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This presentation is part of an educational modular program designed to provide new and beginning farmers and ranchers with relevant information to initiate, improve and run their agricultural operations



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Sustainable agriculture: SOIL



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Sustainable agriculture is a social and ecological movement that evolved as a response to the multiple problems caused by irresponsible and unplanned intensive and extensive agriculture





Intensive and extensive unplanned production systems led to:

- Erosion
- Depletion of soil and water resources
- Contamination of soil and water resources
- Loss of biodiversity
- Deforestation
- Decline of rural areas and family farms





There are many basic strategies for sustainable agriculture, but in general they all are based on:

- Embracing farming practices that mimic natural ecological processes
- Promoting health and wellbeing of all the elements in the environmental (soil, water, plants, animals, humans)
- Providing a profitable and stable income for farm families and communities





Examples of practices of Sustainable agriculture:

- Reduces external inputs fuels, fertilizers, pesticides, feed
- Cycles nutrients back into the soil for fertility and conservation
- Smart water use strategies
- Grazing and pasture management
- Minimize tilling
- Promotes healthy soils by encouraging plant diversity and frequent rotation of the vegetation in each spot
- Avoid the use of chemical fertilizers and pesticides and instead implement practices of integrated pest and weed management and reintegration of on-farm resources, such as manure, litter, crops, etc.
- Waste management plans





Table 1. Comparison
of the conventional
and sustainable
models of agriculture

<u>Conventional model</u>	<u>Sustainable model</u>
Fuel and input intensive	Information and labor intensive
Linear process	Cyclical process
Farm as factory	Farm as ecosystem
Enterprise separation	Enterprise integration
Single enterprises	Many enterprises
Monoculture	Diversity of plants and animals
	
Single-use equipment	Multiple-use equipment
Passive marketing	Active marketing



Elements in the Farm Ecosystem



- Soil
- Water
- Plants
- Animals
- Humans



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Soil





SOIL

- The soil consists of several layers that differ in texture, structure, consistency, color, chemical, biological and physical characteristics
 - These characteristics are affected by parent materials, climate, slope, organisms, temperature and time
 - An ideal soil would have 45% minerals (sand, silt, clay), 25% water, 25% air and 5% organic matter





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Soil

Goal:

- Sustain crop productivity
- Maintain and improve soil fertility
- Promote soil coverage to foster underground biodiversity and avoid erosion





Soil

- Sustainable Strategies
 - Cover crops (also called green manure)
 - Conservation tillage (none or reduced tillage)
 - Composts





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Soil

Cover crops





Cover crops

- Cover crops are plants planted primarily to manage soil fertility, water, weeds, pests, disease, biodiversity and wildlife in agroecosystems
 - Often they are grown for a specific period and then plowed under before reaching full maturity in order to improve soil fertility and quality
 - They usually contain legumes due to their high nitrogen content and nitrogen fixation abilities.





Cover crops

Benefits:

- Add specific nutrients (such as nitrogen)
- Increase level of organic matter
- Improve soil structure
- Increase water and nutrient holding capacity of the soil
- Prevent erosion
- Reduce water runoff and improve water usage
- Reduces weeds





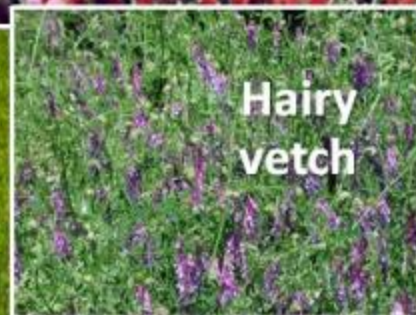
Cover crops

- The specific type of crop used depends on the particular requirements of the soil in the farm or the management goal, but these plants are commonly used as cover crops:

- Sweetclover (*Melilotus officinalis*)
- Rye (*Secale cereale*)
- Hairy vetch (*Vicia villosa*)
- Red clover (*Trifolium pratense*)
- Sorghum-sudangrass (*Sorghum bicolor*)
- Members of the *Brassicaceae* family (mustards or crucifers)



Cover crops





Cover crops

- Some cover crops can suppress certain parasitic nematodes and soil borne diseases: including the rye grass and mustards
- Reduce erosion and attract beneficial bugs
- Cover crops have weed suppressing effects by competing with weeds for light and smothering unwanted plants or through allelopathy

Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival and reproduction of other organisms (that is, that some plants can inhibit the growth of other plants)



For example, this *Casuarina* tree inhibits the growth of all plants underneath it.



