such as legumes, that add nitrogen to soil
- Continuous Crop- single-plant crops that are not rotated and rely on artificial fertilizers and pesticides
- Ecological Sustainability- Biological systems' capacity to endure and remain diverse and productive over time
- Heavy Feeders- plants such as corn and tomatoes, that require a lot of nutrients from the soil
- Microorganisms/Soil Food Web- life in the soil that facilitate nutrient cycling from the nutrient reservoir to plant roots See (Soil Science Module)

Historic Precedence

Ancient Greek, Egyptian, and Chinese farmers used Crop Rotation.

It's only been since the 1950's that large, continuous crop farming has been attempted. Monoculture fails to work as well as rotated crops and requires harmful chemical pesticides and fertilizers.

Crop rotation has proven itself in a 100+ year study in the U.S. and is widely recognized as a cornerstone of good agricultural practice.

See Old Rotation for the proof.

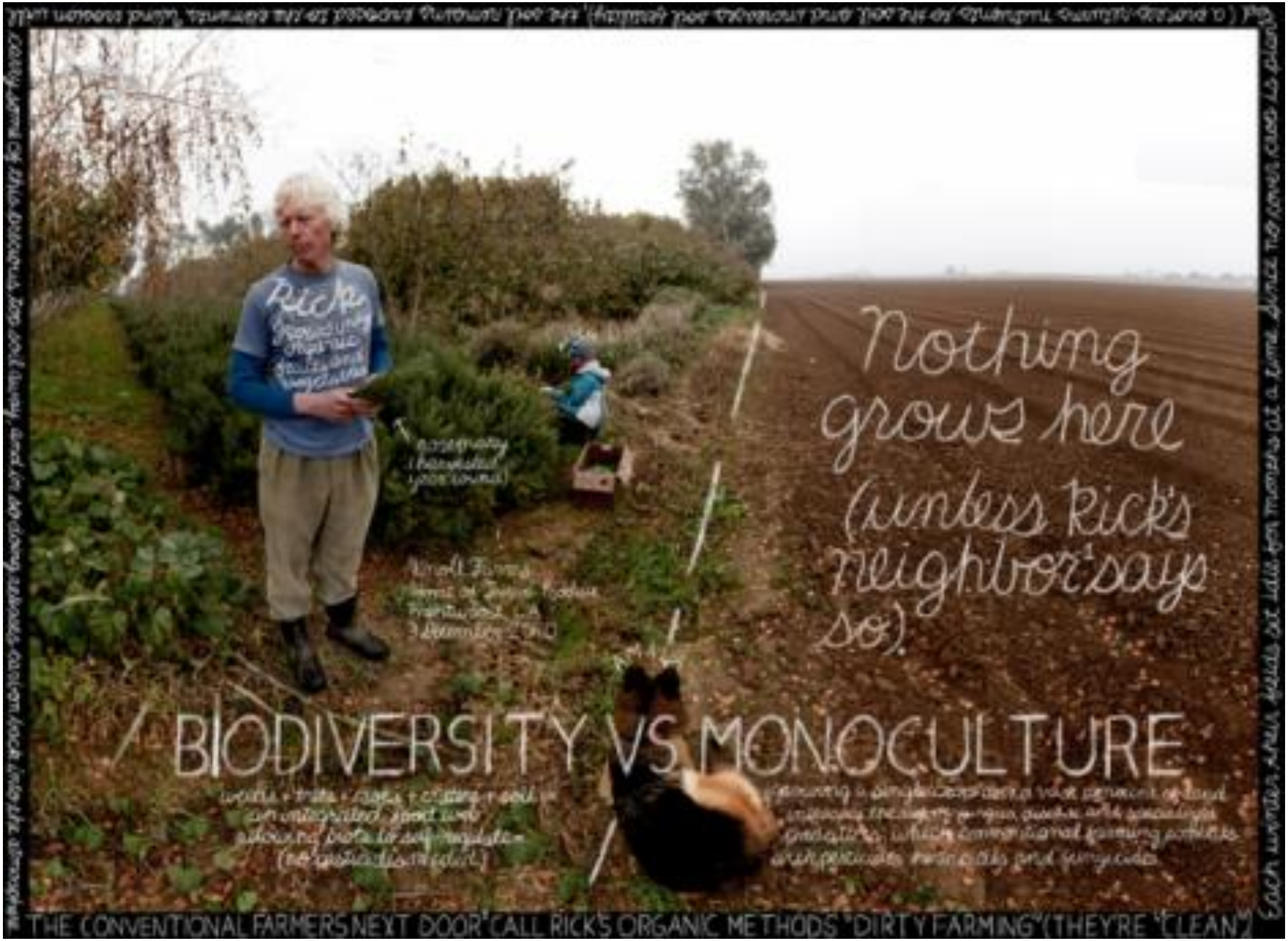
Basic Science:
Crop Rotation ➡ Diversity ➡ Health

Plants have different nutrient and mineral requirements and deplete the soil of certain elements while leaving behind other minerals, bacteria, and environments.

