

## *Lecture: - 18*

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### **BREEDING FOR ABIOTIC STRESS**

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- Stress is any change in environmental conditions that might reduce or adversely change plant's growth and development (Levitt, 1972).
- Adverse force or influence that tends to inhibit normal systems from functioning (Jones, 1989).
- Biological stress is an adverse force or a condition, which inhibits the normal functioning and wellbeing of a biological system such as plants.
- Types of Stress:- a) Abiotic stress  
b) Biotic stress

**18.1 Abiotic stresses:-**include potentially adverse effects of Salinity, Drought, Flooding, Metal toxicity, Nutrient deficiency, High temperature and Low temperature. In addition, abiotic stresses can include Shade, UV exposure, Photo inhibition, Air pollution, Wind, Hail and Gaseous deficiency which are often sporadic and highly localized in occurrence. Plants can experience abiotic stress resulting from the shortage of an essential resource or from the presence of high concentrations of a toxic or antagonistic substance. In some cases, such as the supply of water, too little (drought) or too much (flooding) can both impose stress on plants.

**Drought:-**Drought can be defined as an extended period of deficient rainfall relative to the statistical mean for a region.

- **Meteorological drought** is qualified by any significant deficit of precipitation.
  - **Hydrological drought** is manifest in noticeably reduced river and stream flow and critically low groundwater tables.
  - **Agricultural drought:** indicates an extended dry period that results in crop stress and crop yield. The impact of drought on agriculture is due to a deficit of moisture in the soil, when the moisture in the soil is no longer sufficient to meet the needs of growing crops.
- **Effects of drought stress on crops:-**
- Reduced seed germination and seedling development.
  - Poor vegetative growth.
  - Reproductive growth is severely affected.

- Plant height and leaf area reduced.
- Significantly reduction in leaf weight.
- Reduced photosynthesis.
- Reduced stomatal conductance.
- Significantly reduction in the total dry matter.

➤ **Drought resistance:-**

The ability of crop plants to grow, develop and reproduce normally under moisture deficit conditions is referred to as drought resistance.

➤ **Mechanisms of Drought Resistance:**

- **Drought escape:-** Plant avoid the injury of stress by regulating its life cycle to avoid meeting with stress. This is not the kind of resistance – some short-lived, desert ephemeral plants germinate, grow and flower very quickly following seasonal rains. They thus complete their life cycle during a period of adequate moisture and form dormant seeds before the onset of dry season.
- **Drought avoidance:-** Drought avoidance refers to ability of the plant to maintain a favourable internal water balance under moisture stress. In other words, plants which avoid drought retain high water contents in their tissues. Drought avoidance can permit a longer growth period in the crop through reduced water use or increased water uptake
- **Drought tolerance :-** The ability of crop plants to withstand low tissue water content is referred to as drought tolerance. Drought tolerance is more desirable because the crop can produce more yield at lower water potential.
- **Drought resistance:-** Drought resistance is the sum of drought avoidance and drought tolerance. It refers to the ability of crop plants to give higher yield under moisture stress conditions or survival of plants under water deficit conditions without injury.

➤ **Source of Drought Resistance in Plant Breeding:**

- **Cultivated varieties:-** Transfer of drought resistance is easy from cultivated variety and germplasm of cultivated species, because such material can be easily used in the breeding programmes. Moreover, there is no problem of cross incompatibility
- **Germplasm collections**

- **Wild relatives and wild species:-**When the source of drought resistance is a wild species, the transfer of resistance poses several problems such as cross incompatibility, hybrid inviability, hybrid sterility and linkage of several undesirable genes with desirable ones. Wild sources of drought resistance have been reported in wheat, sugarcane, tomato, and several other crops.

#### ➤ **Plant Breeding Methods for Drought Resistance:-**

Breeding methods for drought resistance are the same as for yield and other economic characters. Breeding for drought resistance refers to breeding for yield under soil moisture stress condition. Four breeding methods, viz.; Introduction, Selection, Hybridization, Mutations are commonly used for development of drought resistant crop cultivars.