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Conservation tillage





Conservation tillage

- Tillage is the agricultural preparation of the soil by different methods (also called plowing)

It is usually classified as:

- Intensive tillage: leaves less than 15% of crop residue cover before the next planting period
- Reduced tillage: leaves between 15-30% of the crop residue before the next planting period
- Conservation tillage: leaves a minimum of 30% of the previous crop on the soil before the next planting period



Conservation tillage

- Prepares the ground for seedlings and transplants
- Provides a range of residue incorporation options depending on the goal
- Enables the incorporation of soil amendments (manure, minerals, etc.)
- Improves soil aeration, and breaks up soil clods to form good seed and root beds
- Improves water infiltration
- Increases rate of microbial activity and mineralization
- Deep tillage can break through compacted layers





Tillage

It is used to remove weeds, shape the soil into rows for crop plants and furrows for irrigation

Positive effects

Plowing loosens and aerates the top layer of the soil which can facilitate the planting of the crop

Helps in the mixing of residue from the harvest, organic matter and nutrients evenly throughout the soil

It can destroy and expose weeds

Negative effects

Dries the soil before seeding

The soil can lose nutrients like carbon, nitrogen and its ability to store water

Can lead to erosion of the soil

Reduces organic matter in the soil (microbes, earthworms, ants, etc.)

Breaks soil aggregates





Conservation tillage

Conservation tillage PROS

- Properly timed or limited tillage reduces energy and labor costs
- Reduces soil compaction
- Residue cover protects soil from wind and water erosion
- Allows for greater moisture retention
- Favor “stable” ecosystem conditions underground (organisms, nutrients and pH)

Conservation tillage CONS

- Residue cover lowers soil temperature and thus affects seed germination and slow seedling growth
- Weed control is difficult without the use of herbicides
- Requires specialized equipment to plant through thick layer of residue





Conservation tillage

- Limited or no tillage promote invertebrate and microorganism populations that are important in organic matter breakdown
 - Including:
 - Earthworms
 - Springtails
 - Ants
 - Millipedes
 - Termites
 - Beetles
 - Woodlice
 - Insects
 - Fly larvae
 - Mites
 - Caterpillars
 - Others





Conservation tillage

- Effects of soil organisms on crop productivity:
 - Breakdown of organic matter
 - Release of nutrients in available form
 - Physical soil turnover: especially important under no till
 - Improved soil aeration
 - Better drainage
 - Increased water holding capacity
 - Pest and disease suppression







Composts

- Compost is organic matter that has been decomposed and recycled as a fertilizer and soil amendment
- It provides organic matter and nutrients to the soil and improves soil structure and helps to hold moisture and soluble minerals
- Composting can destroy pathogens and unwanted seeds and weeds



On farm composting



Composts

- In addition to the traditional compost pile, there are other composting methods that add special characteristics to the final product:
 - **Vermicompost:** usually adds worms (red wigglers, white worms and earthworms) to speed and improve the composting process
 - **Bokashi composting:** usually adds a starter culture of “effective microorganisms or EM” including yeasts and certain probiotic bacteria to the compost. This can accelerate the decomposition of the compost and the liquid from the compost can be used as “compost tea”
 - **Compost tea:** it is the liquid extract from steeping compost in water 3-7 days. It is used as fertilizer but also to treat fungal diseases in crops.