Crop rotation allows the plants' effects on the soil to benefit the next crop.

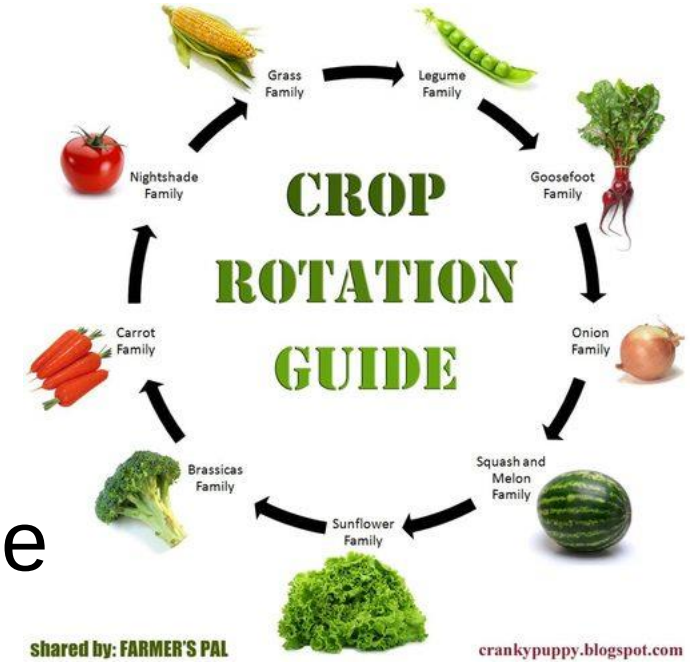
Basically, crop rotation capitalizes on what is already happening when plants grow, and prevents the negative consequences that can result from random plantings.

For a further breakdown of what crop rotation is see Agriculture 101



http://grist.org/sustainable-food/2012-01-13-lexicon-of-sustainability-biodiviersity-vs-monoculture/

Six Benefits:



1. Naturally fertilizes
2. Improves soil structure
3. Controls weeds, diseases, and harmful insects
4. Increases microbiology; bacteria and insects
5. Preserves the environment

Benefit 1: Naturally Fertilizes

- Balances minerals and nutrients by alternating heavy feeders and nitrogen fixers
- A well-managed legume rotation can add 150 pounds/acre of nitrogen --about half the inorganic nitrogen applied to corn in the Midwestern US http://people.oregonstate.edu/~muirp/sustfert.htm
- Soil organic carbon (SOC) is an important indicator of soil quality because it influences soil structure. Soil structure increases soil stability, as well as its capacity to hold water, and it is a driving force in nutrient cycling. SOC building is accomplished with crop rotation.
- Organic farmers can attempt to build higher SOC with sustainable farming practices. However, they should realize that following a change in land management, SOC changes slowly.

CEFS "Crop Rotations on Organic Farms" Keith Baldwin

Benefit 2: Improves Soil Structure

- Increases the overall biomass of the soil
- Reduces need for tilling by alternating different root length plants to pull minerals up from subsoil
  http://soils.usda.gov/sqi/management/files/sq_atn_2.pdf
- Improves weed suppression by maintaining better soil health and providing living leguminous mulches which add nitrogen.
- Most problems are caused by, or made worse by continuous cropping. Inappropriate use of cultivation is largely responsible for soil structural decline. A pasture or crop phase that allows a build-up of organic matter in the soil (as through crop rotation) is a method of improving soil structure and soil structural stability.

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/127279/Improving-soil-structure-by-crop-

Benefit 2: Improves Soil Structure (cont)