#### **Salt tolerance:**

Ability of plants to prevent, reduce or overcome injurious effects of soluble salts present in their root zone.

- Salinity can be overcome by
- **Soil reclamation:** costly, time consuming and short lived.
- **Resistant varieties:** less costly, more effective, long lasting.

#### ➤ **Classification of plants based on salt tolerance:-**

- **Highly tolerant crops:** Sugar beet, barley, cotton, date palm, asparagus.
- **Moderately tolerant:** Barley, rye, sorghum, wheat, safflower, Soya bean.
- **Moderately sensitive:** Rice, corn, foxtail millet, cow pea, peanut, sugar cane, tomato, potato, radish, cabbage.
- **Extremely sensitive:** Citrus, strawberry, melon, peas, carrot, okra, onion.

#### ➤ **Mechanism of salt tolerance:-**

- **Salt tolerance:** By accumulating salt, generally in their cells or glands & roots. Halophytes show tolerance by ion accumulation mechanism.
- **Salt avoidance:** By maintaining their cell salt concentration unchanged either by water absorption (e.g. Rice, chenopodiaceae) or by salt exclusion (e.g. tomato, Soya bean, citrus, wheat grass) Glycophytes (nonhalophytes) owe their resistance primarily to avoidance e.g. barley.

- **Breeding strategies:-** Breeding for yield potential should have greater emphasis than breeding for salt resistance. Selection should be done in stresses target environments Screening techniques 1. Sand culture by using nutrient solution in sand & irrigation with saline water. 2. Solution culture by using solution culture tanks 3. Micro plot techniques by using small micro plots.
- **Achievements:-** Rice : Mohan, pokkali, SR23b, SR26b, CSR-2, CSR-3, CSR-6. Onion: Hissar-2, pb selection, Karchia, Karna-92. Okra: Pusa Sawani Barley: Ratna, RS-16, Karan-18, 19, 92 Sugar cane: Co7717, Co1148, Bo9.

### **Chilling tolerance:-**

- **Chilling:** When temp remain above freezing i.e.  $>0^{\circ}\text{C}$  to  $< 10-15^{\circ}\text{C}$ .
- **Freezing:** When temp remains below freezing i.e.  $<0^{\circ}\text{C}$ .
- a) Chilling resistance:-Chilling sensitive plants are typically tropical plants. Temperate plants generally tolerate chilling injury.
- **Chilling tolerance mechanisms involve:-**Membrane lipid un-saturation, Reduced sensitivity of photosynthesis, Increased chlorophyll accumulation, Improved germination, Improved fruit/seed set,
- Pollen fertility Sources of chilling tolerance: Late adopted breeding populations e.g. maize, Germ plasm, Induced mutants for cold tolerance ,Cold tolerant somaclonal variants, Related wild species eg.tomato.

### **Mechanism of freezing resistance:-**

- **Freezing avoidance :** The ability of plant tissues / or genes to avoid ice formation at sub zero temperature Super cooling is a mechanism of freezing avoidance which is controlled by Lack of ice nucleators, Small cell size, Little or no intercellular space, Low moisture contents, Barriers against external nucleators
- **Freezing tolerance:** Ability of plants to survive the stress generated by extra cellular ice formation and to recover and re grow after thawing Components of freezing tolerance, Osmotic adjustment , Amount of bound water, Plasma membrane stability, Cell wall components properties, Cold responsive proteins, e.g. ABA

- **Genetic resources for freezing tolerance:**-Cultivated varieties, Germplasm lines, Induced mutations , Related wild species e.g. Wheat: *Agropyron* sp., Rye Oats: *Avena sterilis*  
Transgenes: e.g. chemical synthesized anti freeze protein gene, *ala3* in tobacco
- **Selection criteria:** Freezing test in laboratory, Cryo freezing, Osmoregulation, Field survival.