Compost tea



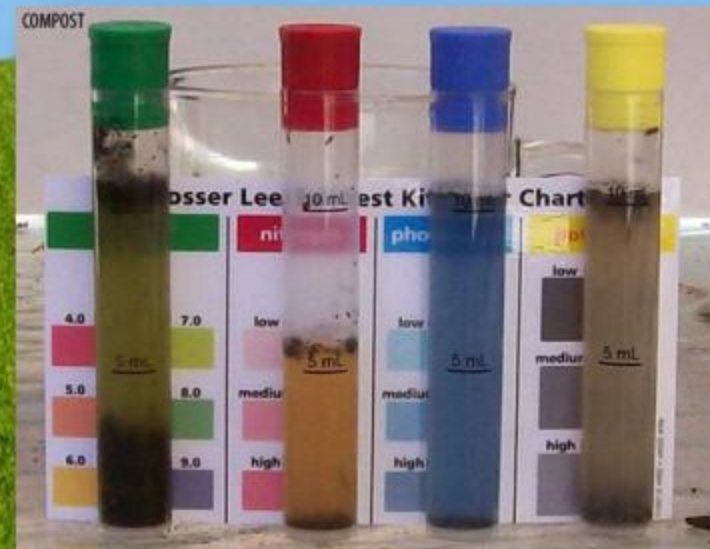
Vermicompost



Composts

- Use of composts in crop production and grass farming is beneficial to build soil organic matter, add nutrients to the soil and retain water
- Ease and economics of use, local availability and costs as well as variability of quality
- It is important to have your soil and the compost tested to ensure correct usage rates
 - How much compost to apply and timing will depend on this

You can buy home kits to get a general idea of the condition of your soil and your compost, but you should send at least one soil sample once or twice each year to your extension agent for testing





Compost

- It is important to test the compost, or any other amendment, and the soil before mixing them
 - If you add too much of a nutrient you may push the system into an excess state and this can lead to nonpoint pollution
 - Excess phosphorus or nitrogen added to farms that don't need it have resulted in eutrophication in water bodies

Eutrophication is the ecosystem response to the addition of extra nutrients into a water system. One example is the “bloom” of phytoplankton or other algae that can cause oxygen depletion in the water and kill animal populations





Compost

- Even if you add the compost, or another amendment, if you don't have it tested you can still have deficiencies of specific minerals in the soil and this can cause reduced yield, plant nutrient deficiencies and increased susceptibility to pests and pathogens.



Experiment showing the effect of
nitrogen deficiency in crop of
alfalfa (lucerne)



Soil Amendments

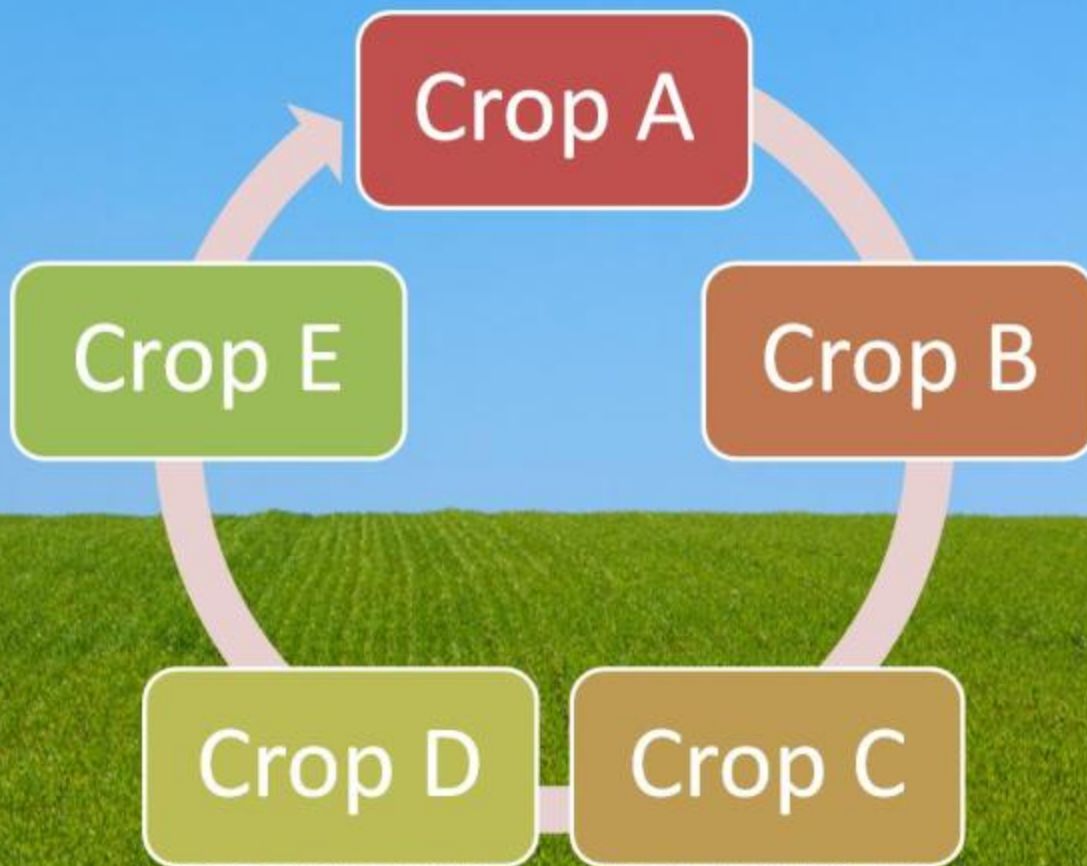
- Allowing animal manure from grazing animals to get incorporated into the soil is a great way to recycle nutrients back into the soil
 - There are variations in the nutrient profiles of animal manures, so you must test your soil to know what kind of animal would be of benefit to your operation
- Animal manure can also be picked up at milking stalls or other areas where the animals are and treated in manure (or fermentation) pits before adding it to the soil. This reduces problems with smells and pathogens in the fields
- Due to the risk of pathogens in manure, animals should not graze in areas where plants will be harvested in the next 120 days





