HORT-5601

Plant Environment; Climate (temperature, light, humidity) and Soil (structure, texture, fertility)

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Temperature

- **The temperature of a substance may be defined as a measure of the relative speed with which its molecules are vibrating.**
- **All vibrations cease at absolute zero (-273°C). Temperature reflects the *intensity* of heat, which is a qualitative indicator without any regard for the quantity of heat present in a body of matter.**
- **The narrow range of temperature in which plants can grow makes temperature one of the most limiting factors in crop cultivation.**
- **The optimum temperature for growth of most horticultural plants lies between 15° and 35°C.**
- **The tolerance limits for maximum and minimum temperature vary with species. Tomatoes, for example, cannot withstand freezing temperatures, whereas a hardened apple tree will not be harmed at -35°C. Tropical plants like bananas will suffer chilling injury at 4°C.**

7.2.1 Heat

- **Heat is a form of energy that causes an increase in the temperature of matter when transferred into it. A corresponding reduction in temperature takes place when heat is removed, provided the matter does not change states during the process of heat transfer.**
- ***Specific heat:*** **The number of calories of heat required to change the temperature of 1 g of a substance by 1°C is called**

Table 7.1 Specific heat, heat of fusion, and heat of vaporization of some common substances

Substance	Sp. heat (cal/g/°C)	Heat of fus. (cal/g)	Heat of vap. (cal/g)
Water	1.00	80.00	540
Ice	0.50	–	–
Steam	0.48	–	–
Alcohol (ethyl)	0.58	25	204
Wood	0.42	–	–
Glass	0.20	–	–
Steel	0.11	–	–
Oxygen	–	3.3	51

Source: Halfacre and Barden 1979:168.

- **Substances with a high specific heat undergo a relatively small change in temperature in response to a given amount of heat energy.**
- **Because of its high specific heat, water has a strong modifying effect on temperature change. This has great significance for plants, especially for frost protection.**
- ***Heat of fusion:*** **The amount of heat absorbed in changing 1 g of a substance at its melting point from the solid to the liquid state, or released when the substance changes from the liquid to the solid state is its heat of fusion.**
- ***Heat of vaporization:*** **To change 1 g of a substance at its boiling point from the liquid *to* the vapor state, the heat requirement is called the heat of vaporization.**
- **Like specific heat, the heat of fusion and heat of vaporization of water are very high compared to those of other substances.**

Temperature measurement

- **The freezing point of water is O°C, and its boiling point is 100°C on the Celsius (centigrade/metric) scale.**
- **On the Fahrenheit scale, the freezing point is 32° and the boiling point 212°.**
- **The Kelvin absolute temperature scale begins at absolute zero, at which point matter contains no heat energy. It is equivalent to -273°C or -460.4°F.**
- **Ice melts at 273°K and water boils at 373°K.**

- **The following equations can be used to convert temperatures from one scale to another.**

$$°F = (9/5\ °C) + 32$$
$$°C = 5/9\ (°F - 32)$$
$$°K = °C + 273$$
$$°C = °K - 273$$

Factors Influencing temperature

- **Solar radiation**
- **Latitude**
- **Season**
- **Elevation**
- **Time of day**
- **Topographic factors**
- **Soils**

FACTORS INFLUENCING TEMPERATURE

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1. Solar radiation

- **Main source of heat is sun**
- **Sun is located at distance 1.5×10^{8} Km from earth**
- **Diameter 1.4×10^{6} Km which is 100 times**
- **Its estimated surface temperature is about 6000 °C**
- **Main function radiation**
- **In coming**
- **UV (ultraviolet) 10% (absorb by Ozone)**
- **Visible 40%**
- **Infrared radiation 50%**
- **Reflected back**
- **34% by clouds**
- **19% absorbed by Atmosphere**
- **47% reaches to earth**

2. Latitude

The distance of a place north or south of the earth's equator

- **In general temperature increases with decreasing latitude**
- **Temperature differences are caused by differences in the amount of radiation received from the sun (Insolation)**
- **Latitude is a measurement from the equator, and indicates how away a point is north or south of the equator.**
- **Altitude indicates how high a point is (like a mountain top) from the earth's surface.**
- **Elevation is a measure of how high something is on the earth, starting at sea level.**
- **Latitude is a measure of a particular area on the earth's surface. Latitude is a location and elevation is height.**

3. Seasons

- **Seasons effects on temperature are closely related to latitude.**
- **When one moves away from the equator, temperatures not only decline but vary more between summer and winter.**

- **At the equator, day length is 12 hours around the year and solar angle is always close to 90 ^{0}**
- **As distance from equator increases**
- **Summer day length Increases**
- **Winter decreases**
- **Pakistan lies between 25^{0} and 35^{0} N latitude**

4. Elevation

height above a given level, especially sea level.

