# Drought:

## Introduction:

Low rainfall or failure of monsoon rain is a recurring feature in India. This has been responsible for droughts and famines. The word drought generally denotes scarcity of water in a region. Though, aridity and drought are due to insufficient water, aridity is a permanent climatic feature and is the culmination of a number of long term processes. However, drought is a temporary condition that occurs for a short period due to deficient precipitation for vegetation, river flow, water supply and human consumption. Drought is due to anomaly in atmospheric circulation.

Aridity Vs. Drought.

| Particulars | Aridity | Drought |
|---|---|---|
| Duration | Permanent feature | Temporary condition of scarcity of varying duration |
| Factors | Culmination of many long term processes , considers all climatic features | Caused by deficient rainfall |
| Aspect described | Description of Climate | Description of Water availability |

## Definition of drought:

"Prolonged deficiencies of soil moisture adversely affect crop growth indicating incidence of agricultural drought. It is the result of imbalance between soil moisture and evapo-transpiration needs of an area over a fairly long period so as to cause damage to standing crops and to reduce the yields.

### Classification of drought:

Drought can be classified based on duration, nature of users, time of occurrence and using some specific terms.

**1 Based on duration:**

a. **Permanent drought:** This is characteristic of the desert climate where sparse vegetation growing is adapted to drought and agriculture is possible only by irrigation during entire crop season.

**b. Seasonal drought:** This is found in climates with well defined rainy and dry seasons. Most of the arid and semiarid zones fall in this category. Duration of the crop varieties and planting dates should be such that the growing season should fall within rainy season.

**c. Contingent drought:** This involves an abnormal failure of rainfall. It may occur almost anywhere especially in most parts of humid or sub humid climates. It is usually brief, irregular and generally affects only a small area.

**d. Invisible drought:** This can occur even when there is frequent rain in an area. When rainfall is inadequate to meet the evapo-transpiration losses, the result is borderline water deficiency in soil resulting in less than optimum yield. This occurs usually in humid regions.

**2. Based on relevance to the users (National Commission on Agriculture, 1976)**

**a) Meteorological drought:** It is defined as a condition, where the annual precipitation is less than the normal over an area for prolonged period (month, season or year).

**b) Atmospheric drought:** It is due to low air humidity, frequently accompanied by hot dry winds. It may occur even under conditions of adequate available soil moisture. It refers to a condition when plants show wilting symptoms during the hot part of the day when transpiration exceeds absorption temporarily for a short period. When absorption keeps pace with transpiration the plants revive. (Mid day wilt).

**c) Hydrological drought:** Meteorological drought, when prolonged results in hydrological drought with depletion of surface water and consequent drying of reservoirs, tanks etc. It results in deficiency of water for all sectors using water. This is based on water balance and how it affects irrigation as a whole for bringing crops to maturity.

**d) Agricultural drought (soil drought):** It is the result of soil moisture stress due to imbalance between available soil moisture and evapotranspiration of a crop. It is usually gradual and progressive. Plants can therefore, adjust at least partly, to the increased soil moisture stress. This situation arises as a consequence of scanty precipitation or its uneven distribution both in space and time.

Relevant definition of agricultural drought appears to be a period of dryness during the crop season, sufficiently prolonged to adversely affect the yield. The extent of yield loss depends on the crop growth stage and the degree of stress. It does not begin when the rain ceases, but actually commences only when the plant roots are not able to obtain the soil moisture rapidly enough to replace evapo-transpiration losses.

**3 Based on time of occurrence::**

**a) Early season drought:** It occurs due to delay in onset of monsoon or due to long dry spells after early sowing

**b) Mid season drought:** Occurs due to long gaps between two successive rains and stored moisture becoming insufficient during the long dry spell.

**c) Late season drought:** Occurs due to early cessation of rainfall and crop water stress at maturity stage.

**4. Other terms to describe drought:**

**a) Relative drought:** The drought for one crop may not be a drought situation for another crop. This is due to mismatch between soil moisture condition and crop selection. For Eg. A condition may be a drought situation for growing rice, but the same situation may not be a drought for growing groundnut.

**b) Physiological drought:** Refers to a condition where crops are unable to absorb water from soil even when water is available, due to the high osmotic pressure of soil solution due to increased soil concentration, as in saline and alkaline soils. It is not due to deficit of water supply.

