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## Drought Stress and Its Effects on Vegetable Crops

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**D**rought is an environmental phenomenon defined by below-average precipitation rates for extended periods, resulting in decreased soil water content available for the growth and development of plants. Agronomically, water stress is essential because it impacts crop performance, especially if it happens at a critical moment in the growing season. It occurs as the air temperature rises, causing plants to close their stomata, decreasing photosynthesis and productivity.

Or

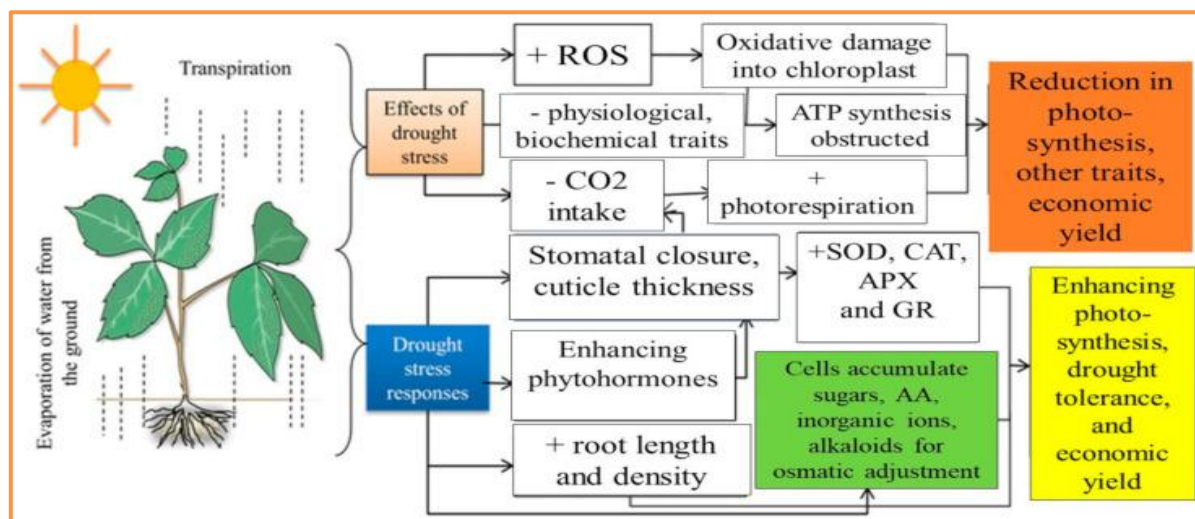
Drought can be defined as an extended period of deficient rainfall relative to the statistical mean for a region.

### Types of droughts:

- 1. Meteorological drought:** is defined as any significant deficit of precipitation.
- 2. Hydrological drought:** is defined as reduced river and stream flow and critically low groundwater tables.
- 3. 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. This results from a lack of input of moisture from rainfall or irrigation for an extended period. It is impossible to specify a period of time without rain as an agricultural drought, as the soil moisture deficit depends on rate of loss as well as rate of input. Furthermore, the severity of stress imposed on crops also depends on the susceptibility of different crops during different stages of their development. When soil moisture is lacking, crop establishment may be reduced, growth limited, normal development patterns disrupted and eventually, final yields lowered.

### Effects of drought stress on vegetable crops

Drought stress causes an increase of solute concentration in the soil environment, leading to an osmotic flow of water out of plant cells. This leads to an increase of the solute concentration in plant cells, thereby lowering the water potential and disrupting membranes and cell processes such as photosynthesis. The timing, intensity, and duration of drought spells determine the magnitude of the effect of drought. Soil moisture deficit at critical growth stages such as active growth, flowering and fruit enlargement greatly reduces vegetable production and product quality. Low fruit set in tomato and chili, splitting in tomato, cabbage, nitrate toxicity in root vegetables and watermelon, bitterness, and crooked fruits in cucumber, etc. are some important consequence of drought stresses. In vegetable crops, there are critical phases of plant growth when irrigation cannot be avoided; otherwise, higher yield loss and quality may be expected.



The critical period of water requirement and its impact on important vegetable crops have been summarized in the following table:

