DISCIPLINE SPECIFIC COURSE (DSC)
SEMESTER - V
PAPER - IV

BOT-MJ- 354 PLANT PHYSIOLOGY AND BIOCHEMISTRY

(Credits: 2, Lectures: 30)

Unit 2: Physiology of flowering (06 Lectures)

2.1. Photoperiodism:
a) Introduction, Definition
b) Classification of plants: SDP, LDP, DNP
c) Photoperiodic induction
d) Phytochrome and role of phytochrome in flowering

2.2. Vernalization:
a) Introduction and Definition
b) Mechanism of vernalization, hypothesis of phasic development and hypothesis of hormonal involvement
c) Devernalization

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1. Introduction

- Flowering is an important stage in the life cycle of plants.
- Flowering is influenced by environmental factors such as:
    - Light
    - Temperature
    - Water
    - Nutrition
- **Photoperiodism** is one of the major environmental factors controlling flowering.
- It was first studied systematically by **W. W. Garner and H. A. Allard (1920)**.
- They observed that flowering in some plants was controlled by the relative duration of light and darkness.

2. Definition

- **Photoperiodism:** The physiological response of plants to the relative lengths of **light and dark periods**, especially in relation to flowering.
- The **duration of uninterrupted darkness (night length)** is often more important than day length.

3. Critical Photoperiod

- **Critical photoperiod** = the specific day length that determines whether a photoperiodic plant will flower.
- SDP flower when day length is **below** the critical value.

- LDP flower when day length is **above** the critical value.

4. Classification of Plants
A. Short-Day Plants (SDP)

- Also called **long-night plants**.
- Flower when day length is shorter than the critical photoperiod.
- Require a **long, uninterrupted night**.
- A short interruption of the night with light may inhibit flowering.

Examples:

- Tobacco
- Soybean
- Rice
- Chrysanthemum
- Xanthium

B. Long-Day Plants (LDP)

- Also called **short-night plants**.
- Flower when day length is longer than the critical photoperiod.
- Require a **short uninterrupted night**.
- Night interruption with light may promote flowering.

Examples:

- Wheat
- Barley
- Spinach
- Radish
- Hyoscyamus

C. Day-Neutral Plants (DNP)

- Flowering is not significantly controlled by photoperiod.
- They can flower under a wide range of day lengths if other conditions are suitable.

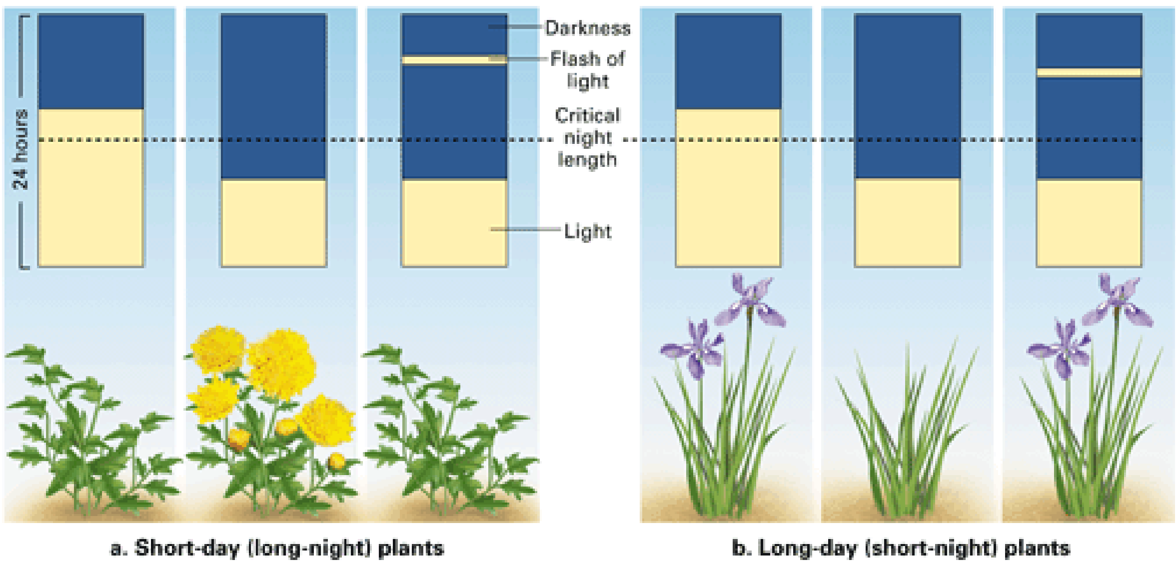
Examples:

- Tomato
- Cotton
- Sunflower
- Cucumber

5. Important Point

- **SDP → long night**
- **LDP → short night**
- **DNP → photoperiod has little/no major effect**

Fig-Classification of plants: SDP, LDP, DNP



Lecture 2: Photoperiodic Induction

1. Definition

- **Photoperiodic induction** is the process by which exposure to one or more appropriate photoperiodic cycles induces a plant to flower.