**Important causes for agricultural drought are:**

- Inadequate precipitation
- Erratic distribution
- Long dry spells in the monsoon
- Late onset of monsoon
- Early withdrawal of monsoon
- Lack of proper soil and crop management

**Periodicity of drought:**

The Indian Meteorological Department examined the incidence of drought for the period from 1871 to 1967, utilizing the monthly rainfall of 306 stations in the country. It was seen that during 1877, 1899, 1918 and 1972 more than 40 per cent of the total area experienced drought. General observation on the periodicity of drought in respect of different meteorological sub divisions of India is given below.

| Meteorological sub divisions | Period of recurrence of drought |
|---|---|
| Assam | Very rare, once in 15 years |
| West Bengal, MP, Konkan, Coastal AP, Kerala, Bihar, Orissa | Once in 5 years |
| South interior Karnataka, Eastern UP, Gujarat, Vidharbha, Rajasthan, Western UP, TN, Kashmir, Rayalaseema and Telangana | Once in 3 years |
| Western Rajasthan | Once in 2.5 years |

**Effect of drought on crop production:**

a) Water relations: Alters the water status by its influence on absorption, translocation and transpiration. The lag in absorption behind transpiration results in loss of turgor as a result of increase in the atmospheric dryness.

b) Photosynthesis: Photosynthesis is reduced by moisture stress due to reduction in Photosynthetic rate, chlorophyll content, leaf area and increase in assimilates saturation in leaves (due to lack of translocation).

c) Respiration: Increase with mild drought but more serve drought lowers water content and respiration.

d) Anatomical changes: Decrease in size of the cells and inter cellular spaces, thicker cell wall , greater development of mechanical tissue. Stomata per unit leaf tend to increase.

e) Metabolic reaction: All most all metabolic reactions are affected by water deficits.

f) Hormonal Relationships: The activity of growth promoting hormones like cytokinin, gibberlic acid and indole acetic acid decreases and growth regulating hormone like abscisic acid, ethylene, etc., increases.

g) Nutrition: The fixation, uptake and assimilation of nitrogen is affected. Since dry matter production is considerably reduced the uptake of NPK is reduced.

h) Growth and Development: Decrease in growth of leaves, stems and fruits. Maturity is delayed if drought occurs before flowering while it advances if drought occurs after flowering.

i) Reproduction and grain growth: Drought at flowering and grain development determines the number of fruits and individual grain weight, respectively. Panicle initiation in cereals is critical while drought at anthesis may lead to drying of pollen. Drought at grain development reduces yield while vegetative and grain filling stages are less sensitive to moisture stress.

j) Yield: The effect on yield depends hugely on what proportion of the total dry matter is considered as useful material to be harvested. If it is aerial and underground parts, effect of drought is as sensitive as total growth. When the yield

consists of seeds as in cereals, moisture stress at flowering is detrimental. When the yield is fibre or chemicals where economic product is a small fraction of total dry matter moderate stress on growth does not have adverse effect on yields.

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. )

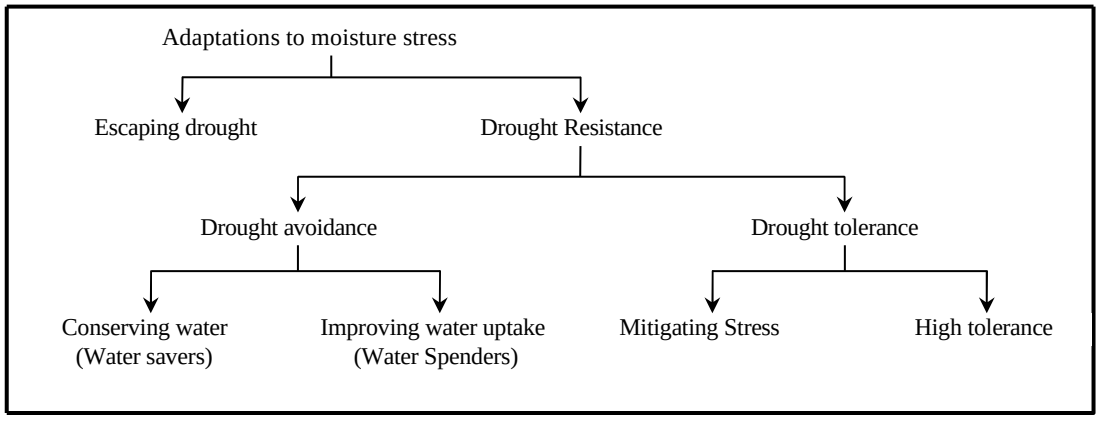


Fig. Flow chart showing different mechanisms for overcoming moisutre stess

1.Escaping Drought:

Evading the period of drought is the simplest means of adaptation of plants to dry conditions. Many desert plants, the so called ephemerals, germinate at the beginning of the rainy season and have an extremely short life period (5 to 6 weeks) which is confined to the rainy period. These plants have no mechanism for overcoming moisture stress and are, therefore, 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. However, only very few crops have such a short growing season to be called as ephemerals. Certain varieties of pearl millet mature within 60 days after sowing. Short duration pulses like cowpea, greengram, blackgram can be included in this category. In addition to earliness, they need drought resistance because there may be dry spells within the crop period of 60

days. The disadvantage about breeding early varieties is that yield is reduced with reduction in duration.

2 Drought Resistance

Plants can adopt to drought either by avoiding stress or by tolerating stress due to different mechanisms. These mechanisms provide drought resistance.

3. 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.

## Strategies for drought management:

The different strategies for drought management are followed for mitigate to drought.

