M.tech (Previous year)

AGRICULTURAL DRAINAGE SYSTEM, M.TECH

Agricultural drainage comprises of removal of excess surface water and ground water from agricultural land. Drainage & irrigation are complementary processes which together have the end goal of creating a soil moisture regime and salt balance in the soil root zone for optimum growth of crops and for sustaining them without adverse effect on the environment and ecology.

Plant roots must have a favourable environment to be able to extract water & water soluble nutrients to the plant's requirements .Excess water or concentration of salts in the root zone or at the land surface do not permit the plant roots to function properly, resulting in poor growth and yield of the plants.

The excess soil moisture (waterlogged conditions) affects crop growth mainly due to deficient aeration . The function of a drainage system is to remove excess water and salts from the soil profile in root zone or the crops. It is well known that when an area is irrigated excessively over an extended period of time, the ground water level rises. When it reaches a height which is equal to the capillary rise of moisture in the soil the soil moisture is brought to the surface where it evaporates thus leaving the salts at the surface ,thereby making the soil either saline or alkaline, which adversely affects plant growth.

Agricultural drainage is the removal of excess water known as the free water or gravitational water, from the surface or below the surface of land so as to create favourable conditions for plant growth.

The process of removing the excess water from the land surface is known as surface drainage. If the excess water saturates the pore spaces of the soil, the process of its removal by the downward flow through the soil is known as subsurface drainage or internal drainage.

The excess water that is drained is gravitational water which is not available for plant growth. Drainage does not remove the capillary water and there is no danger of over drainage the soil .

WATER LOGGING- Definition, Characterization & Effects

Water logging: It is the condition of land in which the subsoil water table is located at or near the subsurface, with the result that the yield of crops, commonly grown on it ,is reduced well below the normal for the land. The National Commission on Agriculture has defended an area as waterlogged, when the water table rises to an extent that the soil pores in the root zone of a crop becomes saturated, resulting in the restriction of the normal circulation of air, decline in the level of oxygen & increase in the level of carbon dioxide.

" The Working Group on Problem Identification in Irrigated Areas of Ministry of Water Resource, GOI (1991) adopted the following norms for identification of waterlogged areas:

(i) Waterlogged areas: water table within 2 m. From the land surface.

(ii) Potential areas for water logging : water table between 2-3 m from the land surface.

(iii) Safe area: water table below 3 m. From the land surface.

NORMS FOR CLASSIFYING WATER LOGGED AREAS

The following are the common approaches to express the water table depth below soil surface:

A. Depth of water table, pre monsoon (April/ May)
B. Depth of water table, post monsoon (Oct./ Nov.)
C. Average water table depth over a season or year
D. Sum of excess water days above a specific depth of water table.

ADVERSE EFFECTS OF WATER LOGGING AND SALT ACCUMULATIONS

The imbalance of air and water in the crop causes adverse effect on crop growth. The problem gets more serious when water brings salts to the root zone. The following are some of the adverse effects:

1. Depletion of oxygen in the root zone & increase or saturation of carbon dioxide due to water logging. The anaerobic condition adversely affects beneficial microorganisms while harmful organisms proliferate and restrict plant growth.
2. Physical, chemical and biological activities in the soil are disturbed due to low temperature resulting from water logging conditions. They increase the problem of pests & diseases.
3. Water logging makes field operations difficult or impossible.
4. The adverse effects of water logging get accelerated when the capillary water brings salts from lower horizon of the soil or when they are present in the ground water used for irrigation.
5. Water logging adversely affects the soil- water- crop relationship, thereby creating ecological imbalance.
6. With the excess soluble salts and/ or salinity in the crop root zone the physical condition of the soil deteriorates. The highly deteriorated alkaline soil have very low infiltration rate. Most of the rain falling on such soil goes out as runoff, causing flood and damaging the crops in adjoining areas.

CAUSES OF WATER LOGGING

The excess water on land in the soil may originate from excess rainfall/ over irrigation/seepage from reservoirs, canals or ditches. Main causes of water logging and salt problems are as follows:

1 Adverse topography & unfavorable sub soil geology: Poor natural drainage, as a consequence of flat & concave topography with restricted surface flow and very limited out flow after flooding coupled with inadequate outlet for surface flow results in serious water logging problems. The problem gets more serious due to unfavorable sub soil geology & poor hydraulic conductivity of the soil profile.

