Limiting factors of plant production

Here are the main limiting factors of plant production, categorized for clarity:

1. Environmental/Abiotic Factors

1- Light: Intensity, duration (day length), and quality are crucial for photosynthesis.

Light acts as a primary environmental factor influencing plants through three main components:

1. Light Intensity (Brightness):

- Effect: Drives the rate of photosynthesis (light reactions). Low intensity limits sugar production and growth. However, excessively high intensity can cause photoinhibition, damaging the photosynthetic apparatus (especially Photosystem II) and leading to bleaching or sunscald.
- Plant Adaptation: Plants adapt through sun/shade leaves. Sun leaves are thicker with more palisade cells, while shade leaves are broader and thinner to capture more light.

2. Photoperiod (Day Length / Duration):

- Effect: Acts as an environmental signal regulating key developmental stages. It controls photoperiodism—the physiological response to day/night length.
- Key Processes:
    - Flowering: Classifies plants as long-day (e.g., spinach), short-day (e.g., poinsettia), or day-neutral (e.g., tomato).
    - Tuber/Bulb Formation: In crops like potatoes and onions.
    - Bud Dormancy: Signals deciduous trees to prepare for winter.
    - Seed Germination: For some species.

3. Light Quality (Spectral Composition/Wavelength):

- Effect: Different pigments absorb specific wavelengths.
  - Photosynthesis: Driven mainly by blue (430-450 nm) and red (640-680 nm) light, absorbed by chlorophyll.
  - Morphogenesis (Photomorphogenesis): Regulated by photoreceptors like phytochrome (sensitive to red/far-red light) and cryptochrome (sensitive to blue light).
- Key Processes Influenced:
  - Stem Elongation & Internode Length: Low Red: Far-Red ratios (e.g., under a canopy) trigger shade avoidance syndrome (elongated growth).
  - Seed Germination: Phytochrome determines light requirements.
  - Stomatal Opening: Triggered by blue light.
  - Phototropism: Growth toward light, mediated by auxin and phototropins (blue light receptors).

Summary: Light is not just an energy source. Its intensity governs photosynthetic capacity, its duration acts as a seasonal calendar for timing life cycles, and its quality shapes plant form and directs growth through complex signaling pathways.

2- Water: Both deficiency (drought stress) and excess (waterlogging) limit growth.

Water is the fundamental medium for plant life, and its availability (both deficiency and excess) critically regulates all aspects of growth, metabolism, and survival.

A. Water Deficiency (Drought Stress):

1. **Physiological & Metabolic Disruption:**
   - **Turgor Loss:** Cells lose rigidity, causing wilting of leaves and young stems.

- **Stomatal Closure:** To conserve water, stomata close, which simultaneously **limits CO_2 intake**, drastically reducing photosynthesis.
- **Reduced Enzyme Activity:** Disrupts metabolic pathways.
- **Accumulation of Abscisic Acid (ABA):** The primary stress hormone that triggers stomatal closure and stress-response genes.
- **Oxidative Stress:** Leads to the production of damaging reactive oxygen species (ROS).

2. **Growth & Developmental Effects:**
   - **Inhibited Cell Expansion:** Reduced turgor pressure limits cell growth, leading to **stunted overall growth**.
   - **Altered Resource Allocation:** Biomass is shifted preferentially to roots (to seek water) over shoots.
   - **Reduced Yield:** Impaired flower, fruit, and seed development.
   - **Premature Senescence & Leaf Abscission:** Shedding leaves to reduce water loss.
3. **Structural & Long-Term Adaptations:**
   - **Xeromorphic Features:** Thick cuticles, sunken stomata, reduced leaf area, succulence, and dense root systems.
   - **Osmotic Adjustment:** Accumulation of solutes (proline, sugars) to lower cell water potential and maintain water uptake.

B. Water Excess (Waterlogging / Flooding):

1. **Root Zone Hypoxia/Anoxia:****
   - The primary stress. Water fills soil pores, displacing oxygen. Roots cannot perform aerobic respiration.
2. **Immediate Metabolic Consequences:**

- **Energy Crisis:** Roots switch to inefficient anaerobic fermentation, producing only 2 ATP (vs. 36 in aerobic) and toxic byproducts like **ethanol and lactic acid**.
- **Ion Uptake Imbalance:** Disruption of root membrane function and energy-dependent ion pumps (e.g., for K^+, NO_3^-).

