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NAAC ACCREDITED 'A' GRADE



Topic: PHOTOPERIODISM
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Phytochrome

Introduction:

Borthwick and Hendricks first showed that flowering in response to photoperiod was strongly influenced by the color of light. It has already been seen that a brief exposure with red light(620-660nm) during a critical dark period inhibits flowering in short-day plants and this inhibitory effect can be reversed by a subsequent exposure with far-red light(730nm). They by studying the action spectrum of different pigments ultimately isolated the pigment responsible for this red far-red interconversion and called this pigment phytochrome.

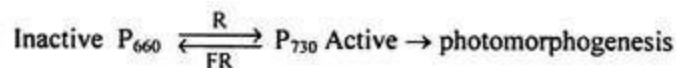
Similarly, the prolongation of the critical light period or the interruption of the dark period stimulates flowering in long-day plants. The stimulation of flowering in long-day plants also involves the operation of phytochrome.

Different forms of phytochrome:

Phytochrome, the **photoreceptor is a blue green pigment** existing in two different interconvertible forms:

- (i) Red light absorbing form which is designated as **Pr or P660**.
- (ii) Far-red light absorbing form which is designated as **Pfr or P730**.

- ii. These two forms of the pigment are photo chemically inter convertible.
- iii. When the Pr form of the pigment absorbs red light (660-665nm), it is converted into Pfr form.
- iv. When Pfr form of the pigment absorbs far-red light (730-735nm), it is converted into Pr form.
- v. The Pfr form of the pigment gradually changes into a Pr form in dark.



Apart from absorbing red and far-red light, the phytochrome also absorbs blue light. The Pr form of phytochrome is blue while Pfr form is olive-green in colour. But owing to very low conc. of phytochrome, the colour of this pigment is not visible in plant tissues. (Phytochrome accounts for less than 0.2 % of the total extractable protein in etiolated seedlings).

The role of red and far-red light on the initiation of flowering in the LD and SD plants :

It is considered that during the day (as normal sunlight contains more red light than far-red light) the Pfr form of the pigments is accumulated in the plant which is inhibitory to flowering in short-day plants (SD) but is stimulatory in long-day plants (LDP). At the onset of a dark period the Pfr is converted to Pr form which is stimulatory to flowering in SD plants and

inhibitory to flowering in LD plants. The interruption of the dark period with red light will return the accumulated Pr form to Pfr form, thus inhibiting flowering in SD plants. If the red light break is followed by a far-red break the red light influence is reversed, since Pfr is converted to pr form, and flowering occurs .

The effect of phytochrome on the flowering of SD plants may be explained as follows:

- At the end of a light period Pfr is in high concentration and Pfr and Pr ratio is such that it prevents formation of flowering stimulus.
- If the dark period is prolonged, then either Pfr is destroyed or it is reverted to Pr state.
- At this stage the ratio of Pfr to Pr is such which triggers processes leading to formation of flowering stimulus.
- Under the situation where the dark period is briefly interrupted by red light, there is formation of Pfr from Pr and the ratio of two is altered and therefore formation of flowering stimulus is prevented.

In the LD plant the role of Phytochrome can be explained as follows:

- Long day plants need a high ratio of Pfr to Pr to trigger flowering stimulus. This ratio is attained at the end of a long day.
- Once the night is long then Pfr is reversed back to Pr and the formation of flowering stimulus is prevented.

- Under the conditions where night is interrupted by a red light, there Pr is changed to Pfr.
- Here the ratio of the two pigments is high and a flowering stimulus is produced.
- These explanations, however, fail to provide an explanation for the initiation of flowering stimulus as mediated by phytochrome.