2 Lack of watershed area protection : Faulty cultivation, deforestation & lack of proper in situ moisture conservation measures. This causes accelerated soil loss resulting from watershed protection measures.

3 Rainfall characteristics: The rainfall characterized by large amounts with high intensity and frequency & comparatively short duration, all of which add to accumulation of runoff in the lower reaches.

4 Seepage from canal system & higher irrigated areas: Seepage from unlined water distribution network render the adjacent land wet for long periods. Seepage from higher reaches, particularly irrigated regions to low lying flat land result in water logging of the low land.

5 Men – made causes: Unplanned construction of roads & blocked drains, rail line embankment & other structures which obstruct natural drainage leads to severe water logging.

6 Injudicious use of water: Field to field irrigation in paddy land, excess application of water to crops particularly during the initial years of irrigation development when the command area is not adequately developed, & water releases in the canals during the period when irrigation is not required to the crops. Another major problem leading to water logging & land degradation is the inception of canal irrigation without taking consideration the characteristic of soils and subsoil for their irritability.

Beside the above other factors are as follows:

A. Poor on farm management practices
B. Lack of proper prioritization in irrigation systems
C. Lack of integrated management of the water resources of the command area.
D. Lack of people participation.

Saline, Alkaline & Saline- alkaline soil:

Problem of water logging, soil salinity and alkalinity are closely related and interlinked. Salt problems in soil may originate from a variety of sources such as

^ weathering of rocks and minerals on the earth crust.

^ Accumulation of salts on land surface due to irrigation under inadequate drainage

^ Irrigation with salt laden canal water

^Poor quality underground water.

^ Fossil salts.

^Seepage from higher areas containing salts.

Saline soil: It contains soluble salts mainly chlorides& sulphate of sodium, calcium and magnesium in quantities sufficient to interfere with the physiological activities of most crop plants. The soil pH of saturated paste under these soil is less than 8.5, electrical conductivity more than 4 dS/m and Exchangeable Sodium Percentage (ESP) less than 1.5.

Saline sodic soil is a soil with sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts.

Alkaline Soil: These soil contain salts dominated by bicarbonate, carbonate and silicates of sodium, capable of alkaline hydrolysis or sufficient exchangeable sodium to interfere with the physiological activities of most crops. The pH of alkaline soil is greater than 8.5, EC of saturation extract is less than 4 dS /m & ESP is more than 15.

The salinity/ alkalinity in the soil depends on the

^ total salt content (salinity) ^ sodium carbonate and bi carbonate concentration in relation to calcium and magnesium concentration (sodicity) & ^toxicity of specific ions of chloride & boron

The salinity/ alkalinity is expressed either in terms of electrical conductivity (EC) or in terms of concentration in parts per million (PPM) or mg per litre

Irrigation with poor quality of water, inadequate leaching, seepage from canals and adjoining areas together with the presence of shallow water table & high evaporation rate, account for secondary salinization of irrigated soil.

Among the soluble constituents in irrigated water, sodium is considered to be most hazardous.

FACTORS INFLUENCING DRAINAGE:

The factors which are of prime importance are as follows:

- Topography of the affected area and the adjacent watershed which contribute flow in to the problem area.
- Soil characteristics.
- Rainfall and other climatic factors.
- Crop factors.

TYPES OF LAND REQUIRING DRAINAGE : In order to achieve a high level of agricultural productivity, lands under the following conditions require drainage:

1. High water table: the water table is within or near to the root zone. A water table within 1.5 m. Is not in general desirable.
2. When the water stands on a land surface for long periods: Tolerance of crops to standing water table varies widely- 2 to 4 hour for sensitive vegetables, 1 day for maize and small grains & 4 days or more for water tolerance grass crops.
3. In regions where the annual evaporation exceeds annual rainfall- Soil salinity & rise of water table due to excess irrigation water are the problems of the region. Drainage aids in leaching of salts, reduces the for salt accumulation & remove excess irrigation water.
4. Excessive soil moisture content- Soil moisture content above field capacity for considerable length of time is harmful to the crops.
5. Humid regions with continuous or intermittent heavy rainfall.
6. Flat lands with fine textured soil.