3. **Whole-Plant Symptoms & Damage:**
   - **Root Death:** Due to energy starvation and toxin accumulation.
   - **Shoot Wilting & Chlorosis (Yellowing):** Paradoxical wilting occurs because damaged/rotting roots cannot absorb water, even though soil is saturated. Chlorosis results from nutrient deficiency (especially nitrogen).
   - **Ethylene Accumulation:** Promotes leaf epinasty (downward curling), stem thickening, and root cell death.
4. **Plant Adaptations & Responses:**
   - **Aerenchyma Formation:** Development of air-filled channels in roots and stems to facilitate internal oxygen transport from shoots to roots (e.g., in rice, mangroves).
   - **Adventitious Roots:** Growth of roots above the waterline for better gas exchange.
   - **Hyponastic Growth:** Upward bending of leaves to escape water.

Summary: Water is the pivotal environmental factor. **Deficiency** imposes a hydraulic and metabolic crisis centered on carbon starvation and osmotic stress, while **excess** creates a respiratory crisis centered on root oxygen deprivation. Plants have evolved a range of anatomical, physiological, and biochemical adaptations to cope with both extremes.

3- Temperature: Each plant has optimal, minimum, and maximum temperature ranges for growth.

Temperature is a master regulator of plant physiology, influencing all biochemical and biophysical processes. Its effects are optimal within a species-specific range, with both low and high extremes causing stress.

A. Effects Within the Optimal Range:

1. **Metabolism & Growth:** Governs the rate of enzymatic reactions (Q_{10} effect). Warm temperatures within the optimum accelerate photosynthesis, respiration, and cell division, promoting growth.
2. **Development:** Influences phenology (timing of life cycle events like bud break, flowering, fruiting, and leaf senescence). Many plants require a period of cold (**vernalization**) to initiate flowering.

B. Low Temperature Stress (Chilling & Freezing):

1. **Chilling Stress (0-15°C for many tropical/subtropical plants):**
    - **Membrane Damage:** Reduced fluidity, leading to leaky membranes and ion imbalance.
    - **Metabolic Imbalance:** Slowed photosynthesis exceeds slowed growth, causing sugar accumulation and potential feedback inhibition.
    - **Chlorosis & Necrosis:** Due to impaired chlorophyll synthesis and function.
2. **Freezing Stress (Below 0°C):**
    - **Ice Crystal Formation:** The primary damage. Extracellular ice formation draws water out of cells, causing lethal **cellular dehydration and mechanical damage** to membranes and organelles.
    - **Solution Effects:** High solute concentration damages proteins.

Plant Adaptations to Cold:

- **Cold Acclimation:** Process involving accumulation of **compatible solutes** (proline, sugars) to lower freezing point and protect proteins (**cryoprotection**).

- **Membrane Remodeling:** Increasing unsaturated fatty acids to maintain fluidity.
- **Antifreeze Proteins:** Proteins that inhibit ice crystal growth.
- **Supercooling:** Avoiding ice formation by keeping water in a liquid state below 0°C.

C. High Temperature Stress (Heat Stress):

1. **Protein Denaturation & Aggregation:** Loss of function of critical enzymes and structural proteins.
2. **Membrane Damage:** Increased fluidity leading to loss of integrity and leakiness.
3. **Inhibition of Photosynthesis:** Damage to **Photosystem II (PSII)** and the electron transport chain is a primary lesion. Increased photorespiration reduces net carbon gain.
4. **Oxidative Stress:** Accelerated production of damaging **reactive oxygen species (ROS)**.

Plant Adaptations & Responses to Heat:

- **Synthesis of Heat Shock Proteins (HSPs):** Act as molecular chaperones to prevent protein aggregation and aid in refolding damaged proteins.
- **Transpirational Cooling:** Increased water evaporation from leaves.
- **Morphological Changes:** Smaller, thicker leaves, reflective surfaces (wax, trichomes), and leaf rolling or orientation to reduce heat load.
- **Antioxidant Systems:** Upregulation of enzymes (e.g., superoxide dismutase, catalase) to scavenge ROS.