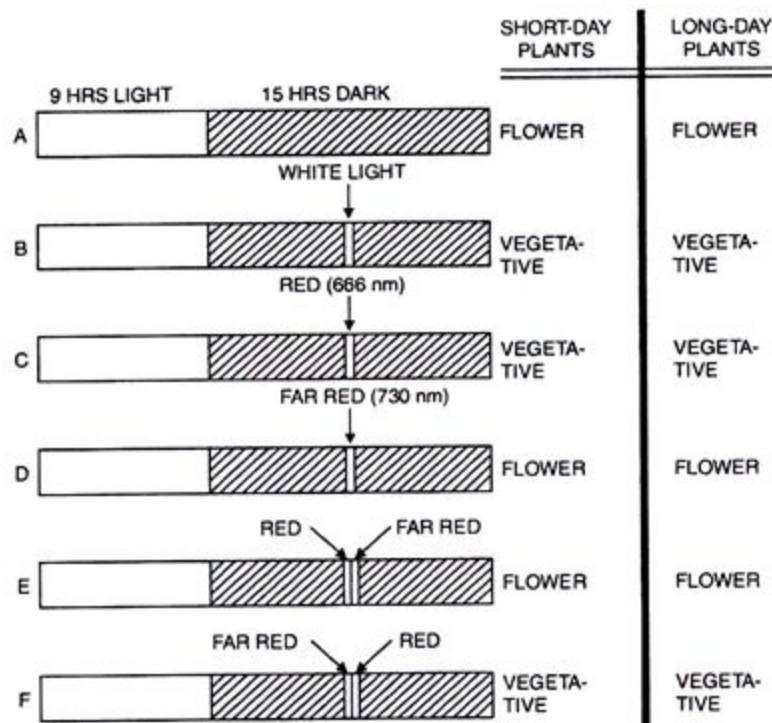


Fig. 22-6. The effect of red and far-red light during the night break on the flowering of LD and SD plants. The light is obtained either from sunlight or high-intensity radiation. Observe contrasting effects of two spectral qualities of light on SD and LD plants.

Chemical nature of phytochrome:

Successful purification of intact native phytochrome (from etiolated oat seedlings) was first reported by Vierstra and Quail in 1983.

- The native phytochrome is a **soluble chromoprotein with a molecular weight of about 250 kDa**.
- It's a homodimer of two identical polypeptides each with a molecular weight of about 125 kDa.
- Each polypeptide has a prosthetic group called **chromophore** (a light absorbing pigment molecule) which is covalently linked to the polypeptide via a sulphur atom (**Thioether Linkage**) in the cysteine residue of the polypeptide.
- The protein part of the phytochrome is called **apoprotein**.
- Apoprotein along with chromophore constitute holoprotein.
- The chromophore of phytochrome is an open tetrapyrrole which is related to phycocyanobilin in structure and therefore, more recently this chromophore has been called as phytochromobilin.
- The structures of chromophores or the prosthetic groups of Pr and Pfr forms of phytochrome which are cis and trans isomers of each other respectively, are given in Fig 18.5. The cis-trans isomerization occurs at carbon-15 in response to red and far-red light.

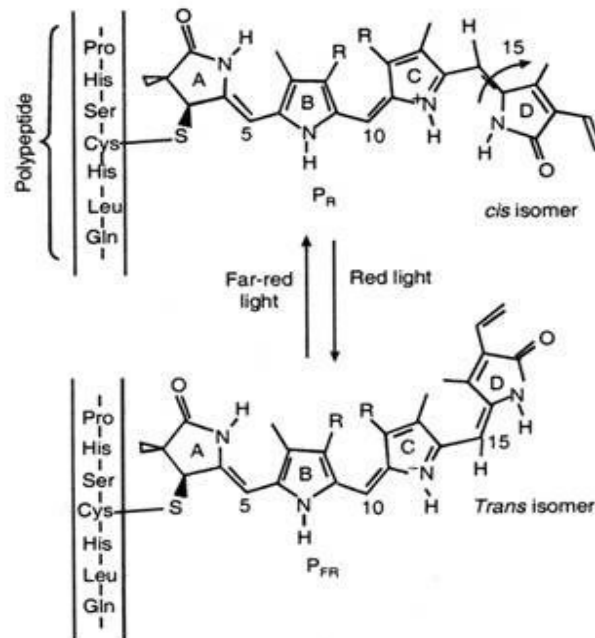


Fig. 18.5. Structures of the chromophores of P_R and P_{FR} forms of phytochrome covalently linked to the peptide region through a sulphur atom in the cysteine residue of the polypeptide.