BENEFITS OF DRAINAGE:

- Drainage provides a better environment for plant growth. : The excess water which impedes the root respiration & which directly attacks the root tissues of most crops is removed. The depth of plant rooting zone is increased. Plant develops large root system. The ability to grow an extensive root system means that the plant has large volume of soil from which to extract nutrients & water.
- Free water in the soil fills the pore spaces and air is excluded. The presence of air in the soil is essential for the growth of beneficial soil bacteria, which converts the soil organic matter and fertilizer into available plant food.
- Drainage improves the soil structure and soil infiltration characteristics of the soil is improved. Higher infiltration rate reduces soil erosion.
- Optimum conditions for tillage are provided over a long range of time.
- Drainage hastens the warning of soil and maintains desirable soil temperature. The removal of free water by drainage allows the soil to warm up more quickly as considerably less heat is needed to raise the temperature of a well drained soil as compared to saturated soil. Proper soil temperature accelerates plant growth and better germination.
- Drainage promotes increased leaching of salts and prevents their accumulation in soil. Drainage not only improves the productivity of soil but also provides a better environment.

- Increased supply of nitrogen can be obtained from the soil when drainage lowers the water table in the root zone.
- Large crop growing season can be achieved with good drainage due to earlier possible planting dates.
- A good crop variety of crops can be grown successfully on a well drained land.
- Well drained grazing supports more livestock, with less compaction damage to vegetation and soil from animal traffic.
- Good drainage reduces diseases that thrive on wetland.

DRAINAGE SURVEY AND INVESTIGATION

Investigation for finding out the degree of water logging & excess salt concentration should be done simultaneously. In both the cases, some are investigated on the field while others are in the laboratory.

DRAINAGE INVESTIGATION

The source of water logging are mainly due to seepage from canals, hill side or higher irrigation areas, accumulation of runoff in low lying areas.

It is interesting to note that about 1 cm. Of excess water, which may percolate below the crop root zone and reach the ground water, may raise the water table about 8 to 10 cm..

A programme of drainage investigation in an area should comprise of the identification of the source of water logging and extent of drainage required in the problem area and providing a suitable drainage system to obtain the optimum environment for plant growth on a permanent basis.

Drainage investigation consists of getting the necessary information on the techo – economic feasibility of the proposed project and particularly the source of water logging.

A general study of the problem area will provide a good deal of information on the possibilities of a suitable outlet area of the watershed contributing runoff to low lying areas, extant and severity of the drainage problem, cost of land, soil type and types of crops which may be grown in the area.

This is followed by topographic & ground water surveys. A topographic map of the problem area and the surrounding watershed will provide the information on the characteristics of runoff into the area, possible location of the drains and allied structures including culverts.

OBSERVATION WELLS

An observation well is a hole or augured into the ground for the purpose of observing the fluctuations in water table. At any point of time the depth of water table is obtained by the observation wells.

An uncased auger hole can be used to measure the depth of water table. The water table observation wells are usually installed to a depth, deep enough to penetrate the minimum expected position of water table.

In an observation well, water enters through the entire saturated zone. The level of water surface in the well indicates the water table at the time of measurement.

A 2.5 cm. Diameter galvanized iron pipe is usually used in making the observation wells. Gravel packing is usually provided for observation in formation having fine sand.

Observation wells or piezometer are usually installed in a grid pattern. The grid spacing varies from 30 to 300 meters or more depending on the precision required. Piezometers are installed in a battery form & the minimum spacing between the individual piezometers in a battery is 60 cm. Piezometers are driven vertically into the ground.

DETERMINATION OF HYDRAULIC GRADIENT

Hydraulic gradient is measured by installing several piezometers side by side but at different depth below the soil surface. If the pressure head at A is h_1 at B is h_2 & at C is h_3. The gravitational head are respectively, Z_1, Z_2, Z_3 & the hydraulic head

At A, $H_1 = h_1 + Z_1$

At B, $H_2 = h_2 + Z_2$

The distance from A to B is $Z_2 - Z_1$, therefore the hydraulic gradient is

$$= h_1 - h_2 + Z_1 - Z_2 / Z_2 - Z_1$$

Water table contour map : The elevations of the water table contour at the piezoelectric stations are plotted on a base map of the field by interpolation & extrapolation. The completed map represents the surface configuration of the water table at a specific time. Water table contour map provides direct visual representation on the slope of the water table.

Information to be obtained from drainage Survey

1. A map of the area showing watershed location, areas & vegetative cover of the area.
2. Profile on the central line of the proposed drainage ditches & tile mains
3. Outlet conditions: adequacy of capacity, high water elevation & frequency of flood.
4. Physical properties of soil affecting drainage requirements, infiltration capacity of the surface & permeability characteristics of the lower horizon.
5. Amount of soluble salts in the soil to be leached.