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Crop rotation





Crop rotation

- Crop rotation is the practice of growing a series of dissimilar types of crops in the same area in sequential seasons

Benefits:

- Replenishment of nutrients (such as nitrogen)
- Mitigates the build-up of pathogens and pests
- Improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants

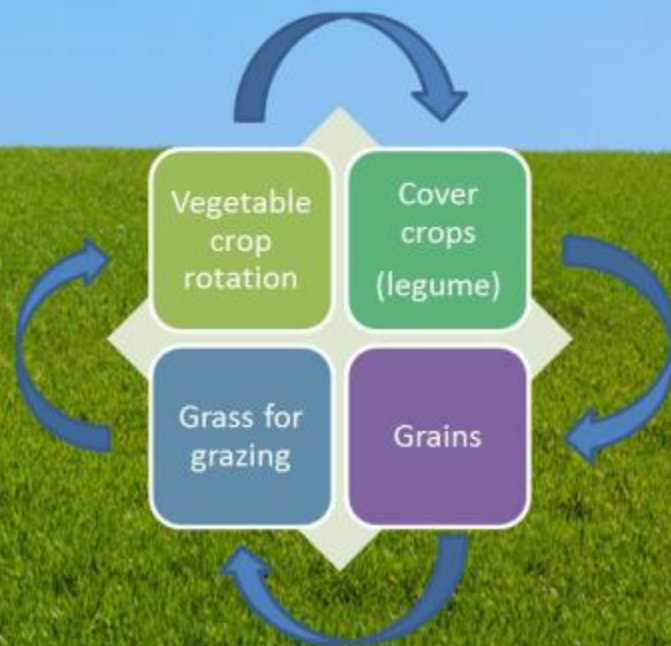
During history, crop rotation has been used to allow the soil to recover after a crop. However, during the Green revolution, this practice was replaced by the practice of supplementing the soil with fertilizers to replenish what the soil had lost during that growing season



Crop rotation

- Crop rotation also provides benefits that fertilizers can not replace such as soil structure, breaking the cycles of animal pests and weeds
- It provides an opportunity to diversify productivity in the farm and allows to incorporate animal grazing into the plan

Choice and sequence of rotation crops depends on the nature of the soil, climate, precipitation, as well as crop marketing and economic variables





Crop rotation considerations

- Avoid rotation of plants that share similar pests and diseases
 - All plants in the *Solanaceae* family share similar diseases so they should not be planted together or in rotation (including potatoes, tomatoes, eggplants, peppers)
- Rotate crops to maximize use of nutrient inputs and distribute nutrient demand placed on soil
 - Another option to ensure that plants get enough nutrients is intercropping (planting plants together that can benefit from this interaction, for example planting carrots or basil with tomatoes, or beans with corn)
- Most people recommend leaving a period of rest of the soil by planting a cover crop for a season or a year, and then turning it under





Some guidelines for crop rotations

- Don't follow one crop with another closely related species, since insects, disease and nematode problems are frequently shared by members of closely related crops
- Follow a legume-sod crop with a high-nitrogen-demanding crop such as corn to take advantage of the nitrogen supply
- Grow less nitrogen demanding crops such as oats, barley or wheat in the second or third year after a legume sod
- Grow some crops that will leave a significant amount of residue, like sorghum or corn harvested for grain, to help maintain organic matter levels
- Use longer periods of perennial crops, such as legume sod, on sloping land and on highly erosive soils
- Try to grow a deep-rooted crop such as alfalfa, safflower or sunflower as part of the rotation





