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WATERLOGGED SOIL APPRAISAL AND MANAGEMENT

*[1]Dr. V. N. Palsande, Dr. M. C. Kasture[2] and Dr. S. S. More[3]
[1] Assistant Professor, College of Horticulture
Mulde, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli (MS)
[2]Deputy Director of Research (Agri.),
Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli (MS)
[3]Assistant Professor, College of Agriculture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli (MS)
*Corresponding author's: vjpalsande01@gmail.com

Waterlogging is excess water in the root zone accompanied by anaerobic conditions. The excess water inhibits gaseous exchange with the atmosphere, and biological activity uses up available oxygen in the soil air and water – also called anaerobiosis, anoxia or oxygen deficiency. India has approximately 11.6 M ha i.e. 8.3% of its net sown area under waterlogged condition (Planning Commission 2011) out of which more than 20 % falls in the eastern region where surface waterlogging is a major cause rendering the area unproductive. **Waterlogging** is defined as turning the soil unproductive and infertile due to excess moisture and creation of anaerobic condition called as waterlogged soils.

The soil is intermittently saturated with water, oxidation of organic matter is slow and it accumulates in the in "A" horizon. In the second horizon Fe and Mn are deposited as rusty mantels or streaks if the diffusion is rapid they are deposited as concretions. In submerged soils due to diffusion of oxygen in the water, the organic form nitrogen undergoes mineralization to form NH_4 to NO_2 and NO_2 to NO_3 takes place in the aerobic layer. But in an anaerobic layer the absence of oxygen inhibits the activity of the nitrosomonas microorganisms that oxidizes NH_4 and nitrogen mineralization stops at the Ammonical form. The accumulation of NH_4 on submerged soils take placed the NH_4 diffuse aerobic volatilization and nitrification the NO_3 nitrogen in aerobic layer diffuses into reduced zone undergoes denitrification to form N_2. The availability of N drops on submerged conditions due to denitrification, volatilizations of ammonia, ammonium ions fixation by clay minerals leaching and runoff NO_3 and NH_3.

These conditions affect agricultural plants in several ways:

- nutrient deficiencies or toxicities
- root death
- Reduced growth or death of the plant.

A. Different type of water logging in the field

1. Riverine flood waterlogging: In the rainy season, flood may come to the adjacent land from the river having surplus floodwater.

2. Seasonal water-logging : Run off water accumulates in the low lands and depression in the rainy season.

3. Perennial water-logging : Deep water, swamp etc, get rain water runoff water and seepage water from canal causing perennial water-logging.

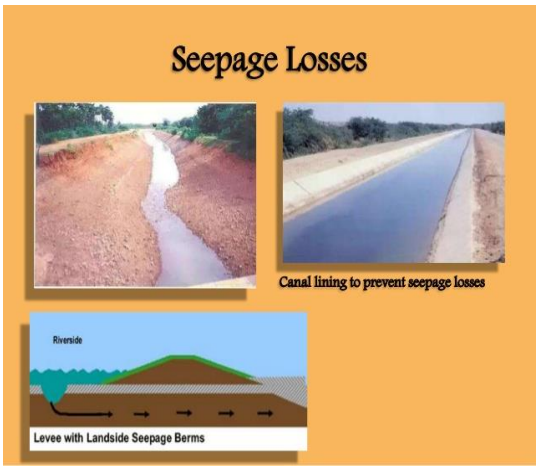
4. Sub soil water-logging : High water table in the rainy season is normally unsuitable for root growth.

5. Oceanic floodwater logging : Sea water spreads in the adjacent land cause waterlogging.

1. Riverine flood waterlogging

2. Oceanic floodwater logging

3. Sub soil water-logging



4. Perennial water-logging

5. Seasonal water-logging

B. Factors affecting formation of water-logging

1. **Climatological factor:** due to high rainfall water accumulates on the soil surface.
2. **Flood:** Flood water is usually causing water-logged situation in the field.
3. **Seepage from canal**: Ground water levels are closer to the surface due to seepage from canal
4. **Land shape:** Saucer-shaped land gets water from high-lands which results into water-logging
5. **Uncontrolled and unwanted irrigation:** Excess irrigation may cause accumulation of water on the soil surface
6. **Drainage:** Poor drainage system is responsible for water-logging in the field.

C. Problems of water-logged soils as follows

1. Water depth : Low land areas are usually flooded to depths of about 50 cm and the limitations to crop production associated with extensively low reduction potentials and partly because of low phosphorus availability. In the 'deep-water' (flooding to depths of 50 to 100 cm) and 'very deep-water' or 'floating' (water depth more than 100 cm) areas, the principal problem of rice production is the tendency for the rice crop to be submerged for periods of up to 10 days or more.

2. Poor aeration : Due to water-logging, a part of the soil air moves out into the atmosphere as it is displaced by the incoming water. Inadequate supply of oxygen either retards or ceases plant growth as the accumulated carbon dioxide hampers the growth of the plant roots. Poor aeration results in the development of toxin and other injurious substances. Only rice plants can survive poor aeration due to water-logging.

3. Soil structure : Continuous water stagnation destroys the soil structure and makes the soil compact

4. Soil temperature : Water-logging lowers down the soil temperature. Moist soils have a higher specific heat than dry soils. Consequently, a moist soil has lower temperature than dry soil. Low temperature affects the microorganism activity which consequently lowered the rate of nitrogen-fixation.

5. Soil pH : There are reversible pH change of the flooded soil, pH tends to increase in acidic soils and decrease in alkaline soil, undoubtedly pH is alter towards normal.

