TILLAGE AND PLANTING SYSTEM

LECTURE 6
Tillage

- **Tillage** is mechanical modification of soil structure.

- Tillage tools modify soil structure through a wide range of soil: tool interactions.

- Tillage has been part of most agricultural systems throughout history because tillage can be used to achieve many agronomic objectives:
Objectives of tillage

• Soil conditioning (modification of soil structure to favor agronomic processes such as soil seed contact, root proliferation, water infiltration, soil warming, etc.).

• Weed/pest suppression (direct termination or disruption of weed/pest life cycles).

• Residue management (movement, orientation or sizing of residues to minimize negative effects of crop/cover crop residues and promote beneficial effects)
• Incorporation/mixing (placement or redistribution of substances such as fertilizers, manures, seeds, residues, sometimes from a less favorable location to a more favorable spatial distribution).

• Segregation (consolidation of rocks, root crops, soil crumb sizes).

• Land Forming (changing the shape of the soil surface – simplest variant is probably leveling; ridging, roughening and furrowing are also examples).
# Types of tillage

<table>
<thead>
<tr>
<th>Types of tillage</th>
<th>Purpose</th>
<th>Implements</th>
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<tbody>
<tr>
<td>Primary tillage</td>
<td>Create a soil condition from which a seed bed can be prepared using secondary tillage implements. Soil disturbance is generally &gt; 6” deep. Primary tillage is necessary when existing soil conditions prevent the effectiveness of secondary tools.</td>
<td>Moldboard and disk plows invert the soil in a plow layer, resulting in the burial of most crop residues. Aggressive tine tools such as chisel plows, rippers and subsoilers fracture soil but do not invert soil and retain more residue cover. Aggressive rotary powered tools, such as spaders and rotary tillers, can be used for primary tillage. An acceptable seed bed can sometimes be prepared in only one pass.</td>
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<td>Secondary tillage</td>
<td>Seed bed preparation – may involve pulverizing, leveling, and/or residue sizing and burial. Soil preparation is traditionally full field but can be concentrated in row zones.</td>
<td>Tillage tools used for seed bed preparation are generally referred to as “harrrows”. Most harrows are draft implements with gangs of tines, disks, rolling baskets or combinations. Powered harrows (e.g. rotovators, rod weeder, reciprocating harrow) are also used for seed bed preparation and can accomplish more in one pass than draft tools.</td>
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• Conventional tillage
• Conservation tillage
• No-till (or zero-till)

• These types of tillage are defined by the amount of crop residue left on the ground.

• Crop residue is the vegetative material, often referred to as trash or litter, left after a crop has been harvested.
Conventional Tillage

• **Conventional tillage** incorporates or buries most of the crop residue into the soil. Generally involves plowing or intensive (numerous) tillage trips. Weed control is accomplished with crop protection products and/or row cultivation.

• **Benefits of Conventional Tillage**
  - Conventional tillage has the advantage of increasing porosity and loosening soil, allowing for good air exchange and root growth.
  - It is also an effective way of incorporating manure and breaking up sod fields.
Disadvantages of Conventional Tillage

• There is limited amount of residue left on fields from conventional tillage and leaves the soils more vulnerable to wind and water erosion.

• With conventional tillage (complete turning over of the soil), the bare soil is exposed to the erosive action of water, which, in many areas is the major route of soil loss.

• The greater the level of tillage, the greater the loss of soil organic matter.

• It dries out the soil

• Reduces the size and stability of soil aggregates, which increases the risk of compaction and crusting.
Conservation Tillage

• It is any tillage system that maintains 30 percent or more of the soil surface covered with crop/cover crop residue, after planting.

• Conservation tillage systems include a variety of techniques, including "no-till" "minimum till" "ridge till" "chisel plow" and "mulch till."

• It is designed to conserve soil, water, energy and protect water quality.
1. **No-till or zero tillage:**

- A system of conservation tillage in which the soil is left undisturbed by tillage and the residue is left on the soil surface.
- It is the most effective soil-conserving system.
- Research shows that land left in continuous no-till can eventually create a soil, water and biological system that more closely resembles characteristics of native soils before the advent of agriculture.
- No-till systems also can provide cover for wildlife if the stubble from the previous crop is left standing.
2. Ridge-till:

- The soil is left undisturbed from harvest to planting except for nutrient injection.
- Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters or row cleaners.
- Residue is left on the surface between the ridges.
- Weed control is accomplished with herbicides and/or mechanical cultivation.
- Ridges are rebuilt during cultivation.
3. **Mulch-till:**

- The soil is disturbed prior to planting.

- Tillage tools such as chisels, field cultivators, disks, sweeps, and blades are used.