- Crop Rotation should also alternate deep and shallow rooting plants to breaking up subsoil and reducing the effects of soil compaction as shown below right. These differing root systems also aerate the soil.
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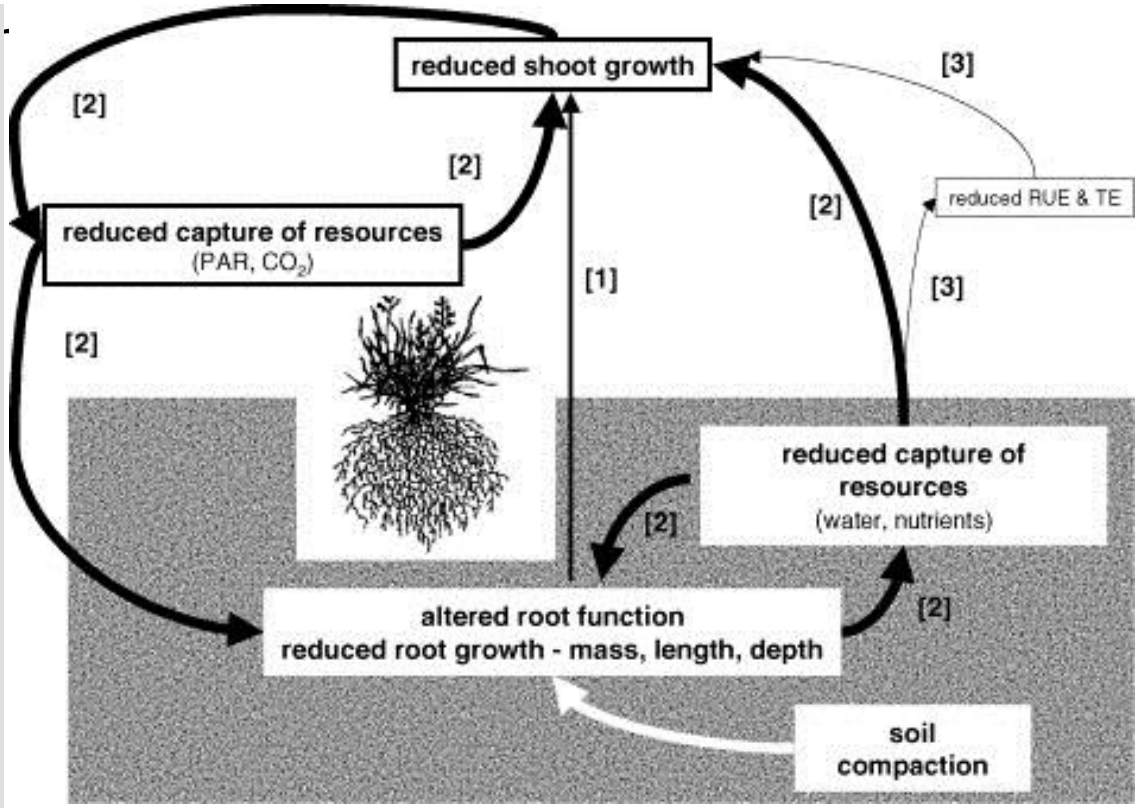


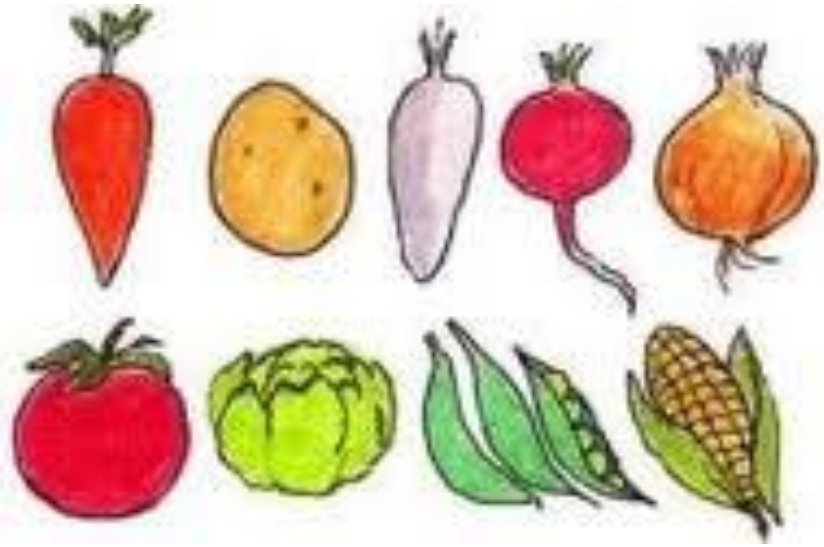
Benefit 3: Controls weeds, diseases, and harmful insects

For example, Colorado potato beetles like to eat potato plants, but they also enjoy feasting on tomato leaves and eggplant foliage. Since these beetles overwinter in the soil, if you plant eggplant in a spot where you grew potatoes the year before, you could be inviting a beetle problem for your eggplants from the day they're planted. Likewise, several serious bacterial and fungal diseases overwinter in plant debris in the soil.

http://www.organicgardening.com/learn-and-grow/crop-rotation

Benefit 3: Controls weeds, diseases, and harmful insects (continued)