Summary: Temperature dictates the speed of plant life processes. Low temperatures cause membrane and hydration crises, while high temperatures cause protein and metabolic dysfunction. Plants survive extremes through a suite of biochemical adjustments (osmoprotectants, HSPs), membrane modifications, and morphological adaptations.

4- Mineral Nutrients: Deficiency or toxicity of essential nutrients (e.g., Nitrogen, Phosphorus, Potassium, Iron).

5- Atmospheric Gases: CO_2 concentration (limits photosynthesis), and pollutants (e.g., ozone).

6- Soil Factors: Poor structure, salinity, acidity/alkalinity (pH), and toxicity (e.g., aluminum).

2. Biological/Biotic Factors

1- Competition: Weeds compete for light, water, and nutrients.

2- Pests: Insects, mites, nematodes, rodents, and birds that damage plants.

3- Diseases: Caused by pathogens like fungi, bacteria, viruses, and viroids.

4- Parasitic Plants: e.g., Striga (witchweed) and Orobanche (broomrape).

3. Management/Human-Induced Factors

1- Poor Agronomic Practices: Incorrect planting density, timing, or irrigation practices.

2- Inadequate Crop Rotation: Leads to nutrient depletion and pest/disease buildup.

3- Poor Seed Quality: Use of low-vigor, non-certified, or contaminated seeds.

4- Lack of Inputs: Insufficient application of fertilizers, pesticides, or water where needed.

5- Soil Degradation: Erosion, compaction, and loss of organic matter due to poor management.

Key Concept: Liebig's Law of the Minimum.

This principle states that plant growth is controlled not by the total resources available, but by the scarcest resource (the limiting factor). Even if all other factors are optimal, the single most deficient factor will determine the yield.

Cold affects plant production in several ways:

1-Slows Metabolism: Low temperatures reduce enzyme activity, which slows photosynthesis and respiration

Plant metabolism depends on **enzymes**, which are biological catalysts that control and speed up chemical reactions inside plant cells. These enzymes are highly sensitive to temperature.

When the temperature decreases:

1. **Enzyme Activity Declines**
   Enzymes work best within an optimal temperature range. In cold conditions, molecules move more slowly, so enzymes and substrates collide less frequently. This reduces the rate of biochemical reactions.

2. **Photosynthesis Slows Down**
   Photosynthesis involves many enzyme-controlled reactions (especially in the Calvin cycle). At low temperatures:
   - Energy conversion efficiency drops.
     As a result, the plant produces less glucose for growth and development.

3. **Respiration Decreases**
   Respiration is also controlled by enzymes. When it slows:
   - Energy (ATP) production decreases.
   - Cellular processes such as growth, repair, and nutrient transport are reduced.

4. **Overall Effect on Growth**

Because both photosynthesis (food production) and respiration (energy release) slow down, plant growth becomes weak and limited. Prolonged cold stress may even lead to dormancy or tissue damage.

In summary, low temperature reduces molecular movement, which decreases enzyme efficiency, leading to slower metabolic processes and reduced plant productivity.

1. **Reduces Photosynthesis**: Cold conditions limit chlorophyll function and carbon dioxide absorption, decreasing food production in plants.

Reduces Photosynthesis: Cold conditions limit chlorophyll function and carbon dioxide absorption, decreasing food production in plants

Photosynthesis is the process by which plants use light energy to produce glucose (food). Cold temperatures negatively affect several important steps in this process:

1. Effect on Chlorophyll Function

Chlorophyll is the green pigment responsible for absorbing light energy. In cold conditions:

- The efficiency of chlorophyll in capturing light energy decreases.
- The structure of chloroplast membranes can become less flexible.
- Energy transfer within the photosystems becomes slower.

As a result, light energy is not converted into chemical energy efficiently.