2. Important Features

- The **leaves are the major organs that perceive photoperiod**.
- The shoot apex is the site where the transition to flowering occurs.
- The leaf perceives the appropriate light/dark period.
- A flowering stimulus is produced in the leaf.
- This stimulus is transported to the shoot apical meristem.
- The shoot apex changes from:
  - **Vegetative state → Reproductive state**

3. Sequence of Photoperiodic Induction

Light/dark period → Photoreceptor in leaf → Flowering signal → Transport through phloem → Shoot apex → Flowering

4. Florigen

- The hypothetical flowering stimulus was traditionally called **florigen**.

- Modern studies associate flowering signalling with **FT protein and related signals** in many plants.
- FT is produced in leaves under appropriate conditions.
- It can move through the phloem to the shoot apex.
- At the apex, it participates in activation of flowering genes.

5. Number of Inductive Cycles

- Some plants require only **one or a few inductive cycles**.
- Others require many cycles.
- Once sufficiently induced, flowering may continue even after the plant is returned to non-inductive conditions.

6. Night-Break Experiment

- A short exposure to light during the dark period is called a **night break**.
- In SDP:
  - Long uninterrupted night → flowering
  - Light interruption → flowering may be inhibited
- In LDP:
  - Light interruption during a long night → flowering may be promoted.

7. Importance

- Helps plants flower at the appropriate season.
- Synchronizes flowering with environmental conditions.
- Useful in crop production and horticulture.

Lecture 3: Phytochrome and Its Role in Flowering

1. Phytochrome

- **Phytochrome** is a light-sensitive pigment/protein.
- It plays an important role in:
  - Photomorphogenesis
  - Seed germination
  - Shade responses
  - Photoperiodic flowering
  - Biological clock-related responses

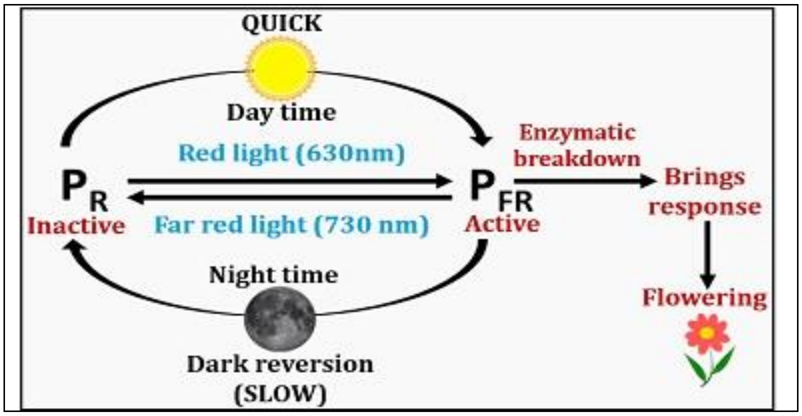
2. Forms of Phytochrome

Phytochrome exists mainly in two forms:

Form	Absorbs	Conversion
Pr	Red light (~660 nm)	Pr → Pfr
Pfr	Far-red light (~730 nm)	Pfr → Pr

3. Conversion
Pr + Red light → Pfr
Pfr + Far-red light → Pr

- The two forms are photointerconvertible.
- Pfr is generally considered the physiologically active form in many phytochrome responses.



4. Role of Phytochrome in Flowering
A. Detection of Light

- Phytochrome detects the quality and duration of light.
- It helps plants distinguish between different light/dark conditions.

B. Measurement of Night Length

- Phytochrome participates in the plant's response to the duration of darkness.
- This is particularly important in photoperiodic plants.

C. Night Break

- A red-light flash during the night converts **Pr → Pfr**.
- In many SDP, this can inhibit flowering.
- In many LDP, it can promote flowering.

D. Red/Far-red Reversibility

- A red-light response can often be reversed by far-red light.
- This demonstrates the involvement of phytochrome.

5. Summary
Red light → Pr → Pfr → flowering response
Far-red light → Pfr → Pr → modification/reversal of response
6. Important Exam Point

- **Phytochrome acts as a photoreceptor involved in sensing light conditions and regulating flowering responses.**

Lecture 4: Vernalisation — Introduction, Definition & Mechanism

1. Introduction

- Some plants require exposure to **low temperature** before they can flower.
- This phenomenon is called **vernalisation**.
- It is particularly important in:
    - Winter annuals
    - Biennial plants
    - Winter cereals

2. Definition

Vernalisation: The acquisition or acceleration of the ability to flower by exposure of a plant or its growing tissues to **low temperature for a specific period**.