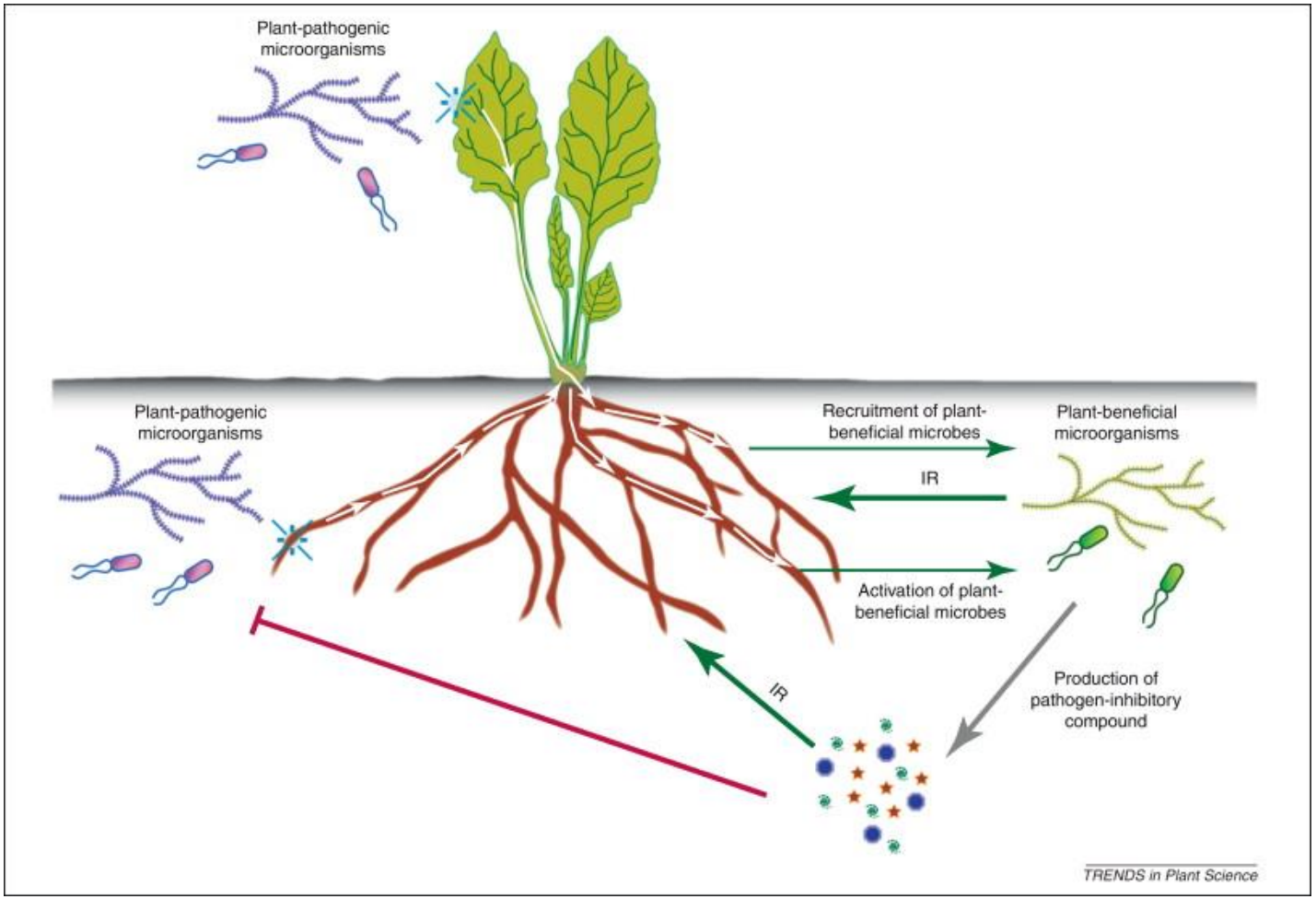
- Disperses predator problems, big and small



- Lengthy rotations are sometimes necessary to control chronic soil-borne problems. Bean anthracnose fungus can persist in soil for up to three years, so a four-year rotation is needed to keep the disease at bay.