2. Slower Enzymatic Reactions (Calvin Cycle)

The second stage of photosynthesis (the Calvin cycle) depends on temperature-sensitive enzymes. In cold conditions:

- Carbon dioxide fixation slows down.
- The production of glucose decreases.
- The overall rate of photosynthesis declines.

Even if light is available, the plant cannot efficiently use it to produce sugars.

3. Reduced Carbon Dioxide Absorption

Cold temperatures often cause:

- Partial closure of stomata (tiny pores in leaves).
- Slower diffusion of carbon dioxide into leaf tissues.

With less CO_2 entering the leaf, the plant cannot produce enough glucose.

4. Overall Impact on Food Production

Since glucose is the main source of energy and building material for plants:

- Growth becomes slow.
- Biomass production decreases.
- Crop yield may be reduced in agricultural plants.

In summary, cold stress interferes with light absorption, enzyme activity, and carbon dioxide intake, leading to reduced photosynthesis and lower food production.

2. **Delays Germination**: Many seeds require warm conditions to germinate; cold soil slows or prevents germination.

Delays Germination: Many seeds require warm conditions to germinate; cold soil slows or prevents germination

Germination is the process by which a seed begins to grow into a new plant. This process requires specific environmental conditions, especially suitable temperature. Cold soil negatively affects germination in several ways:

1. Reduced Enzyme Activity

Germination depends on enzymes that break down stored food (such as starch) inside the seed into simple sugars.

- In cold conditions, enzyme activity slows down.
- Food reserves are not converted efficiently into usable energy.
- The embryo does not receive enough energy to grow.

2. Slow Water Absorption (Imbibition)

The first step in germination is water absorption.

- Cold temperatures slow water movement into the seed.
- Cell expansion and metabolic activation are delayed.

Without sufficient water uptake, germination cannot begin properly.

3. Delayed Cell Division and Growth

After activation, the embryo starts dividing and elongating.

- Low temperature slows cell division (mitosis).
- Root (radicle) emergence is delayed.
- Shoot growth above the soil becomes slow or weak.

4. Increased Risk of Seed Rot

When seeds remain too long in cold, wet soil:

- Fungal and bacterial infections may occur.
- Seeds may rot before germinating.

5. Possible Dormancy Maintenance

Some seeds remain in a dormant state under cold conditions and wait for warmer temperatures to begin growth.

Overall Effect

Cold soil reduces metabolic activity, slows energy production, delays embryo growth, and may completely prevent germination in sensitive plant species.

3. **Limits Nutrient Uptake**: Cold soil reduces root activity, decreasing the absorption of water and minerals.

Limits Nutrient Uptake: Cold soil reduces root activity, decreasing the absorption of water and minerals

Roots are responsible for absorbing water and essential mineral nutrients (such as nitrogen, phosphorus, and potassium) from the soil. Cold soil temperatures negatively affect this process in several important ways:

1. Reduced Root Metabolic Activity

Root cells depend on active metabolism to absorb minerals, especially through **active transport** (which requires energy in the form of ATP).

- Low temperature slows respiration in root cells.
- Less ATP is produced.
- Active transport of nutrients across cell membranes becomes inefficient.

As a result, mineral uptake decreases.

2. Slower Water Absorption

Water enters roots mainly through osmosis. In cold soil:

- Cell membrane permeability decreases.
- Water movement through root tissues slows down.
- Root pressure becomes weaker.

This reduces the amount of water transported to the stem and leaves.

3. Decreased Root Growth

Cold conditions slow cell division and elongation in root tips.

- Roots grow more slowly.
- The total root surface area becomes smaller.
- Fewer root hairs are formed.

With less surface area, the plant absorbs fewer nutrients and less water.

4. Reduced Nutrient Availability in Soil

Cold temperatures also affect the soil environment:

- Microbial activity decreases.
- Decomposition of organic matter slows.
- Nutrient release into the soil solution is reduced.

So even if nutrients are present in the soil, they may not be available in absorbable forms.

Overall Effect

Limited water and mineral absorption leads to:

- Nutrient deficiencies.
- Poor leaf development.
- Weak growth and lower crop productivity.

In severe cases, plants may show symptoms like yellowing leaves and stunted growth.