- **Temperature decreases with increase in elevation**
- **Increases in 100 m in elevation, 0.6 ºC decrease in temperature**
- **Permanent snow exists above 4500 m in the tropics**
- **3000 m in temperate zone**
- **Effect of elevation depends upon balance between incoming and out going radiations**

5. Time of Day

- **Temperature at any given time depends upon balance between incoming and out going heat**
- **Maximum temp at mid-afternoon**
- **Minimum daily just before sunrise**
- **Annual maximum temperature North (June to August)**
- **Minimum late winter**
- **This effect called Lag effect**

6. Topographic factors

- **Large bodies of Water has profound effect on temp**
- **Water has higher heat and thermal conductivity than soil**
- **Temperature vary less over oceans and other large bodies of water than over continents**
- **The moderating effect of oceans on and other large bodies of water on climate is called oceanic effect**
- **Karachi and Multan temp**

Slope

- **The direction in which a slope faces affects its temperature.**
- **In general, angle of the slopes beings equal, a south slope warmest earlier followed by west, east and north.**
- **These difference are the results of differences in the amount of solar radiation received by the soil.**
  South slopes receive the most radiation because they are exposed to sunlight almost all day, even in winter when the sun is low in the sky.
- **A west slope tends to be warmer than an east slope because it is warmed by the sun all morning.**
- **Horticulturist should keep slope effect in mind when selecting site for relatively tender plants**

Air Drainage

- **During the night the air near the ground is colder and dense than the warm air above**
- **Cold air flows downhill and collects in low areas from which it cannot drain, an effect called cold-air drainage**
- **This leads to the formation of frost pockets or depression which collect cold air; the slope itself remains a relatively warm area or thermal belt.**
- **Plants in frost pockets are most danger of freeze damage**

7. Soil

- **Different type of soil warm at different rate in spring**
- **Depends upon**
- **Color, density, Air space, Water holding capacity**
- **Sandy soil (low water holding capacity and warm first in spring) known as Early soil**
- **Organic soil (warm up slowly) Late soil**

Types of Plants

- **Hardy plants can withstand minimum temperatures of -4 to -2°C. Peas, spinach, turnips, and cabbage are hardy plants.**
- **Half-hardy Plants: can survive minimum temperatures of -1 to 0°C. Some half-hardy plants are carrots, beets, and lettuce.**
- **Tender plants: cannot tolerate O°C. Beans, corn, squashes, melons, cucumbers and tomatoes fall in this category. These crops need a frost free growing season or frost protection.**

A second classification involves the *optimum* growing season temperatures.
There are two classes: cool-season and warm-season crops.

Cool seasons crops

- Optimum temp: 18-24 ^{o}C

Warm season crops

- Optimum temp: 25-35 ^{o}C

- **Tolerance level of temperature (Min and Max) depend upon species**
- **Tomato can not with stand frost temp**
- **Apple bear -35°C**
- **Banana suffer chilling injury at 4°C**

TEMPERATURE MANAGEMNET

- Plants respond to changing temp.
- Temp. extremes:
  - if even for a short time - irreversible loss. Such death of whole plant or part of plant will occur
- Field conditions
  - No direct temp. control
- Adaptation can be made through
  - Selection of location
  - Site
  - Choice of plants
  - Appropriate cultural practices

1 HARDENIG

- Refers to the process that increase the ability of plants to survive environmental stress.
- Hardening also refers to developing the ability to withstand cold/warm injury
- Cool weather and short days in fall,
  - bring dormancy and hardiness.
  - Growth slows down.
  - CH_2O accumulate
  - Water moves from protoplasm to vacuoles
    - Stabilizes cell structure &
    - imparts hardening
  - Nursery plants
    - hardened before transplanting

Methods of Hardening in Plants

  - Withhold water and excessive nitrogen fertilization.
- Gradual exposure of plants
  - to cold along with withholding water
- Root pruning
- Avoid over hardening
- Interfere with the subsequent development of seeding after transplanting