| Vegetable               | Critical Stage                   | Impact of water deficit  |
|-------------------------|----------------------------------|--|
| Tomato                  | Flowering and fruit enlargement  | Flower shedding, lack of fertilization, reduced fruit size, fruit splitting and development of calcium deficient disorder i.e. blossom end rot (BER) |
| Eggplant                | Flowering and fruit development  | Reduces yield with poor colour development in fruits   |
| Chilli and capsicum     | Flowering and fruit set          | Shedding of flowers and young fruits, reduction in dry matter production and nutrient uptake   |
| Cabbage and cauliflower | Head/curd formation, enlargement | Tip burning and splitting of head in cabbage; browning and buttoning in cauliflower  |
| Root crops              | Root enlargement                 | Distorted, rough and poor growth of roots, strong and pungent odour in carrot, accumulation of harmful nitrates in roots                             |
| Cucumber                | Flowering and fruit development  | Deformed and non-viable pollen grains, bitterness and deformity in fruits  |
| Okra                    | Flowering and pod development    | Considerable loss of yield and fiber development   |
| Melons                  | Flowering and fruit development  | Poor fruit quality in muskmelon due to decrease in TSS, reducing sugar and ascorbic acid, increase nitrate content in watermelon fruit               |
| Lettuce                 | Throughout development           | Toughness in leaves, tip burning   |
| Pea                     | Flowering and pod filling        | Reduction in root nodulation and plant growth, poor grain fill   |
| Potato                  | Tuberization and enlargement     | Poor tuber growth and yield, splitting   |
| Leafy vegetables        | Throughout development           | Toughness of leaves, poor foliage growth, accumulation of nitrates   |



## Mitigation of Drought stress

### 1. Selection of varieties

Selected drought-tolerant varieties of vegetable crops for planting in a drought-prone area.

| Sr. No. | Crop         | Varieties                   |
|---------|--------------|-----------------------------|
| 1       | Tomato       | Arka Vikas                  |
| 2       | Brinjal      | Bundelkhand Deshi           |
| 3       | Chilli       | Arka Lohit, IIHR - Sel.-132 |
| 4       | Onion        | Arka Kalyan, MST 42, MST 46 |
| 5       | Potato       | Kufri Sheetman              |
| 6       | Cassava      | TP White, Narukku-3         |
| 5       | Sweet potato | Sree Bhadra                 |

- 2. Improved method of seedling production:** At the nursery stage, coco peat, nylon net protection, and bio-fertilisers/bio-pesticide inoculation in Portray seedlings have a high probability of producing strong and consistent seedlings. However, with reduced root damage and a better chance of survival in water-stress conditions, these seedlings will be more successful when transplanted into the main field.
- 3. Adoption of soil and moisture conservation techniques:** Soil moisture conservation can be achieved through various agricultural practices, including cropping, mulching and zero tillage. For optimal soil and water conservation in arid locations, mechanical techniques such as graded bunding, contour bunding, vertical mulching, bench terracing, and so on must be employed. Another option for maximizing runoff utilization is water harvesting and recycling. For example, runoff water can be collected in dug-out ponds or tanks and earthen or masonry dams for rainwater collection. In areas with rainfall between 500 and 800 mm, rainwater harvesting is possible.
- 4. Mulching Practices in Vegetable Production:** Soil and water conservation can be achieved by using mulch, which can be made from organic agricultural waste or synthetic plastic sheets. Fruit and vegetable crops can be mulched using farm waste and other organic material. However, it has recently been popular to use plastic mulches because of their apparent advantages of effective moisture retention, weed control, and soil structure conservation.
- 5. Use of drip irrigation:** Drip irrigation in horticulture has proven superior to other conventional irrigation methods because of its precise and direct application of water in the root zone. The additional benefits of drip irrigation are significant water savings, weed control, labour savings, and increased growth, development, and yields of fruits and vegetables. Drip irrigation can be used in fruit crops and all vegetable crops, including those with small spacing, such as onions and beans. Water savings range from 30 to 50 per cent depending on crop and season.
- 6. Application of foliar nutrition:** Foliar application of nutrients during water stress situations promotes more significant development by absorbing nutrients more quickly. Drought resistance is induced in vegetable crops by K and Ca spraying. Crop yields and quality are improved by spraying micronutrients and secondary nutrients.
- 7. Uses of anti-transpirants:** Anti-transpirants are chemicals sprayed on plants to form a film which increases the diffusion resistance of water from stomata and thus reduces

transpiration losses of water. Several chemicals have been successfully used like acropyl in grapes, polycot in banana and kaolinite (3-8%) in different fruit plants.

8. **Use of osmoprotectants:** Osmoprotectants help in mediating osmotic adjustment and protect subcellular structures under stressed condition. Osmolytes like Proline, trehalose, fructan, mannitol, glycine betaine can be used against stress condition.
9. **Use of plant growth regulators:** ABA and Cycocel reduces shoot growth and increase root growth. Exogenous application of gibberellic acid increased the net photosynthetic rate, stomatal conductance and transpiration rate under drought stress. Exogenously applied uniconazole, brassinolide and abscisic acid increased yields both under well-watered and water deficit conditions. Plant growth regulator treatments significantly increased water potential, and improved chlorophyll content under water stress conditions.
10. **Use of PGPR's:** PGPRs can balance the levels of plant hormones by synthesizing and secreting phytohormones thus facilitating an increase in the total surface area and length of roots, number of root hairs, and the overall growth of the root system.