4. **Causes Frost Damage**: Ice crystals can form inside plant tissues, damaging cells and sometimes killing the plant.

Causes Frost Damage: Ice crystals can form inside plant tissues, damaging cells and sometimes killing the plant

Frost damage occurs when temperatures drop to or below 0°C (32°F), causing water inside or around plant cells to freeze. This can seriously harm plant tissues in several ways:

1. Ice Crystal Formation Inside Cells

Plant cells contain a large amount of water. When temperatures fall below freezing:

- Water inside the cells may turn into ice.
- Ice crystals expand as they form.
- The sharp crystals can puncture cell membranes and cell walls.

This mechanical damage destroys the structure of the cell, often leading to cell death.

2. Ice Formation Between Cells

Sometimes ice forms in the spaces between cells first.

- This draws water out of the cells.
- Cells lose water and become dehydrated.

- Severe dehydration causes shrinkage and metabolic disruption.

Even if the cell membrane is not physically broken, dehydration can kill the cell.

3. Membrane Damage

Freezing temperatures make cell membranes less flexible.

- Membranes may lose their selective permeability.
- When the plant thaws, damaged membranes leak vital substances.
- Cells cannot function properly after thawing.

4. Visible Symptoms of Frost Damage

After frost exposure, plants may show:

- Wilting or water-soaked appearance
- Blackened or brown leaves
- Soft, collapsed tissues
- Death of flowers or young fruits

Young tissues are usually more sensitive than mature tissues.

5. Severe Frost and Plant Death

If freezing affects vital tissues such as:

- The growing points (meristems)
- Vascular tissues (xylem and phloem)

The entire plant may die, especially in frost-sensitive species.

Overall Effect

Frost injury reduces plant growth, destroys reproductive organs, lowers crop yield, and in extreme cases, causes total plant loss.

5. **Shortens Growing Season: In cold regions, plants have less time to grow and reproduce.**

However, some plants are adapted to cold environments and can survive freezing temperatures through special physiological mechanisms.

Shortens Growing Season: Cold temperatures reduce the length of time plants can grow and complete their life cycle

The growing season is the period of the year when environmental conditions (especially temperature) are suitable for plant growth. In cold climates, this period becomes shorter due to low temperatures in early spring and late autumn**.**

1. Late Start in Spring

- Cold soil temperatures delay seed germination.
- Frost risk prevents early planting.
- Root and shoot development begin slowly.

As a result, plants start growing later than in warm regions.

2. Early End in Autumn

- Early frost can damage leaves, flowers, and fruits.
- Photosynthesis stops when temperatures drop too low.
- Many plants die or enter dormancy.

This means plants stop growing sooner.

3. Limited Time for Growth and Reproduction

Because the growing period is short:

- Plants have less time to produce leaves and stems.
- Flowering and fruit development may be incomplete.
- Seed formation may be reduced.

This directly reduces total biomass and crop yield.

4. Impact on Agricultural Production

In cold regions:

- Farmers must select fast-growing or cold-tolerant crops.
- Only one growing cycle per year may be possible.
- Crop variety choices are limited.

5. Ecological Effects

Short growing seasons affect:

- Plant diversity
- Food availability for animals
- Overall ecosystem productivity