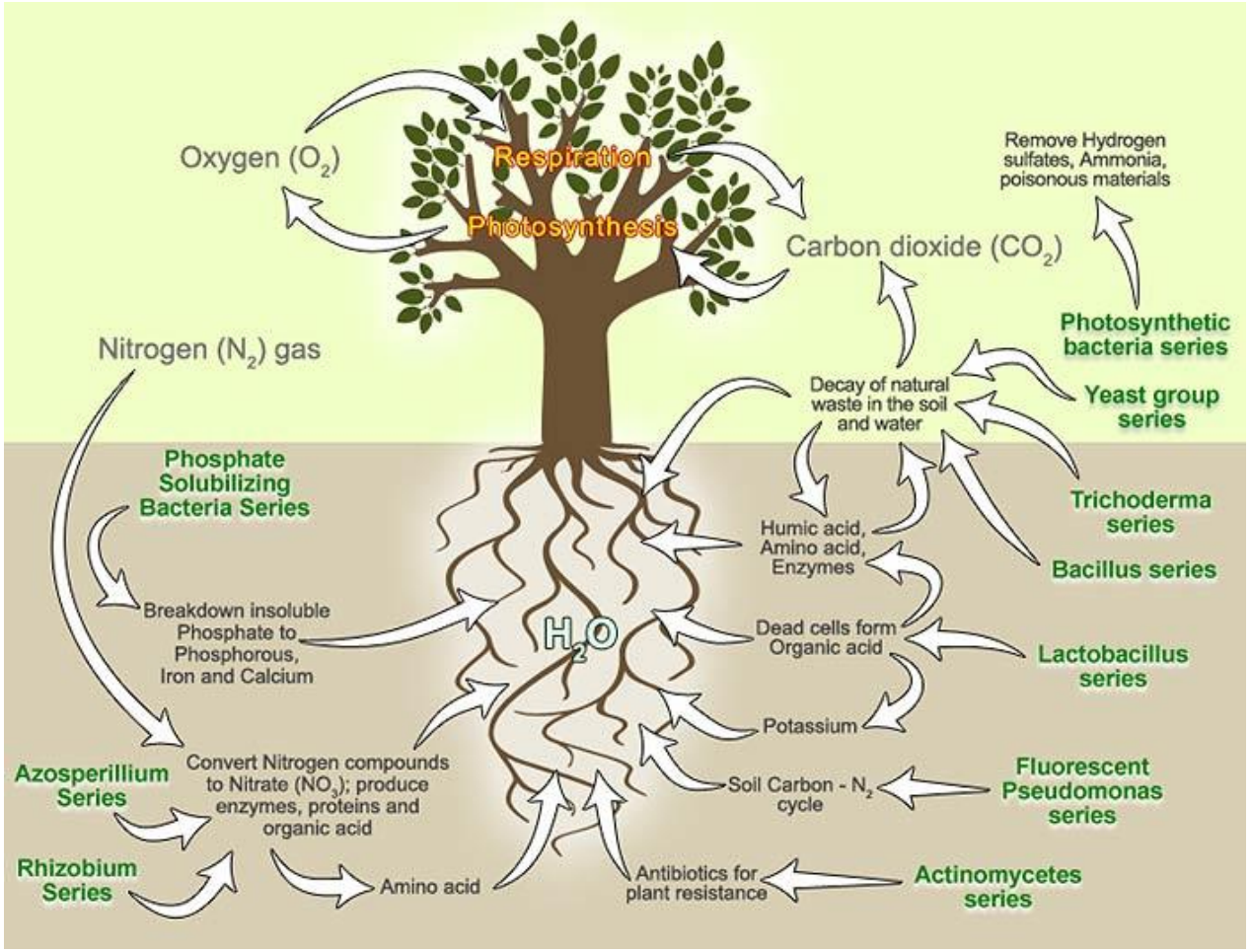
Benefit 4: Increases beneficial microbiology

- The key to great microbiology is diversity. Crop rotation aides in diversifying the soil food web.



Benefit 4 continued

Bacterial improvements for plants are enhanced by diversity of life through crop rotation



Benefit 5: Preserves the Environment

- Prevents erosion with deep roots and rich soil that holds on to water and nutrients
- Increases organic matter
- Improves physical properties of soil, allowing the earth to sustain life and healthy conditions
- Breaks cycles of disease, insect pests, and weeds
- Improve nutrient and water usage.

http://soils.usda.gov/sqi/management/files/sq_atn_2.pdf

- A study conducted in 1988 found 6 inches more topsoil on an organic farm than on an adjacent conventional farm in the Palouse region of Washington state. *CEFS "Crop Rotations on Organic Farms" Keith Baldwin*

Benefit 6: Decreases Costs, Increases Revenue

- Crop rotation can increase yields when compared to continuous crops.
  http://aprodev.eu/files/Trade/crop%20rotation%20briefing_pan_ifoam_aprodev_foee_fina.pdf
- Provides valuable food and materials for livestock while enriching the soil.
- Less or no need for pesticides and artificial fertilizers
- Adds to crop and market diversity
- Crop Rotation allows for organic crops which are increasingly more important to consumers

  Cooking with Class

Cover Crops and Green Manures

A farmer decides to plant tomatoes, which are relatively *heavy* feeders, in late spring after all danger of frost has passed. In the early spring, in preparation for planting tomatoes, the farmer incorporates a hairy vetch cover crop into the soil to add organic matter and nitrogen to the soil. When the vetch is tilled in, it becomes a green manure.

