DRAINAGE AND IRRIGATION

LECTURE 5
DRAINAGE AND IRRIGATION

Drainage

• Drainage is the removal of excess water from soil. Improper drainage can lead to poor soil quality and subsurface seepage which could be harmful to the soil environment.
Importance of Drainage

- The purpose of agricultural drainage is to remove excess water from the soil in order to enhance crop production.

- In some soils, the natural drainage processes are sufficient for growth and production of agricultural crops, but in many other soils, artificial drainage is needed for efficient agricultural production.
• Improving drainage on agricultural land not only enhances crop production but also has a role in soil conservation.

• Agricultural drainage improvement can help reduce year-to-year variability in crop yield, which helps reduce the risks associated with crop production.

• Improved field access through enhanced drainage also extends the crop production season and reduces damage to equipment and soil that can occur under wet conditions.
1. Drainage is important to avoid excess water stress to the crop.

2. Excess water has been shown to decrease yields of certain crops such as wheat, oats and barley.

3. Other benefits of drainage include:
   • maintaining soil temperature for optimum plant growth
   • increased soil air in root zone
   • increased availability of nutrients
   • reduced risk of delayed harvesting, less damage to equipment, less overlapping of inputs during field operations and more effective weed control.
• Historically, the main reason for drainage on agricultural land has been to enhance crop production.
• Drainage removes excess water from the soil and helps to create a well-aerated root environment that enhances plant uptake of nutrients.
• Drainage on wet agricultural soils allows timely field operations, and helps plant growth to begin early, continue vigorously, and achieve improved levels of productivity.
• In areas that depend heavily on irrigation from surface water supplies, subsurface drainage is often used to prevent harmful buildup of salt in the soil.
• Drainage benefits crop production by minimizing risks, improving efficiency, and increasing net income.
Flooded Soil

- Flooded soils occur with complete water saturation of soil pores, and generally result in anoxic conditions of the soil environment.
- Flooded soil environments may include such ecosystem as: rice paddies; wetlands (swamps, marshes, and bogs); compacted soils; and post-rain soils.
- Additionally, similar redox conditions (where oxygen is lacking) can also be found within soil aggregates and along pollutant plumes, and thus many of the concepts discussed in this section may be applied to those environments.
• When a soil is flooded (anaerobic conditions), microorganisms use the available soil $O_2$ to survive.
• Free $O_2$ in the soil is usually depleted within a couple of days after flooding.
• The longer the soil is flooded, the lower the soil $O_2$ levels become (more reduced).
• The deeper the flood, the less $O_2$ can move from the air into the soil.
• Most upland crops cannot tolerate prolonged saturation or flooding.
• In contrast, rice has the ability to transport $O_2$ from the leaves and stems to the roots.
Effects of Flooding

• In waterlogged soil, diffusion of gases through soil pores is so strongly inhibited by their water content that it fails to match the needs of growing roots.

• A slowing of oxygen influx is the principal cause of injury to roots, and the shoots they support (Vartapetian and Jackson, 1997).

• This small amount is quickly consumed during the early stages of flooding by aerobic microorganisms and roots.
• In addition to imposing oxygen shortage, flooding also impedes the diffusive escape and/or oxidative breakdown of gases such as ethylene (Arshad and Frankenberger, 1990) or carbon dioxide that are produced by roots and soil micro-organisms.

• This leads to accumulations that can influence root growth and function. For example, accumulated ethylene may slow root extension, while carbon dioxide in the soil can severely damage roots of certain species e.g.,
Effect of flooding on (i) the displacement and exclusion of aerial oxygen from the soil, entrapment of metabolically generated gases in the soil and (ii) the consequences, over time, of bacterial respiration for soil redox potential, loss of free nitrate and subsequent generation of chemically reduced end-products. (Developed from (Setter and Belford, 1990)
Methods of Drainage

1. Surface Drainage
   • Surface drainage is designed to remove standing water from the soil surface.
   • The purpose of using surface drainage is to minimize crop damage from water ponding after a precipitation event, and to control runoff without causing erosion.
   • This type of drainage includes land leveling and smoothing; the construction of surface water inlets to subsurface drains; and the construction of shallow ditches and grass waterways, which empty into open ditches and streams.
Construction of **surface drainage** ditch systems for runoff water
2. **Subsurface Drainage**

- Subsurface drainage is designed to remove excess water from the soil profile.
- The water table level is controlled through a series of drainage pipes (tile or tubing) that are installed below the soil surface, usually just below the root zone.
- Subsurface drainage pipes are typically installed at a depth of 30 to 40 inches, and at a spacing of 20 to 80 feet.
- The subsurface drainage network generally outlets to an open ditch or stream.
Subsurface drainage pipes

Drainage pipes or "tile"

Flow to main or ditch

Water table

Saturated soil

Subsurface drainage pipes
Comparison of water table and root development in tiled and untiled conditions (Sands, 2001).
Irrigation

• **Irrigation** is the application of water to the soil to supplement natural precipitation and provide an environment that is optimum for crop production.

• **Objectives of Irrigation**
  • To Supply Water Partially or Totally for Crop Need
  • To Cool both the Soil and the Plant
  • To Leach Excess Salts
  • To improve Groundwater storage
  • To Facilitate continuous cropping
  • To Enhance Fertilizer Application- Fertigation
1. Sprinkler system

• Sprinkler irrigation is where water is sprayed from overhead.

• This system is more tolerant of variable soil textures since the rate of application can be more adequately controlled.
Sprinkler system
2. **Drip Irrigation**

- While drip irrigation may be the most expensive method of irrigation, it is also the most advanced and efficient method in respect to effective water use.

- Usually used to irrigate fruits and vegetables, this system consists of perforated pipes that are placed by rows of crops or buried along their root lines and emit water directly onto the crops that need it.

- As a result, evaporation is drastically reduced and 25% irrigation water is conserved in comparison to flood irrigation.
Drip irrigation system
3. **Flood and Furrow Irrigation**

- In flood irrigation, a large amount of water is brought to the field and flows on the ground among the crops.

- In regions where water is abundant, flood irrigation is the cheapest method of irrigation and this low tech irrigation method is commonly used by societies in developing countries.
Flood and Furrow Irrigation
• It should be applied only to flat lands that do not concave or slope downhill so that the water can evenly flow to all parts of the field, yet even so, about 50% of the water is wasted and does not get used by the crops.

• Furrow irrigation is actually a type of flood irrigation in which the water poured on the field is directed to flow through narrow channels dug between the rows of crops, instead of distributing the water throughout the whole field evenly.
4. **Localized irrigation**

- Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it.

- Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.
References


• Drainage Management Guide. http://www.gov.mb.ca/agriculture/soilwater/soilmgmt/fsm01s06