Overall Effect

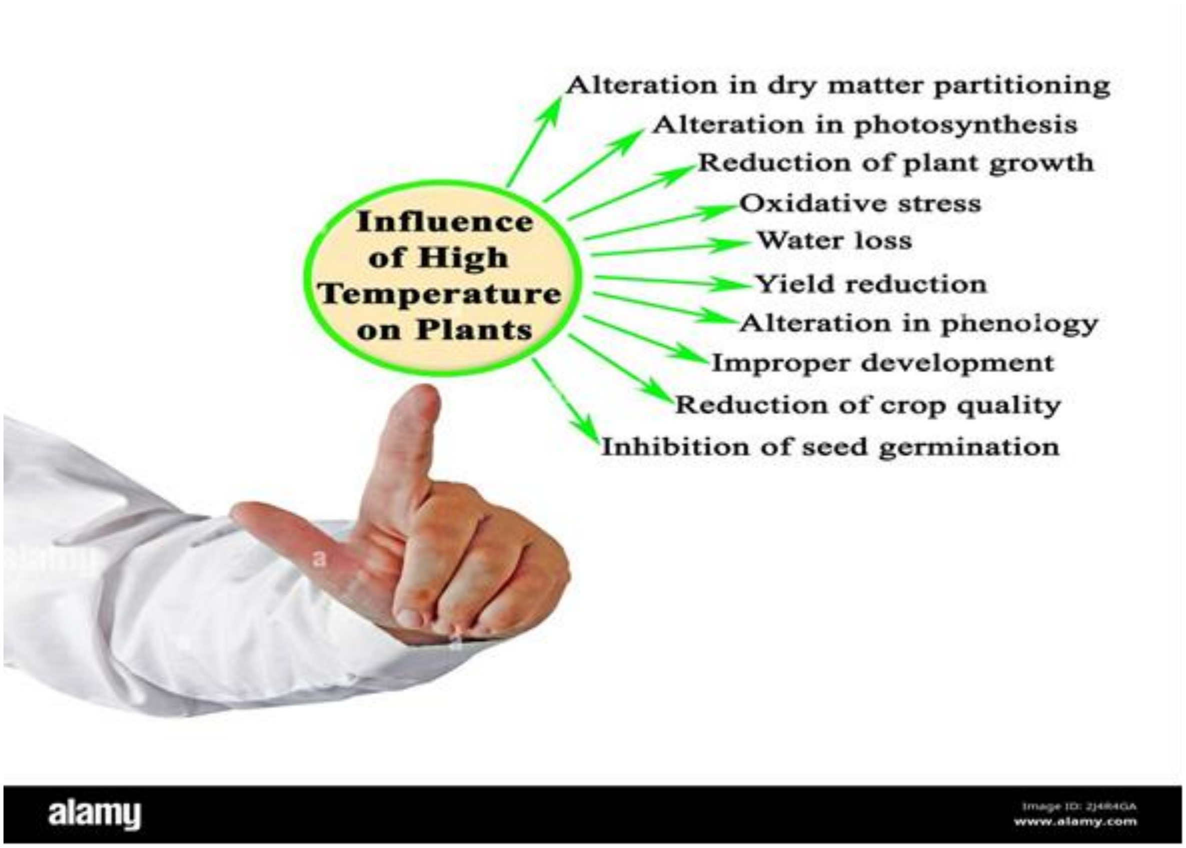
Cold climates shorten the active growth period of plants, limiting development, reproduction, and overall productivity.






Effect of High Temperature on Plant Production

High temperature is an important environmental factor that can significantly affect plant growth and productivity.



1. Increases Respiration Rate

When temperatures rise:

- Respiration increases rapidly.
- Plants consume more sugars for energy.
- Less energy remains for growth and fruit production.

If respiration becomes higher than photosynthesis, plant productivity decreases.

https://www.shutterstock.com/fr/search/heatwave-agriculture

https://www.shutterstock.com/fr/search/heatwave-agriculture

Plant responses to temperature:

https://youtu.be/ap2ypTYxPKQ?si=qxhwevqVY_lO6Qko

https://youtu.be/7VcAws0n7wE?si=KfVEJcUxJZjvMKn-

2. Reduces Photosynthesis

Very high temperatures:

- Damage chlorophyll.
- Reduce enzyme efficiency (especially Rubisco).
- Cause partial stomatal closure to reduce water loss.

This limits carbon dioxide intake and lowers food production.

How Very High Temperatures Reduce Photosynthesis

Photosynthesis is the process by which plants convert light energy into chemical energy (glucose). Very high temperatures can significantly reduce this process through several mechanisms:

1. Damage to Chlorophyll

- Chlorophyll is the pigment that captures light energy.
- Extreme heat can break down chlorophyll molecules.
- Less light energy is absorbed for photosynthesis.

This directly reduces the plant's ability to produce food.

2. Enzyme Inactivation

- Photosynthesis depends on enzymes, especially Rubisco, to fix carbon dioxide.
- High temperatures can denature these enzymes or reduce their efficiency.
- Carbon fixation slows down, and glucose production drops.