2 Mulching and its advantages

- **Mulches**
  - **Surface covers used as insulating agents to regulate soil temperature.**
- **Advantages of mulches**
  - **Keep the soil temperature stable.**
  - **Moisture conservation**
  - **Weed control**
  - **Erosion control**
  - **Clean harvesting from vine crops**
  - **Disadvantages**
  - **Harboring plants pests**
  - **Weeds**
  - **Disease producing microbes**

3. Frost

- Use of smoke
- Flooding
- Spray irrigation

Plant growth structures

- Greenhouse/Glasshouse
- Cold frame
- Hotbeds
- Plastic house/Tunnels
- Shade house

Water

- **Water is the most important limiting environmental factor in selecting a plant site and plant material**
- **Historically, agriculture started along the bank and lakes; when man developed a variety of irrigation systems then Expanded into arid and semiarid areas**
- **An adequate water supply must be ensured for many horticultural plants**
- **It is necessary constituent of all living plant cell**
- **Solvent for nutrients from soil and CO_2 from air**
- **Raw material in the photosynthesis**

- **It is a reagent/substrate for a variety of chemical reactions, act as a pH buffer**
- **It maintains the turgidity of plants cells which is required for growth, development and vital functions like stomatal opening**
- **It also play an important role leaf temp by transpiration of water.**

Humidity

- **Absolute humidity**
- **Specific humidity**
- **Relative humidity**

Absolute humidity

- **It is the weight of water vapor per unit volume of air expressed as grams per cubic meter**
- **The volume of air changes with changing temperature**
- **Absolute humidity will vary with temperature with out any change in absolute moisture content**

Specific humidity

- **It is the weight of water vapor per unit weight of air expressed as grams per kilogram (g/Kg)**
- **It is ratio of weight to weight**
- **Temperature and pressure change do not effect on Specific humidity**

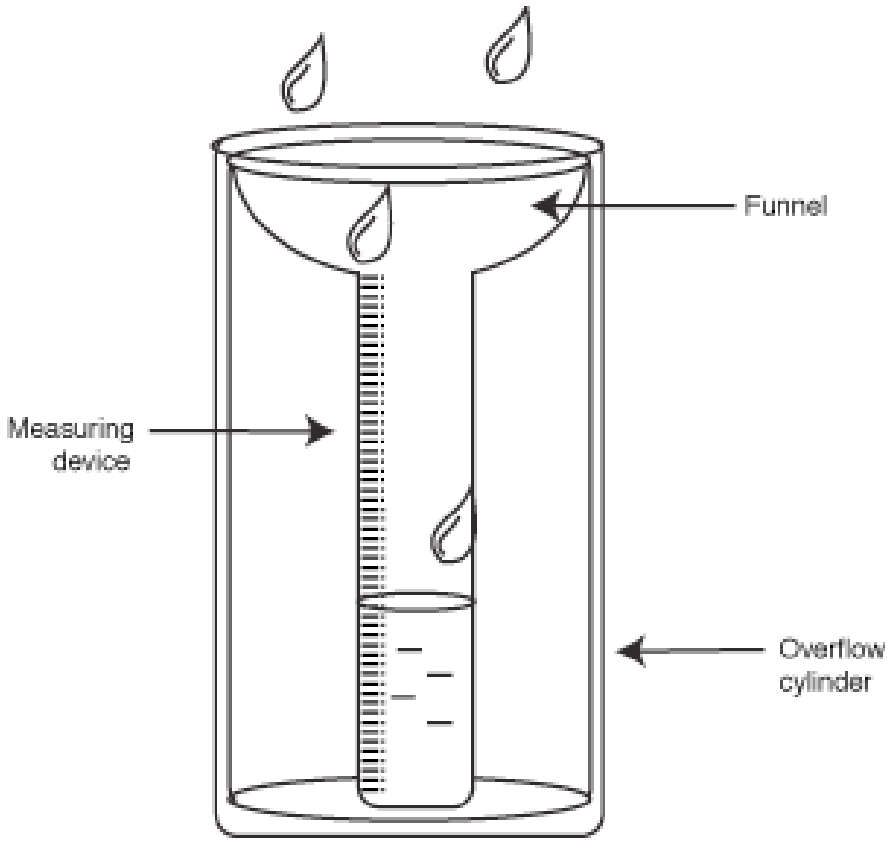
- **Relative humidity**
- **It is the ratio of the amount of water vapour present in the air and the amount at saturation for given temperature and pressure**
- **Expressed as percentage (%)**
- **Water holding capacity of air depends upon temperature**