- Weed control is accomplished with herbicides and/or mechanical cultivation.
Benefits of Conservation Tillage

– Conservation tillage decreases soil erosion, leaching of fertilizer, pesticides and herbicides into the ground water (Subbulakshmi et al., 2009).
– Improved moisture content in soil.
– Healthier, more nutrient-enriched soil.
– More earthworms and beneficial soil microbes.
– Reduced consumption of fuel to operate equipment.
– The return of beneficial insects, birds and other wildlife in and around fields.
– Less sediment and chemical runoff entering streams.
– Reduced potential for flooding.
– Less dust and smoke to pollute the air.
– Less carbon dioxide released into the atmosphere.
– Conservation tillage increases soil infiltration rate and reduces soil evaporation there by increasing soil water storage.
Planting system

- Cropping systems enable the management of crops so as to efficiently use the available climatic and soil resources.

- The cropping systems that producers use are therefore greatly influenced by the environmental conditions of a region.

- Socioeconomic and political factors also have a large effect on what producers grow.

- Soil tillage is a basic part of agricultural production technology.
• Some cultural practices specifically developed to enhance the effectiveness of conservation tillage are as follows:

1. **Agroforestry and Alley cropping**

• **Agroforestry** is a technique of growing annual food crops in association with woody perennials to optimize the use of natural resources, minimize the need for inputs from nonrenewable resources and reduce the risk of environmental degradation e.g. erosion.

• **Alley Cropping** is a form of agroforestry in which annual crops are grown between adjacent hedgerows of leguminous shrubs and woody perennials. The system is suitable in land degradation.
2. **Cover cropping**

- Diversifying a cropping system often increases its stability and reduces the incidence of diseases and pests.
- Growing grass or leguminous cover crops at frequent intervals (once every 2-3 years in the tropics) is necessary in agricultural system.
- Cover crops have the main advantage of conserving soil tillage systems.
- They restore fertility, control weeds, conserve rain water and reduce energy cost. They also help to improve soil physical properties including soil tilth and reduce soil erosion.
3. **Live Mulch**

- A live mulch is a form of mixed cropping.

- In this system, a fast growing perennial legume is established to smother or suppress weeds and a seasonal grain crop is grown through it in such a way that growth and yield of the food crop is not unduly depressed.
4. **Crop Rotations and Multiple Cropping**

- Crop rotation is a planned sequence of different crops grown over years on the same land.

- Crop rotations vary in length and diversity of crop species.

- A good example of crop rotations is corn-soybean (2-year rotation).

- Soybean is a legume; it contributes to biological fixation of nitrogen.
Crop rotations provide several advantages including weed control, disease and insect control, rotation effects, and reduced risks.

Rotations including perennial legumes such as alfalfa are especially effective at reducing soil erosion and improving soil quality.

Multiple cropping is the sequential production of two or more different crops from the same field each year.

It allows for maximum use of the land, improve soil quality and prevent erosion.
5. **Summer fallowing**

- Summer fallow, sometimes called fallow cropland, is cropland that is purposely kept out of production during a regular growing season.
- Resting the ground in this manner allows one crop to be grown using the moisture and nutrients of more than one crop cycle.
- The summer fallow technique provides enough extra moisture and nutrients to allow the growth of crops which might otherwise not be possible and is closely associated with dry land farming.
- Usually this is done in semi-arid regions in order to conserve moisture for the next season.
Sustainable Agriculture

• The Food and Agricultural Organization of the United Nations defines sustainable agriculture as the use of agricultural practices which conserve water and soil and are environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

• Sustainable agriculture integrates three main goals - environmental health, economic profitability, and social and economic equity.

• Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs.
• Sustainable agriculture aims to optimize the use of energy-related inputs.

• It involves the use of improved cultivars, new crops, efficient cropping systems, improved tools, increased fertilizer use efficiency and systems of integrated pest management.

• Sustainable agriculture must be economically, environmentally and socially compatible.
FIGURE 57
Tillage effects on agricultural sustainability (Lal, 1991b)