3. Stomatal Closure

- To conserve water under heat stress, plants may partially close stomata (leaf pores).
- Reduced stomatal opening limits CO_2 intake.
- Less carbon dioxide is available for the Calvin cycle.

4. Increased Photorespiration

- High temperatures increase the rate of photorespiration, a process that consumes energy and releases CO_2 instead of producing sugars.

- This lowers the net photosynthetic rate.

5. Overall Effect

- Reduced glucose production
- Less energy for growth, flowering, and fruiting
- Decreased crop yield in agricultural plants

In summary, very high temperatures damage pigments, enzymes, and leaf function, all of which reduce photosynthesis.

https://youtu.be/ap2ypTYxPKQ?si=qxhwevqVY_lO6Qko

4. Causes Heat Stress and Protein Damage

Extreme heat can:

- Denature enzymes and proteins.
- Disrupt cell membranes.
- Affect cell division and growth.

This may lead to reduced plant development or tissue death.

5. Affects Flowering and Fruit Set

High temperature during flowering can:

- Reduce pollen viability.
- Prevent fertilization.
- Cause flower drop.

How High Temperature Affects Flowering and Fruit Set

The flowering stage is one of the most sensitive stages in a plant's life cycle. Exposure to high temperatures during this period can seriously reduce crop productivity.

1. Reduces Pollen Viability

Pollen grains must be healthy and viable to fertilize the ovule. Under high temperatures:

- Pollen development inside the anther becomes abnormal.
- Pollen grains lose moisture rapidly.

- Protein and enzyme systems inside pollen are damaged.

As a result, pollen viability decreases, meaning fewer pollen grains can successfully germinate.

2. Inhibits Pollen Germination and Tube Growth

Even if pollen lands on the stigma:

- High temperature may prevent pollen germination.
- Growth of the pollen tube through the style becomes slow or abnormal.
- The male gamete may fail to reach the ovule.

This directly prevents fertilization.

3. Prevents Fertilization

Successful fertilization requires proper timing and favorable temperature. Heat stress can:

- Damage ovules (female reproductive parts).
- Disturb hormonal balance.
- Shorten the receptive period of the stigma.

If fertilization does not occur, fruit will not develop.

4. Causes Flower Drop (Abscission)

High temperature can disturb plant hormone balance, especially auxins and ethylene.

- Increased ethylene production promotes flower drop.
- Flowers may fall before fertilization.
- Even small fruits may abort.

This significantly reduces fruit number.

5. Reduces Fruit Set and Yield

Because of poor pollination and fertilization:

- Fewer fruits are formed.
- Fruit size may be smaller.
- Overall crop yield decreases.

Overall Effect

High temperature during flowering reduces pollen quality, disrupts fertilization, increases flower abortion, and ultimately lowers fruit production and yield.

This leads to lower fruit production and yield loss.

6. Shortens Growth Period

In some cases, high temperature accelerates plant life cycles:

- Plants mature faster.
- Vegetative growth period becomes shorter.
- Final biomass decreases.

Overall Effect

Moderate warmth may enhance growth, but excessive heat reduces photosynthesis, increases water stress, damages cells, and ultimately lowers crop productivity.

1. Increases Respiration Rate

How High Temperature Increases Respiration Rate

Respiration is the process by which plants break down glucose to produce energy in the form of ATP. This process is controlled by enzymes and is highly affected by temperature.

1. Faster Enzyme Activity

As temperature rises (within a certain range):

- Enzymes involved in respiration become more active.
- Chemical reactions occur more quickly.
- The rate of glucose breakdown increases.

This means the plant uses stored sugars at a faster rate.

2. Higher Energy Consumption

When respiration increases:

- The plant consumes more carbohydrates.

- More energy is used for maintenance instead of growth.
- Less sugar remains for building new tissues, flowers, and fruits.

If respiration becomes too high, it can reduce plant productivity.

3. Imbalance Between Photosynthesis and Respiration

Normally, plants produce glucose through photosynthesis and use some of it in respiration.
However, under high temperature:

- Respiration may increase more rapidly than photosynthesis.
- The plant may burn more sugars than it produces.
- Growth slows down because energy reserves decrease.

