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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Rainfed Agriculture and Watershed Management

Lecture -7

Mechanism of crop adaptations under moisture deficit condition

Crop Adaptations

The ability of crop to grow satisfactorily under water stress is called drought adaptation. Adaptation is structural or functional modification in plants to survive and reproduce in a particular environment.

- Crops survive and grow under moisture stress conditions mainly by two ways: (i) escaping drought and (ii) drought resistance

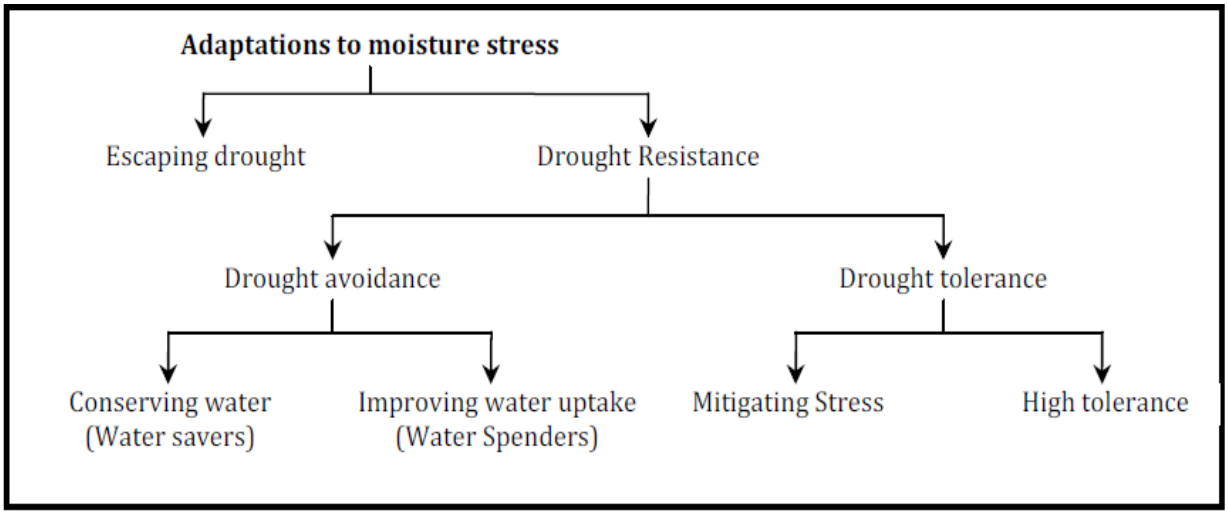

Fig. 4.1 Flow chart showing different mechanisms for overcoming moisutre stess

Escaping Drought

- **Escaping** the drought period is the simplest means of adaptation of the plants under dry soil conditions.
- Many desert plants, Ephemerals have an extremely short life period (5 to 6 weeks). So they germinate at the beginning of the rainy season and completes its lifecycle by the end of rainy period.
- These plants do not have mechanism for overcoming moisture stress therefore these are not drought resistant. Germination inhibitors serve as safety mechanism.
- In cultivated crops, the ability of a cultivar to mature before the soil dries is the main adaptation to growth in dry regions. EX: Certain varieties of pearl millet mature within 60 days after sowing, Short duration pulses like cowpea, greengram, blackgram can be included in this category.

Drought Resistance

- The ability of a crop species or variety to grow and yield satisfactorily in areas subjected to periodic water deficits is termed as drought resistance
- Plants can adopt to drought either by avoiding stress or by tolerating stress due to different mechanisms. These mechanisms provide drought resistance.

Avoiding Stress

- Stress avoidance is the ability to maintain a favourable water balance and turgidity even when exposed to drought conditions, thereby avoiding stress and its consequences.
- A favourable water balance under drought conditions can be achieved either by:

  (i) conserving water by restricting transpiration before or as soon as stress is experienced; or
  (ii) accelerating water uptake sufficiently so as to replenish the lost water.

Conserving water:

1. By closing stomata, we can reduce the transpiration (stomata will be closed due to increasein ABA concentration, thereby reducing water loss).
2. These (CAM) plants store enough water in their tissues. They open stomata at night. They have thick leaves and possess modifications (such as phyllodes and phylloclades) under water stress conditions. They fix carbon during day time with the help of malic acid and CO_2, which is released internally during respiration.
3. By developing smaller leaves with thick cuticle
4. By increasing photosynthetic efficiency. (C_4 crops should be grown under these conditionsbecause they will have high photosynthetic efficiency to supply water compared to C_3 cropsbecause of the presence of enzyme PEP Carboxylase)
5. Having sunken stomata with hairs (pubescence) to reflect light and to reduce the transpiration eg. Soybean, Nerium
6. Shedding their leaves during summer to avoid excess water loss
7. Dehydration of protoplasm
8. Reducing enzyme activity
9. By developing awns, thorns in some crops.
10. By deposition of lipids on the leaf surface to reflect light. Ex: Sorghum, Sugarcane etc.
11. Favoring the syntheses of ABA (stress hormone) and Ethylene (senescence hormone)

Water uptake:

The plants try to uptake more water whenever water is available and act as a water conserver in the future for the growth and development of the crop. Water uptake is done by either more development of roots, root- shoot length.

12. Development of adventitious roots helps the plant to absorb more water and keeps the plant for survival.

13. The crops selecting should have high root length instead of shoot length. Because if moreshoot length and less root length is there means less absorption of water and more transpiration will be there. If mote root than shoot means vice versa will be there and conserves moisture in the metabolism of the plant.
14. Hydraulic conductance of plants (increasing either the diameter of xylem vessels or their numbers).

Drought tolerance with low tissue water potential: The ability of the plant to endure periods without significant rainfall and to endure low tissue water potential. Ability to produce flowers with a minimum of vegetative structure enables them to produce seeds on a limited water supply.

Mitigating stress:

An important aspect of developmental plasticity is the ability of plants to transfer assimilates accumulated prior to seed-filling to the grain during the seed filling stage. It was also suggested that when sufficient water supply is there the food materials stored will be supplied to the grain from the stems and roots in small amounts, but when stress occurs in the seed filling stage, an increased proportion of the prior assimilate is transferred to the seed.

Desiccation Tolerance

Based on the desiccation tolerance of the protoplasm, plants can be classified as poikilohydric or homohydric plants.

1) Poikilohydric (resurrection plants)

The protoplasm of poikilohydric plants can withstand almost complete dehydration and can also withstand dehydration and rehydration in concert with available water without damage.

2) Homoiohydric plants

Majority of the plants are homoiohydric plants. During growth and development, the protoplasm of homoiohydric plants cannot withstand low water potential without injury. Dehydration caused mechanical injury to the protoplast by physical tearing and destruction during water extraction andshrinkage.

Small cells with no vacuoles and also the cells that lose their vacuoles and also the cells that lose their vacuoles during dehydration can withstand the most severe desiccation without mechanical injury. **The changes in viscosity of the protoplasm and permeability of the membrane play a role in desiccation tolerance**. Sugars play a role in protecting this mechanismin desiccation resistant species and varieties. Sugars may also provide protection against desiccation.

Biochemical effect of drought tolerance

1) Accumulation of Proline, Glycine, betaines *etc.*

2) Synthesis of Abscisic acid (ABA) *etc.*