- **Vapor pressure**
- **Is the part of total atmospheric pressure which is due to water Expressed in millimeters of mercury (mm Hg) or millibar (1 mm Hg= 1.32 millibar)**
- **Atmospheric moisture can be measured by Psychrometer, hygrometers or rain gauge Psychrometer used to measure the vapor content of air**

Hygrometers

Psychrometer

Rain Gauge



Types of water in the soil

Free water or gravitational water

- **The portion of water that drain out/down**

Capillary water

- **Water retained by soil**

Hygroscopic water

- **Is not available to plants**

Field capacity

- **When all free water drains from the soil**

- **Wilting point**
- **After the depletion of all available capillary water, the soil water reaches a level called wilting point**
- **Available water**
- **The difference between the wilting point and field capacity is the available water**
- **Available water capacity is the amount of water that a soil can store that is available for use by plants.**

Plant water requirement

- **Determining when and how much water to apply is a major problem in plant Irrigation efficiency**
- **The percentage of applied irrigation water that actually becomes available for use by plants is the irrigation efficiency**

Irrigation frequency

- **Vary**
  - **Species to species**
  - **region to region**
  - **Plant age**
  - **Climatic factors (temperature, humidity)**
- **Should be given to plants when**
  - **most of root zone is nearly dry.**
- **Summer irrigate fortnightly and**
- **Winter every month depending upon precipitation**
- **Frequent but light irrigation for shallow rooted crops and**
- **Heavy but less frequent irrigation for deep rooted plants**

CRITICAL PERIODS FOR DIFFERENT HORTICULTURAL CROPS

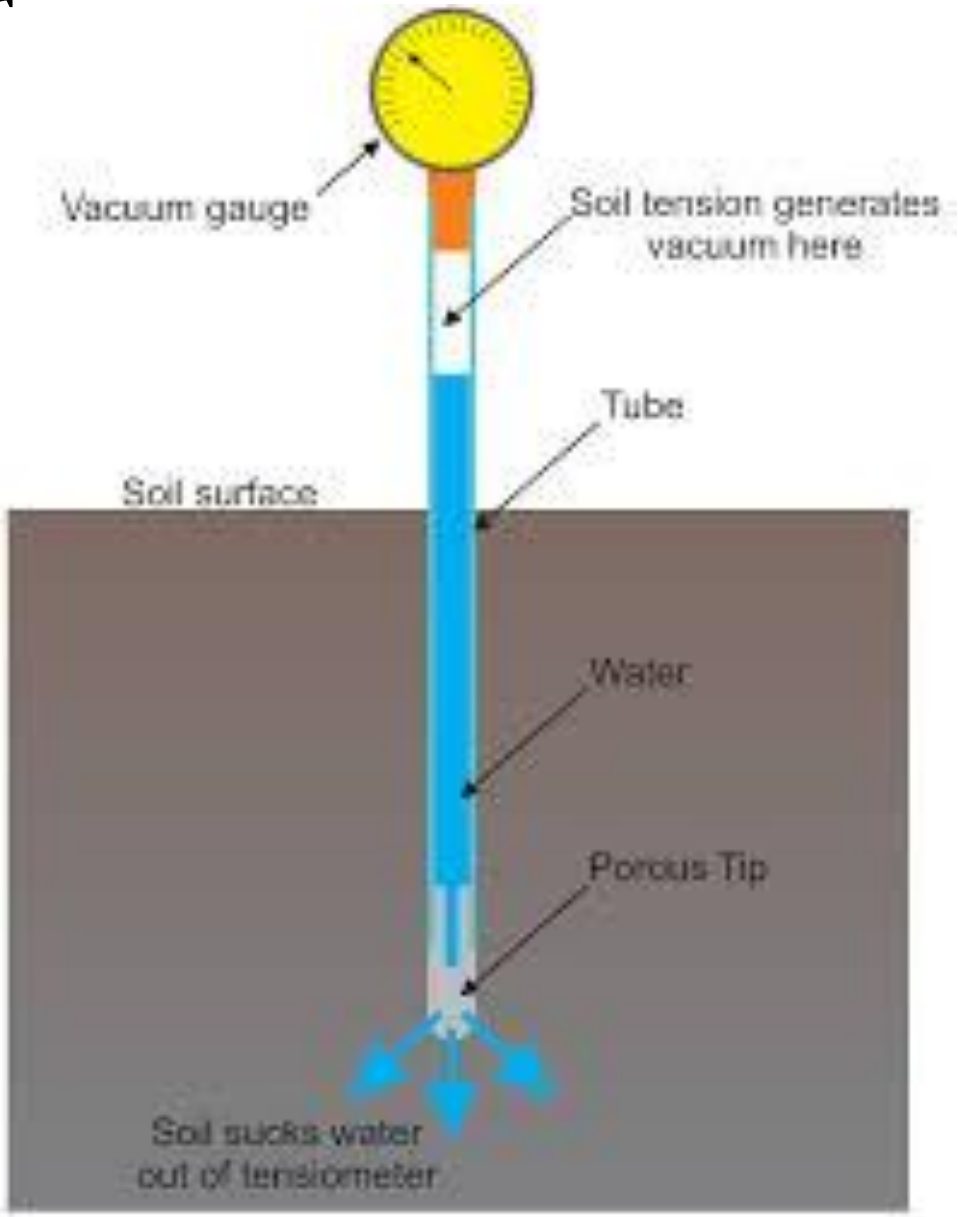
- **During critical period irrigation is essential.**
  - **Non-availability of water badly affect yield**
- **Critical periods for vegetables**
  - **Head development**
    - **cabbage, cauliflower, broccoli**
  - **Flowering, fruit and seed development**
    - **cucumbers and peas**