None of the two components of phytochrome i.e., apoprotein and chromophore, can absorb light alone.

Occurrence and distribution:

1. Phytochromes have been detected in a wide range of plants in angiosperms, gymnosperms, bryophytes and algae.
2. Dark grown etiolated seedlings are richest sources of phytochrome where this pigment is especially concentrated in apical meristems. (Etiolated seedlings have therefore been used extensively in this connection).
3. Phytochromes have directly been detected in different parts of seedlings, in roots, cotyledons, hypocotyls, epicotyls, coleoptile,

stems, petioles, leaf blades, vegetative buds, floral receptacles, inflorescences, developing fruits and seeds. Presence of phytochrome has also been shown indirectly in other plant materials.

4. Within the cells, phytochrome exists in the nucleus and throughout the cytosol.

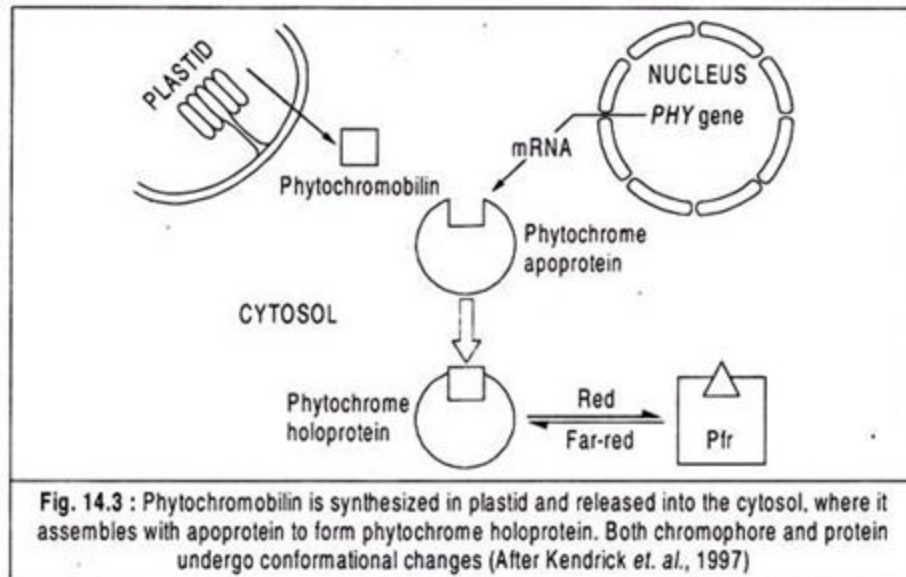
Synthesis:

The **chromophore** of phytochrome is **synthesized in plastids** while **apoprotein is synthesized on the nuclear genome**. **Assembly of these two components** of phytochrome is autocatalytic and **occurs in cytosol**.

It is **derived from 5-aminolevulinic acid** via a pathway that branches from the chlorophyll biosynthetic pathway. After synthesis phytochromobilin leaks out from the plastid into the cytosol where it assembles with phytochrome- apoprotein.

There are two major types of phytochromes in plants, (i) type I and (ii) type II. The type I predominates in etiolated seedlings while type II in green plants and seeds (such as oat seeds). There are minor differences in molecular weight and spectral properties of these two types of phytochromes. Phytochrome is actually encoded by the **multigene family**.

Type I phytochrome is encoded by PHY A gene while type II is encoded by PHY B, PHY C, PHY D and PHY E genes.



Functions:

The exact mechanism of the action of phytochromes is not very clear. They act probably:-

- (a) by controlling active transport of ions and molecules across membranes probably by regulating ATPase activity,
- (b) by controlling the activity of membrane bound hormones such as gibberellins
- (c) modulating the activity of membrane bound proteins and
- (d) by regulating transcription of numerous genes involving multiple signal transduction pathways.