Soil Conservation

Includes a set of management strategies to prevent soil erosion or adverse changes to its integrity, including:

- Critical area planting
- Field border
- Contour farming
- Terraces





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EROSION





Critical area planting

Planting grass, legumes or other vegetation to protect and stabilize small, badly eroding areas, over-grazed hillsides or terrace back slopes





Critical area planting

- Permanently exclude livestock from steep slopes
- Often more intensive conservation strategies are needed, such as stabilization and mulching, before permanent vegetation gets established
- Permanent vegetation stabilizes areas such as gullies, over-grazed hillsides or terrace back slopes controls erosion
- While the primary goal is erosion control, the vegetation can also serve as nesting cover for birds and small animals



Jute netting and ground staples will help secure slope materials.



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Field border

- A strip of grass or legumes at the edge of a field used in place of end rows
- The vegetation prevents erosion, helps filter runoff from the field, and provides habitat for birds and small animals
- The border provides equipment turning and travel lanes





Field border

- The borders should be at least 16 feet wide, or wider if needed to allow your equipment to turn
- Seed with legumes, perennial grasses or a mixture of the two. Check with local conservation specialists
- Shut off sprayers when turning on a field border, and insist that custom applicators do the same
- Fertilize and reseed as necessary to maintain vegetative cover
- Delay mowing field borders until after July 15 to allow nesting birds to leave their nests





Contour farming

- Tilling and planting across the slope following the contours of the land, and breaking the field into alternating bands of row crops and hay or small grains
- Farming on the contour rather than up and down reduces fuel consumption and is easier on equipment





Contour farming

Contour buffer strips

- Strips of grass or other permanent vegetation in a contoured field help trap sediment, nutrients, controls runoff, reduces pollution and erosion
- Keep vegetation tall in spring to slow runoff. You may want to select a grass that yields high-quality hay
- Row crop strips need to be roughly the same width as hay or small grains; consider how many acres of row crops you need. Remember, hay strips will rotate to row crops over time





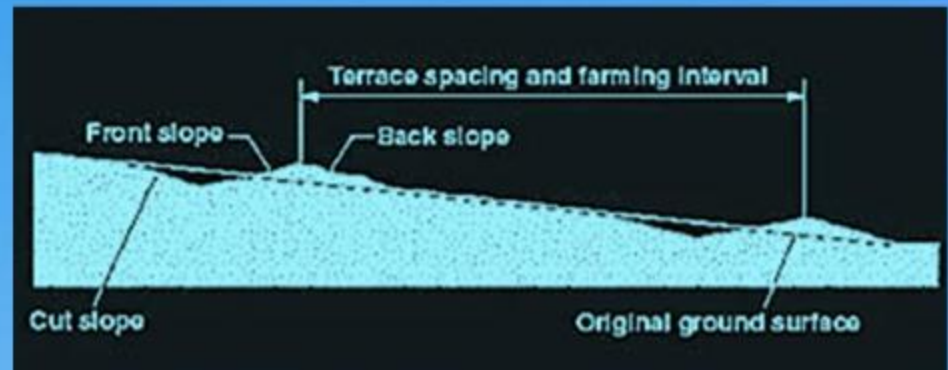
Contour farming

- Keep strip widths consistent from year to year
- In contour farming, establish a narrow, permanent strip of grass along each key contour line to avoid having to lay out new key lines every year





Terrace



- An earthen embankment that follows the contour of a hillside, breaking a long slope into shorter segments and intercepting the flow of water
- They are more expensive and cumbersome to build than other practices, but are most effective in preventing soil loss and stopping nutrients and pollutants from reaching streams and rivers





Terrace

- Terraces can greatly reduce erosion on steep slopes, and control runoff water and guiding it to a safe outlet (such as a grass waterway)
- They should be designed to control runoff from a 10-year, 24-hour storm
- Cropland widths between terraces are designed to match planting equipment width
- Do not drive over the terraces and avoid farming close to the embankment





Soil conservation

- Goals:
 - Return nutrients and organic matter to soil
 - Slow down effects of wind and water
 - Reduce amount of damage done to soil and soil populations by tillage





Sustainable agriculture: SOIL

- Protecting the soil is only one of the elements in sustainable agriculture
- Smart water usage, limited use of synthetic inputs and protection of the natural resources are all important elements in this production system
- Other topics related to sustainable agriculture are included in other modules in this program



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