- The term was introduced by **T. D. Lysenko**.

3. Examples

- Winter wheat
- Winter rye
- Barley
- Cabbage
- Sugar beet
- Some biennial plants

4. Temperature

- Effective temperature varies with species.
- Generally, temperatures around **0–10°C** are effective for many plants.

5. Sites of Vernalisation

- Mainly the **actively growing shoot apical meristem**.
- In some plants, seeds or embryos can also be vernalised.

6. Mechanism of Vernalisation

General sequence:
Low temperature → Temperature perception → Biochemical/genetic changes → Flowering competence → Flowering

7. Molecular Mechanism — Basic Idea

- Vernalisation causes stable changes in gene expression.
- In *Arabidopsis*, cold exposure suppresses the flowering-repressor gene **FLC**.
- Suppression of FLC allows flowering-promoting pathways to become active.
- Epigenetic modifications help maintain the vernalised state.

8. Factors Affecting Vernalisation

- Temperature
- Duration of cold treatment
- Age of plant
- Genotype
- Nutritional condition
- Water availability
- Oxygen supply

Lecture 5: Hypotheses of Vernalisation

A. Hypothesis of Phasic Development
1. Basic Concept

- Proposed mainly in relation to the work of **L. P. Chailakhyan**.
- Plant development occurs through a sequence of **physiological phases**.
- A plant must pass through specific phases before flowering.

2. Major Developmental Phases
Embryonic phase → Juvenile phase → Vernalisation phase → Photoperiodic phase → Reproductive phase
3. Vernalisation Phase

- During this phase, exposure to low temperature is required.
- Cold treatment enables the plant to pass into the next developmental phase.
- After completing the required phases, the plant becomes capable of flowering.

4. Importance

- Explains why plants must reach a particular developmental stage before flowering.
- Explains the role of temperature in the transition to reproductive development.

B. Hypothesis of Hormonal Involvement
1. Basic Concept

- According to the classical hormonal hypothesis, low temperature promotes the formation of a flowering-promoting substance.
- This hypothetical substance was called **vernalin**.

2. Proposed Sequence
Low temperature → Vernalin formation → Transport/action at shoot apex → Flower initiation
3. Vernalin

- Considered a hypothetical flowering-promoting substance.
- It was proposed to explain how cold treatment leads to flowering.
- A specific hormone called vernalin has **not been conclusively identified**.

4. Modern View

- Vernalisation is now understood as a complex process involving:
  - Gene regulation
  - Epigenetic changes
  - Flowering pathways
  - Hormonal interactions
- Gibberellins and other plant hormones can participate in flowering responses in some species.

5. Difference Between the Two Hypotheses

Phasic development hypothesis	Hormonal hypothesis
Plant passes through developmental phases	Cold promotes flowering signal/substance
Emphasizes developmental sequence	Emphasizes physiological/hormonal signal
Vernalisation is one developmental phase	Classical concept involves hypothetical **vernalin**

Lecture 6: Devernalisation + Quick Revision

1. Definition
Devernalisation is the **reversal or loss of the vernalisation effect** due to exposure to relatively high temperatures after cold treatment.
2. Process
Vernalisation → Low temperature → Flowering competence
↓
High temperature → Devernalisation → Reduced/reversed flowering response
3. Characteristics

- High temperature can reverse the effect of previous cold treatment.
- It is more effective when applied soon after vernalisation.
- The response depends on:
  - Plant species
  - Temperature
  - Duration of treatment
  - Developmental stage

- The vernalisation effect becomes more stable as development proceeds.

4. Importance

- Demonstrates that the vernalisation response can be reversible under certain conditions.
- Helps explain the importance of temperature immediately following cold treatment.

☆ **One-Page Revision**
Photoperiodism
Definition: Response of plants to relative duration of light and darkness.
Types:

- **SDP:** Short day + long uninterrupted night → Tobacco, soybean, rice
- **LDP:** Long day + short night → Wheat, spinach, radish
- **DNP:** Not significantly affected by photoperiod → Tomato, cotton

Photoperiodic induction
Leaf perceives photoperiod → flowering signal → transport to shoot apex → flowering
Phytochrome

- **Pr** → absorbs red light
- **Pfr** → absorbs far-red light
- Red: **Pr → Pfr**
- Far-red: **Pfr → Pr**
- Involved in photoperiodic flowering and night-break responses.

Vernalisation
Definition: Promotion/induction of flowering by low-temperature treatment.
Examples: Winter wheat, winter rye, cabbage, sugar beet.
Hypotheses

- **Phasic development:** flowering occurs after completion of sequential developmental phases.
- **Hormonal hypothesis:** classical theory proposed a flowering-promoting substance called **vernalin**.

Devernalisation
High temperature after vernalisation → reversal/reduction of vernalisation effect