When to irrigate plants

- **Visual observation (Wilting)**
- **Tensiometer**

- **Tensiometer is a device which is used to measure water tension/potential in soil**
- **Consist of porous cup which is buried in the soil and connected with tube to a vacuum gauge or mercury manometer situated above the soil surface**
- **Cup and tube filled with water which gradually come to equilibrium with soil moisture**
- **When gauge at 40 or 50 point then irrigation will be applied.**

Tensiometer



Air

- Air composition
  - different gases with
  - N_2 78%
  - O_2 21%
  - Argon 0.9%
  - CO_2 0.03%
  - Vapors 1-3%
- Traces of organic and inorganic compounds

Air effects

- Nitrogen
  - an inert gas, essential element for plants
  - Available in form of nitrate and ammonia ions
- Oxygen
  - basic requirement of life
- Carbon dioxide
  - a very small friction is available
  - Critical to plants as only source of Carbon
  - low in thick populations/greenhouse due to high photosynthesis
  - CO_2 enrichment is done in greenhouse

Air pollution

- Principle source of pollution
  - High industrialization and urbanization caused degradation of air quality
  - auto mobilization
  - Industries using fossil fuels
  - Heating
  - fuel burning

Air pollutant

- **Ozone (O3)**
- **Combustion engines release nitric oxide (NO-) oxidize in air to form nitrogen dioxide (NO2) than photochemical reactions, nitrogen dioxide converts to oxygen (O2) which than form combine with molecular oxygen (O) to form ozone(O3)**
- **So Ozone is highly reactive compound**
- **In the upper atmosphere, a deep layer of ozone is present which protects living organisms on the earth from UV radiation of the sun**
- **Several plant disorder are known to be caused by ozone**
- **Leaves may turn yellow, bronze or red, inhibiting their ability to perform photosynthesis.**
- **Citrus and grape leaves may wither and drop off.**
- **Conifers may show yellow-brown mottling and tip burn. White pines are often stunted and yellow.**

Sulfur dioxide

- Released from burning of fuels and mining operation
- It is toxic to plant, animal and human
- It enter in the leaves through the stomata and is absorbed on wet cell surfaces
- At low concentration interferes with synthesis of protein
- Large amount cause direct injury to the cell of plant

Fluoride

- Are non-degradable hydrocarbons
- They are produced in the aluminum, glass, ceramic and phosphate industries
- Households paints and coolants in refrigerators and air conditioners contain significant quantities of fluorides
- These compounds has been depleting the ozone (O3) layer
- But fluorides enter into the plants through stomata
- They cause mottling (blotches of different shades or colors) and necrosis (premature death of cells in living tissue) at the tips and margins of the leaves of broad leave plants

Other gases

- Ammonia
- Chlorine
- Ethylene
- Will also injure the plants if present in great quantities.