- Aggregation (%, MWD)
- Porosity (% pore size distribution)
- Infiltration capacity
- Hydraulic conductivity
- Thermal conductivity
- pH curves
- Nutrient and organic matter stratification
- Activity and species diversity of soil fauna and flora
- Bio-mass carbon
- Soil moisture regime
- Soil temperature regime
- Crusting
- Compaction
- Aeration
- Erosion
- Leaching and internal drainage
- Mineralization of soil organic matter
- Soil evaporation
- Root development
- Water use efficiency
- Nutrient use efficiency
- Root:shoot ratio
- Harvest index
- Economic yield
<table>
<thead>
<tr>
<th>Region</th>
<th>Issues</th>
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<tr>
<td>Humid tropics</td>
<td>• High subsistence agricultural usage of the land</td>
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<td>• Reduction in fallow period</td>
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<td>• Soils of low fertility and low yields due to resource-based and no-input agriculture</td>
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<td></td>
<td>• Soil degradation due to fertility, depletion, accelerated erosion, structural deterioration and reduction in soil organic matter</td>
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<tr>
<td>Arid and semi-arid tropics</td>
<td>• Risks of desertification due to degradation and aridization of soil and environment</td>
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<td></td>
<td>• Perpetual drought stress</td>
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<td>• High risks of crop failure</td>
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<td>• Nutrient deficiency and soils of low fertility</td>
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<td></td>
<td>• Soil compaction</td>
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<td></td>
<td>• Low carrying capacity of land</td>
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<td>Irrigated agriculture in dryland tropics</td>
<td>• Water shortage</td>
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<td></td>
<td>• Salt imbalance and salinization</td>
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<td>• Poor quality irrigation water</td>
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<td></td>
<td>• Deterioration of soil structure</td>
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<td>Steeplands</td>
<td>• Accelerated soil erosion, mass movement and land slides</td>
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<td></td>
<td>• Shallow soils of low fertility</td>
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<td>• Difficulties of mechanizing farm operations</td>
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<td>• Energy shortage</td>
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<td>• Low carrying capacity and low yields</td>
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### Specific technologies for sustainable management of soil and resources for tropical ecological regions

(Lal, 1983)

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<thead>
<tr>
<th>Humid</th>
<th>Sub-humid</th>
<th>Semi-arid</th>
<th>Arid</th>
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<td>Soil management systems for improving water use efficiency</td>
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<td>Mulch farming</td>
<td>No-till</td>
<td>Rough ploughing</td>
<td>Water harvesting</td>
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<td>No-till</td>
<td>Mulch farming</td>
<td>Tied ridges</td>
<td>Fallowing</td>
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<td>Manual clearing</td>
<td>Contour ridges</td>
<td>Mulch</td>
<td>Early planting</td>
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<td>Drainage and water management</td>
<td>Agroforestry</td>
<td>Micro-catchments</td>
<td>Grass hedges</td>
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<td>Erosion control</td>
<td>Drainage and water management</td>
<td>Diggets</td>
<td>Vetiver</td>
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<td>Water harvesting</td>
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<td>Contour bunds</td>
<td>Salinity</td>
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### Soil/crop management systems for increasing nutrient use efficiency

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<th>Humid</th>
<th>Sub-humid</th>
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<td>Perennial crops</td>
<td>Cover crops</td>
<td>Manure/kraling</td>
<td>Manure/kraling</td>
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<td>Root crops</td>
<td>Mulch farming</td>
<td>Mulch farming</td>
<td>Irrigation</td>
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<td>Cover crops</td>
<td>Water harvesting</td>
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<td>Mulch farming</td>
<td>Mixed cropping</td>
<td>Relay-mixed</td>
<td>N and P fertilizers</td>
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<td>Fertilizers</td>
<td>Crop rotations</td>
<td>cropping</td>
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<td>In situ burning</td>
<td>In situ burning</td>
<td>N and P fertilizers</td>
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<td>Drainage and water management</td>
<td>N and P fertilizers</td>
<td>Irrigation</td>
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<td>Drainage and water management</td>
<td>Leaching and</td>
<td>Salinity and sodicity control</td>
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Components of Sustainable Agriculture

1. Economic sustainability
   • To be truly sustainable, a farm must be economically profitable.
   • The environmental and social benefits of sustainable production methods do not always translate into economic gains.
   • Some farms that operate sustainably may be more profitable than their conventional farming counterparts; however, the reverse can also be true.
   • Many factors aside from crop production methods can affect the bottom line.
   • These can include, among other things, the grower’s management strengths/weaknesses, and decision making abilities, and marketing skills.
2. **Environmental sustainability**

- Sustainable agriculture also seeks to have a positive impact on natural resources and wildlife.

- This can often mean taking measures to reverse the damage (e.g. soil erosion or draining of wetlands) that have already occurred through harmful agricultural practices.

- Renewable natural resources are protected, recycled, and even replaced in sustainable systems.
3. **Social sustainability**

- Social sustainability relates to the quality of life for those who work and live on the farm, as well as those in the local community.

- Fair treatment of workers, positive farm family relationships, personal interactions with consumers, and choosing to purchase supplies locally (rather than from a more distant market) are just some of the aspects considered in social sustainability.

- Community supported agriculture (CSA), farmers markets, U-pick, cooperatives, and on-farm events are just some of the ways a sustainable farm can have a positive impact on the local community.
References