4. Extreme Heat Effects

At very high temperatures:

- Respiration may become excessively high.
- Stored food reserves become depleted.
- Plant growth weakens and yield decreases.

In severe cases, prolonged heat can cause serious stress and reduce crop production.

Overall Effect

High temperature accelerates respiration, increases sugar consumption, reduces energy available for growth, and may lower overall plant productivity.

Photoperiodism II Role of Phytochromes in Flowering II Red Light and Far-red light effect

https://youtu.be/vcH0vouVDmc?si=EPaPyq7tIUqYIHz8

What is Photoperiodism?

Photoperiodism is the ability of plants to measure the **length of day and night** to decide **when to flower**.

Plants detect light using special pigments called **Phytochrome**.

🌿 What are Phytochromes?

Phytochromes are **light-sensing proteins in plants** that detect two types of light:

- **Red light (R)** → about **660 nm**
- **Far-red light (FR)** → about **730 nm**

Phytochromes exist in **two interchangeable forms**:

Form	Activated by	Function
Pr	Red light	Converts to Pfr
Pfr	Far-red light	Converts back to Pr

- **Pr** → inactive form
- **Pfr** → **biologically active form** that controls plant responses like flowering.

🌿 Red Light Effect

When a plant receives **red light**:

Pr → Pfr

The **Pfr form** becomes dominant and can:

- trigger **flowering in long-day plants**
- inhibit flowering in **short-day plants**
- affect other processes like **seed germination and stem growth**

🌿 Far-Red Light Effect

When the plant receives **far-red light**:

Pfr → Pr

This **reverses the effect of red light**.

So if a plant receives:

- **Red light → flowering signal**
- **Far-red light after red → flowering signal is cancelled**

This is called the **photoreversible reaction**.

🌿 Night Interruption Experiment

Scientists discovered that plants measure **night length**, not day length.

Example:

- Long **night** → **short-day plants flower**
- If a **short red light flash** occurs during the night → night is "broken" → flowering may stop.

But if **far-red light is given after the red light**, the effect of red light disappears.

2-The effect of soil on plant production means **how soil properties influence the growth, development, and yield of plants**.

Soil affects plant production through several important factors:

1️⃣ Soil Nutrients
Soil supplies essential nutrients such as **nitrogen, phosphorus, and potassium**, which plants need for growth.

2️⃣ Soil Texture
The proportion of **sand, silt, and clay** affects:

- water retention
- aeration
- root growth.

3️⃣ Soil Structure
Good soil structure allows **roots to penetrate easily**, improving plant growth.

4️⃣ Soil pH
Soil acidity or alkalinity influences **nutrient availability** for plants.

5️⃣ Water Holding Capacity
Soil must retain enough water for plants but also allow **drainage**.

6️⃣ Soil Organic Matter
Organic matter improves **soil fertility, structure, and microbial activity**.

✅ **Conclusion:**
Healthy soil with balanced nutrients, good structure, and proper moisture greatly **improves plant production and crop yield**.

Effect of humidity on plant production

Humidity refers to the **amount of water vapor present in the air**. It plays an important role in **plant growth and plant production**.

Main effects of humidity on plants:

1️⃣Transpiration Rate
Humidity strongly affects **transpiration** (loss of water from plant leaves).

- **Low humidity** → transpiration increases → plants lose more water.
- **High humidity** → transpiration decreases → plants lose less water.

2️⃣Water Balance in Plants
Proper humidity helps plants maintain a **good water balance** between water absorption by roots and water loss through leaves.

3️⃣Photosynthesis
Moderate humidity keeps the **stomata** open, allowing plants to absorb **carbon dioxide**, which improves photosynthesis.

4️⃣Plant Growth
Suitable humidity promotes:

- better **leaf development**
- healthy **stem growth**
- improved **crop yield**

5️⃣Disease Development
Very high humidity can encourage **fungal and bacterial diseases**, which may reduce plant production.

✅ **Conclusion:**
Balanced humidity is important for **healthy plant growth and high crop production**, while very low or very high humidity can negatively affect plants.