The farmer chose hairy vetch as a cover crop because he/she knew that tomato plants need an early-season shot of nitrogen. Hairy vetch, with its low *carbon to nitrogen* (C:N) ratio and rapid decomposition rate, can fulfill that need.

peas

Detailed Science: Importance of Legumes

vetch

- Legumes are described as “nitrogen fixing" plants. Legumes collect nitrogen from the air and fix it on the root systems in the form of nodules.
- Legumes are a great crop to alternate with heavier feeding plants such as corn. The legumes add nitrogen to the soil after the plant is harvested or dies back.
- Legumes fix nitrogen through a symbiotic relationship with bacteria known as rhizobia that is naturally occurring in soil but often introduced in the form of inoculants by the farmer planting the legume.
- **Two types of legumes that are farmed are forages and grain. Common forages are: alfalfa, vetch, and clovers. Common grains are: Beans, lentils and peas.**

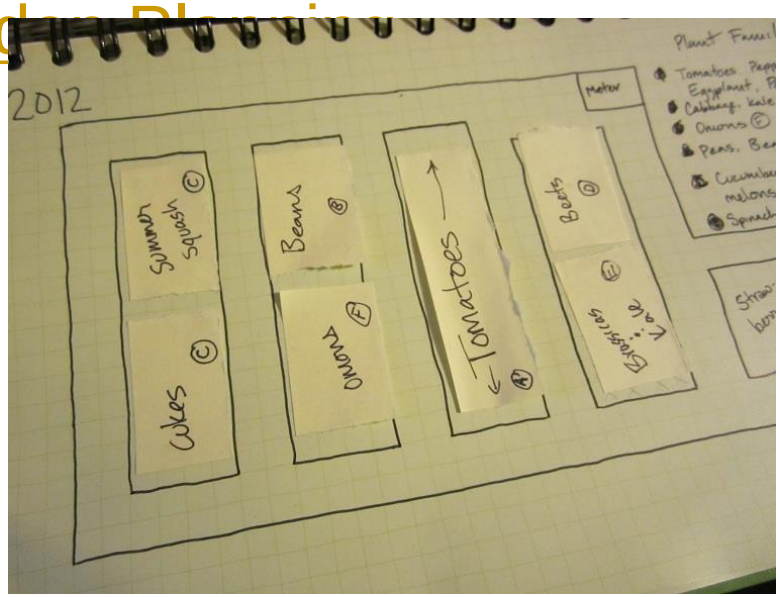
How to rotate crops?

Identify Plant Families

- By type (more reliable) How to Rotate Vegetable Crops
- By feeding categorization Garden Planning

Design your Garden

- Designing a garden



Then, rotate subsequent years' crops

by following a rotation plan.

Sample plans include…

The Corn Belt system on large farms:

- Apply manure, grow corn, follow with soybeans, apply manure, grow corn, and follow with several plantings of alfalfa. In this rotation, legumes fix nitrogen in the soil before the heavy feeder crop (corn, in this example.) Specific plant pest cycles are interrupted. Specific plant disease is similarly suppressed. In this crop rotation, alfalfa cultivation also serves to smother weeds. Manure is applied before the heaviest feeder. Livestock feed is grown for use on farm or for sale.

Intensive vegetable rotational system- 8 years/steps:

This eight year rotational cycle can be adapted to many growing regions. Sweet corn followed by tubers followed by squash, followed by root crops then beans followed by tomatoes, followed by peas then brassicas. This style has been most recently made popular by Eliot Coleman and is benefited by the following relationships.

But why? Read on.

Rotational considerations: Plant by plant

- **Potatoes** follow sweet corn…because research has shown corn to be one of the preceding crops that most benefit the yield of potatoes.
- **Sweet Corn** follows the cabbage family because, in contrast to many other crops, corn shows no yield decline when following a crop of brassicas. Secondly, the cabbage family can be undersown to a leguminous green manure which, when turned under the following spring, provides the most ideal growing conditions for sweet corn.
- **The Cabbage Family** follows peas because the pea crop is finished and the ground is cleared [early] allowing a vigorous green manure crop to be established.

Coleman, Eliot *New Organic Grower*

Rotational considerations: Plant by plant

- **Peas** follow tomatoes because they need an early seedbed, and tomatoes can be under-sown to a non-winter-hardy green manure crop that provides soil protection over winter with no decomposition and re-growth problems in the spring.
- **Tomatoes** follow beans in the rotation because this places them 4 years away from their close cousin, the potato.
- **Beans** follow root crops because they are not known to be subject to the detrimental effect that certain root crops such as carrots and beets may exert in the following year.

Coleman, Eliot *New Organic Grower*

Rotational considerations: Plant by plant

- **Root Crops** follow squash (and potatoes) because those two are good cleaning" crops (they can be kept weed-free relatively easily), thus there are fewer weeds to contend with in the root crops, which are among the most difficult to keep cleanly cultivated. Second, squash has been shown to be a beneficial preceding crop for roots.
- **Squash** is grown after potatoes in order to have the two cleaning" crops back to back prior to the root crops, thus reducing weed problems in the root crops