Dust

- Dust or suspended particulates matter, can be injurious to plants
- Dust in introduced into air by
  - soil erosion
  - Agricultural operation
  - Traffics
  - Winds
  - Industrial process
- The most of vegetables (lettuce and cabbage), many fruit and ornamental plants can be badly damaged the foliage by airborne particles
- Dust particles disturb the photosynthesis process by blocking the stomata of the leaves

Smog

- Smog is made up from smoke + fog.
- It contains
- Dust
- Oxide of nitrogen
- Ozone
- Sulfur dioxide
- Hydrocarbons
- And other emission products

- These emission products from the automobiles react in the atmosphere
- Under the influence of sunlight to produce toxic gases which are injurious to plants
- End product of these reactions are peroxyacetyl nitrate (PAN)
- PAN are toxic to plants at a concentration of 5 ppm for 10 minutes

Soils

- All types are used for raising different horticultural crops
- Types
  - Sandy soils (80-95% sand, 5-20% silt and clay)
  - Sandy loam soils (50-80% sand, 20-50% silt and clay)
  - Silt loam (20-30% sand, 70-80% silt and clay)
  - Clay loam (60-80% silt and clay, 20-40% sand)
  - Silty soils (Active flood plains of Indus delta)

Sandy soils

- Sandy soils
  - Coarse textured
  - Low fertility
    - Speedy decomposition of OM
  - Sand 80-95%
  - Clay and silt 5-20%
  - Well aerated
  - Well drained
- Some part of Punjab and Deserts of Sindh

- Vegetables may be grown for early maturity
  - Yield is low
- Texture improvement
  - Frequent irrigation
  - Heavy manuring
- Crops
  - Watermelon, muskmelon, groundnuts
  - Sweet potato
  - Repeated green manuring
    - May help raising Citrus

Sandy loam soils

- Properties
  - Well aerated
  - Well drained
- Most soils of Punjab and Sindh
- Composition
  - Sand 50-80%
  - Silt and Clay 20-50%
  - Little OM
- Silt and OM increases Water Holding Capacity.
- Crops
  - Wide var.
  - Citrus, mango, date, cucurbits, root crops and ornamentals

Silt loam

- **Common around**
  - **the salt range**
  - **Potohar Plateau in Punjab**
  - **Wet mountains of the N. part of country**
  - **Dry western plateau of Baluchistan**
- **Properties**
  - **Fine textured**
  - **Poorly drained**
  - **Fertile soils**
- **Composition**
  - **Sand 20-30%**
  - **Silt/Clay 70-80%**
  - **High OM**
- **Good soil preparation required for growing**
  - **Apples, pear and stone fruits**
  - **Melons and some vegetables**

Clay loam

- **Clay soils generally have a greater strength when relatively dry,**
- **but are also susceptible to waterlogging,**
- **leading to restricted root and shoot growth.**
- **poor aeration**
- **Sand 20-40%**
- **Silt and clay 60-80%**
- **clay particles the smallest**
- **Crops potato, tomato, Spinch citrus**

Organic soils

- Organic soils are formed from plant material deposits in and around shallow bodies of water and contain over 20% organic matter. They are of two types:
- muck and peat soils.
- **Muck soils contain** 20-70% organic matter and are fine-textured. Plant residue is in an advanced stage of decomposition. These are highly valuable soils, producing high yields of horticultural crops, particularly vegetables and ornamentals.
- **Peat soils** are composed of coarse and fibrous organic matter. The percentage of organic matter in these soils also ranges from 20-70%. They are important in greenhouse production. These soils are not found anywhere in Pakistan. Our soils generally have less than 1% organic matter content (Kausar et al. 1979).

- **Sodic soils** have high levels of alkalis, particularly sodium hydroxide, and are also sometimes called alkali soils. They are black in colour because of accumulated organic matter, and are considered most difficult to reclaim.
- There is another class of soils known as **saline soils**. These soils contain harmful quantities of chlorides, sulphates, and carbonates of sodium,
- Date palm and olives are highly tolerant to acidity as well as alkalinity of soils.

Thank You