6. Availability of nutrients : Nitrogen- nitrogen deficiency is extremely common in water-logged soil. Due to lesser temperature and reduced condition, mineralization of organics is affected.

a. Phosphorus : The inorganic form of P are usually present at higher levels in flooded soils then in upland soils.

b. Potassium : K response is apparent in many lowland soils. Flooding and puddling of the soils during lowland preparation might considerably increase the soil solution concentration of K because of displacement of exchangeable K by the large amounts of Fe and Mn in the soil solution.

c. Sulphur : Sulphur deficiency has been reported from many lowland area. The reduction of SO_4 in flooded soils has three implications for rice culture: the S supply may become insufficient, Zn and Cu may be immobilized, and H_2S toxicity may arise particularly in soils low in Fe.

d. Zinc : Widespread deficiency of Zn to rice crop in wetland conditions is reported. Zinc is most frequently deficient in alkaline soils.

e. Iron and Manganese: Fe^{++} and Mn^{++} an available in excess causing toxicity to the plant.

7. Salinity : Salinity is an important constraint to rice production in many coastal lowlands as well as in some poorly drained in land areas.

8. Effect on crops : Under water-logged condition all field crops cannot survive due to poor aeration and unavailability of nutrients to the plant. Only rice is an exception.

D. Various Ways of Preventing Waterlogging

1. Control the Loss of Water : The seepage loss from the canals can be reduced by a number of measures. First, is by lowering the full supply level (FSL) of the canals to a sufficient extent. Secondly, is by lining the canal section by providing the lining with the seepage loss, which makes the canal section fairly watertight. Thirdly, is by introducing intercepting drains, which are constructed parallel to the canal.

2. Augmenting Outflow and Preventing Inflows : Artificial open and underground drainage grids can be introduced. The same can also be achieved by improving the flow conditions of existing natural drainages.

3. Disposing of the Rainwater : Rainwater should be quickly removed from the soil's surface, thereby preventing a rise in the level of the water table and subsequent waterlogging.

4. Preventing the Loss of Water : The loss of percolation can be eliminated by using water more economically. It can also be achieved by keeping the intensity of irrigation low. Only a small portion of the irrigable land becomes flooded and the only loss in percolation happens in the limited area. This also keeps the water table sufficiently low.

5. Not Using Alkaline Water : Alkaline water used in irrigation affects the soil and makes it more susceptible to waterlogging in the future. For this reason, alkaline water should not be used for irrigation purposes. The mineral Alkali salts can accumulate on top of the soil creating a crust on the surface that prevents the surface water to drain as required.

6. Raise the Beds : If you are working on a small garden which is becoming waterlogged, you might consider raising it and growing your plants on raised beds. You can also slightly slant the bed so that the excess water goes down the bed. It is a tiresome affair, but it keeps your plant roots from sitting in the water.

7. Install Proper Drainage Systems : Draining the water means both the surface and sub-surface waters. It removes the water in a controlled manner and in a quick manner. Before and when draining the water, be sure not to adversely affect the environment or neighboring lands which might also be affected by the waterlogging.

8. Mulching : It is not a preventative measure but a treatment measure that can help a plant grow even in waterlogged soil. Mulching involves the addition of either organic or inorganic materials that are spread on top of the soil. The mulch covers the affected land by covering the soil and helping reduce evaporation losses. Crops can continue to grow even in the waterlogged area, while at the time, working with the aforementioned preventative measures to fix the problem.

E. State the electrochemical changes occur in water logged soil.

1. Change in pH : On flooding, an increase in pH is observed in an acid soil which may be due to reduction of ferric and manganic compounds and release of OH ions, the production of ammonia and CO_2. The decrease in pH is observed in calcareous soils (alkaline). The pH of a submerged soil tends to be buffered around, regardless of initial pH value and other soil properties; by substances produced as a result of submergence, e.g. ferrous carbonate and ferrous hydroxide. Flooding causes the pH of both acid and alkaline soils to converge to a value at which the availability of P and release of nutrients by microbial activity is highest.

2. Change in redox potential (Eh) : The electrochemical property that differentiates a submerged soil from an upland soil is its redox potential. The aerobic soils are characterized by high positive potentials in the range of +500 to +700 millivolts. After flooding there is a sharp drop in the potentials as low as -300 to -400 millivolts depending upon the type of soil organic matter, Fe and Mn content, pH and temperature, i.e. presence of poisoning system and bacterial potential.

3. Change in specific conductance : The specific conductance of a solution is a measure of its ionic content. On flooding the specific conductance of soil increases as Ca^{++} and Mg^{++} are mobilized by CO_2, organic acids and cation exchange, Fe^{++} and Mn^{++} also go into soil solution following the reduction of their insoluble oxidized counterparts and accumulation of NH_4^+.

F. Management of Water -Logged Soils

1. **Levelling of land** : Leveling of land in many wetlands eradicates water by run off.

2. **Drainage** : Drainage removes extra water from the root zone that is injurious for plant growth. Land can be drained by surface drainage, sub-surface drainage and drainage well methods.
3. **Controlled irrigation** : Excess use of water in the irrigation results in waterlogged area
4. **To check the seepage in the canals and irrigation channels** : Due to seepage, land becomes water-logging
5. **Flood control measures** : Construction of bunds may check water flow from the rivers to the cultivable lands.
6. **Plantation of tree having high transpiration rate :** Transpiration rate in certain tree like Eucalyptus, acacia, zyzyphus is very high. In transpiration process the underground water is consumed by trees, thus, lowering the ground water table.
7. **Selection of crops and their proper varieties :** Certain crops like rice waternut, jute and sesbania can tolerate water-logging upto same extent. In rice crop submergence tolerance varies from one variety to another. Generally, lowland and deepwater varieties.

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