Coleman, Eliot *New Organic Grower*

Rotation Plans in 4 steps

A Vegetable-Growing Guide for Beginners

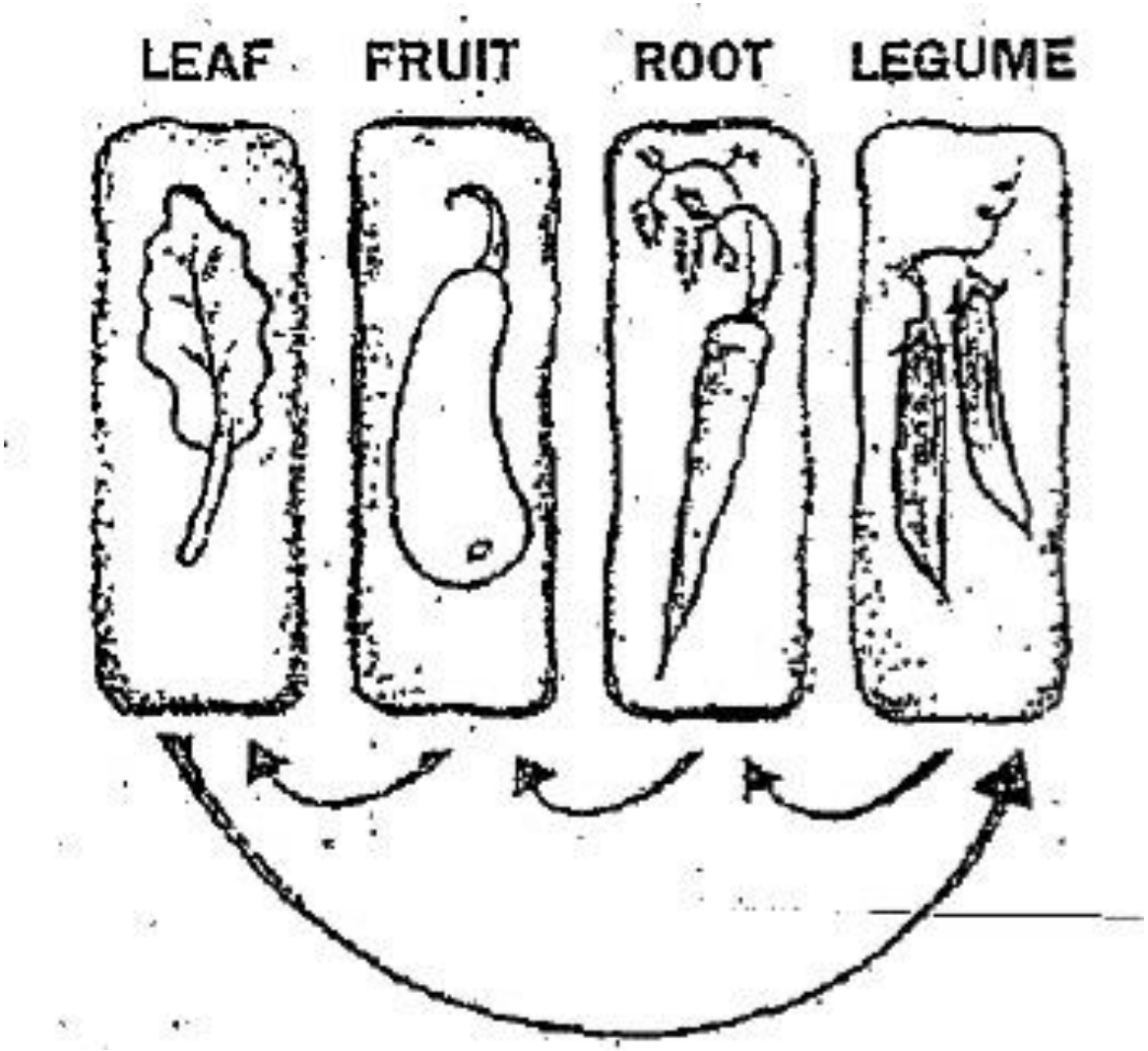
CROP ROTATION

Plot	Season	Year 1	Year 2	Year 3	Year 4
1	Summer	Potatoes, Tomatoes	Peas and Beans	Cabbages	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces
	Winter	Onions, Garlic, Leeks	Green Manure	Cabbages with Lettuces	Green manure
2	Summer	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces in between	Potatoes, Tomatoes	Peas and Beans	Cabbages
	Winter	Green manure	Onions, Garlic, Leeks	Green Manure	Cabbages with Lettuces
3	Summer	Cabbages	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces	Potatoes, Tomatoes	Peas and Beans
	Winter	Cabbages with Lettuces	Green manure	Onions, Garlic, Leeks	Green Manure
4	Summer	Peas and Beans	Cabbages	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces	Potatoes, Tomatoes
	Winter	Green Manure	Cabbages with Lettuces	Green manure	Onions, Garlic, Leeks