1. Adjusting the plant population: The plant population should be lesser in dryland conditions than under irrigated conditions. The rectangular type of planting pattern should always be followed under dryland conditions. Under dryland conditions whenever moisture stress occurs due to prolonged dry spells, under limited moisture supply the adjustment of plant population can be done by

a) Increasing the inter row distance: By adjusting more number of plants within the row and increasing the distance between the rows reduces the competition during any part of the growing period of the crop. Hence it is more suitable for limited moisture supply conditions.

b) Increasing the intra row distance: Here the distance between plants is increased by which plants grow luxuriantly from the beginning. There will be competition for moisture during the reproductive period of the crop. Hence it is less advantageous as compared to above under limited moisture supply.

2 Mid season corrections: The contingent management practices done in the tanding crop to overcome the unfavourable soil moisture conditions due to prolonged dry spells are known as mid season conditions.

a) Thinning: This ca be done by removing every alternate row or every third row which will save the crop from failure by reducing the competition

b) Spraying: In crops like groundnut, castor, redgram, etc., during prolonged dry spells the crop can saved by spraying water at weekly intervals or 2 per cent urea at week to 10 days interval.

c) Ratooning: In crops like sorghum and bajra, ratooning can practiced as mid season correction measure after break of dry spell.

3 Mulching: It is a practice of spreading any covering material on soil surface to reduce evaporation losses. The mulches will prolong the moisture availability in the soil and save the crop during drought conditions.

4 Weed control: Weeds compete with crop for different growth resources ore seriously under dryland conditions. The water requirement of most of the weeds is more than the crop plants. Hence they compete more for soil moisture. Therefore the weed control especially during early stages of crop growth reduce the impact of dry spell by soil moisture conservation.

5 Water harvesting and life saving irrigation: The collection of run off water during peak periods of rainfall and storing in different structures is known as water harvesting. The stored water can be used for giving the life saving irrigation during prolonged dry spells.

## EFFECT OF WATER DEFICIT ON PHYSIO-MARPHOLOGICAL CHARACTERISTIC OF PLANT:

Water deficit has an adverse effect on plant growth. Therefore, drought stress is the most severe environmental stress for plant growth and crop production. Among them, stomata closure in response to water deficit is the best-known physiological plant response. Stomata closure decreases water loss from leaves.

**Responses of plants to water deficit**: Altered cellular metabolism, physiological and developmental events, salt drought, flooding and extreme temperature.

**Morphological response to water stress:**

**A. Growth changes:**

i. Reduction in cell and leaf expansion (Exp: Populus).
ii. Effect of water stress on leaf expansion of sunflower.
iii. Leaf growth rate is reduced.
iv. Leaf area is reduced.
v. Leads to leaf abscission in some cases (Exp: Populus, cotton, paper birch).
vi. Stem length is reduced (ex: soybean, potato, okra).
vii. Cell thickness is increased. Because reduced cell volume causes increase in solute conc. of cell. This in turn compresses plasma membrane & increase thickness.
viii. Wax deposition on leaf surface is increased, which reduces cuticular transpiration & increases reflection

**B. Yield:**

i. Water stress causes reduction in yield.
ii. Water stress → disrupt assimilate partitioning→ reduced leaf area → reduced photosynthetic surface → reduced light interception → reduced dry matter production.
iii. Water stress → stomata closes → reduce intake of $CO_2$ → reduced photosynthesis → reduced dry matter production.

**Physiological changes due to water deficit:**

**Stomata closure:**

The stomata are easily recognized from the surrounding epidermal cells by their peculiar shape. The epidermal cells that immediately surround the stomata may be similar to other epidermal cells or may be different and specialized. In the latter case, they are called as **subsidiary cells**. The guard cells differ from other epidermal cells also in containing chloroplasts and peculiar thickening on their adjacent surface in closed stomata or on surfaces.

**Hydro passive stomatal closure**:

- Occurs in Ferns and Lycopods.
- Loss of water from stomatal guard cells, turgor drops, stoma closes

**Active stomatal closure:**

- Occurs in Angiosperms and Gymnosperms.
- This is mediated by ABA *i.e* produced by roots and leaves during water stress and transported into guard cells.
- Malate Starch. It reduces the osmotic potential & turgor pressure.
- Cell volume reduces & stomata close.

**Photosynthetic responses**:

Photosynthesis is a vital physiological process where in the chloroplast of green plants synthesizes sugars by using water and carbon dioxide in the presence of light. Photosynthesis literally means synthesis with the help of light *i.e.* plant synthesize organic matter (carbohydrates) in the presence of light. Photosynthesis is sometimes called as carbon assimilation (assimilation: absorption into the system).

i. Early effect: mostly via stomatal closure
ii. Late effect: metabolic breakdown reasons for reduction in photosynthesis.
iii. Reduction in photochemical efficiency of PS-I & PS-II and quantum generation
iv. Disruption of cyclic & non-cyclic types of electron transport during the light reaction of photosynthesis