Another way to consider the 4 year rotation

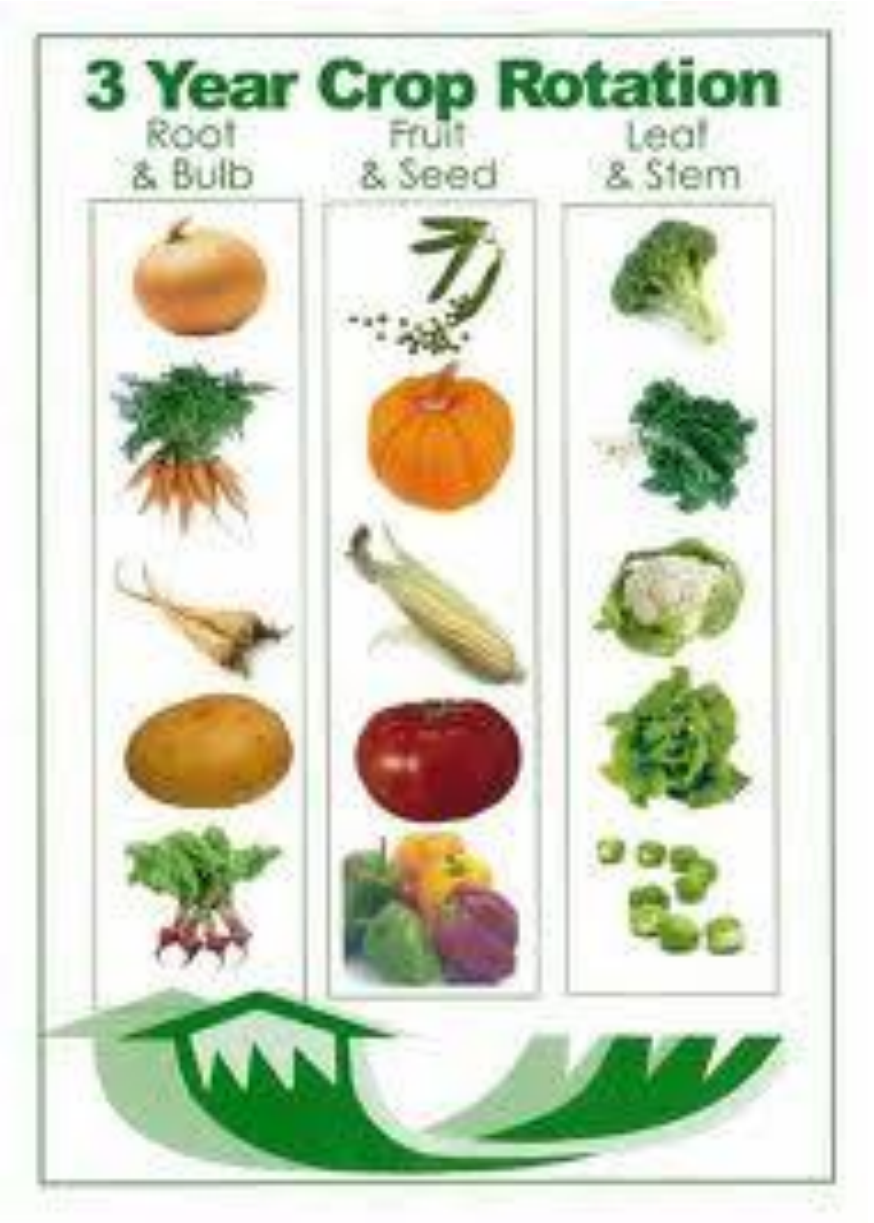
	Year 1	Year 2	Year 3	Year 4
Bed 1	Potatoes family & compatible plants followed by lime	Legumes (Peas/ Beans) followed by additional lime	Brassicas family & compatible plants	Onion family & compatible plants followed by manure
Bed 2	Legumes (Peas/ Beans) followed by additional lime	Brassicas family & compatible plants	Onion family & compatible plants followed by manure	Potatoes family & compatible plants followed by lime
Bed 3	Brassicas family & compatible plants	Onion family & compatible plants followed by manure	Potatoes family & compatible plants followed by lime	Legumes (Peas & Beans) followed by additional lime
Bed 4	Onion family & compatible plants followed by manure	Potatoes family & compatible plants followed by lime	Legumes (Peas & Beans) followed by additional lime	Brassicas family & compatible plants

Even simpler look at 4 year plans



Crop Rotation in 3 Steps… not quite

Though commonly used, this plan is missing a few important elements. How many can you spot?
(*nitrogen fixers are not separate from heavy feeders, need minimum of four years for common soil born problems*)



Assessment/Review

- Why is it important to have a solid understanding of characteristics of specific crops and the relationships between specific crops in order to design an effective crop rotation system?
- What is the importance of legumes in a rotational cycle of planting?
- What are some specific benefits to rotating crops?
- How does rotating crops keep the soil structure healthy?

Resources

- Coleman, Eliot *New Organic Grower*
- *USDA*
- *SARE*