Dr. Rachana Shalini

Deptt. of Botany

Course: **Deg.-II (Subs.)**

Topic: **Photoperiodism (continued)**

Lecture no.-31

Date: **11/05/2020**

Photoperiodism: Phytochrome

Phytochrome:

It has already been seen that a brief exposure with red light during critical dark period inhibits flowering in short-day plants and this inhibitory effect can be reversed by a subsequent exposure with far-red light. Similarly, the prolongation of the critical light period or the interruption of the dark period stimulates flowering in long-day plants. This inhibition of flowering in short-day plants and the stimulation of flowering in long-day plants involve the operation of a proteinaceous pigment called as phytochrome.

i. The pigment phytochrome exists in two different forms:

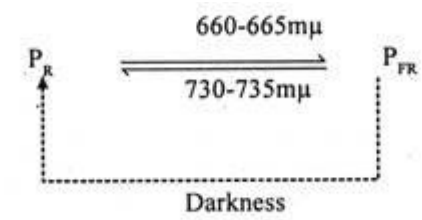
- Red light absorbing from which is designated as P_R and
- Far-red light absorbing form which is designated as P_{FR}.

ii. These two forms of the pigment are photo chemically inter convertible.

iii. When P_R form of the pigment absorbs red light (660-665mp), it is converted into P_{FR} form.

iv. When P_{FR} form of the pigment absorbs far-red light (730-735mp), it is converted into P_R form.

v. The P_{FR} form of the pigment gradually changes into P_R form in dark.



It is considered that during the day the P_{FR} form of the pigments is accumulated in the plant which is inhibitory to flowering in short-day plants but is stimulatory in long–day plants. During critical dark period in short-day plants, this form gradually changes into P_R form resulting in flowering.

A brief exposure with red light will convert this form again into P_R form thus inhibiting flowering. Reversal of the inhibitory effect of red light during critical dark period in SDP by subsequent far-red light exposure is because the P_{FR} form after absorbing far-red light (730-735mμ) will again be converted back into P_R form.

Prolongation of the critical light period or the interruption of the dark period by red-light in long-day plants will result in further accumulation of the P_{PR} form of the pigment, thus stimulating flowering in long-day plants.

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 protein 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 as chromophore 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 as 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 P_R and P_{FR} fomis 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.

Apart from absorbing red and far-red light, the phytochrome also absorbs blue light. The P_R form of phytochrome is blue while P_{FR} 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).

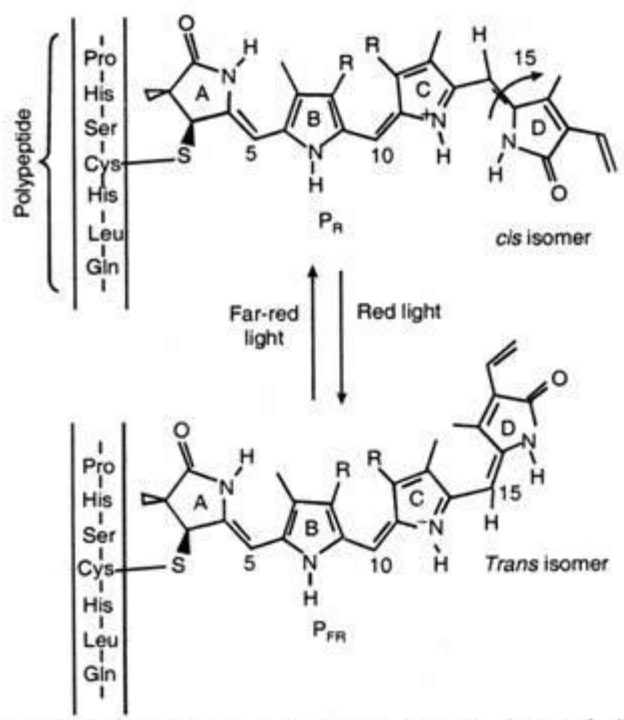


Fig. 18.5. Structures of the chromophores of P_R and P_{FR} forms of phytochrome covalently linked to the peptide region through a sulphur atom in the cysteine residue of the polypeptide.

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

Phytochromes have been detected in wide range of plants in angiosperms, gymnosperms, bryophytes and algae. 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).

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.

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

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

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.

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.

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.

Gibberellins and the Flowering Response:

It is now well known that the gibberellins can induce flowering in long-day plants even under non-inductive short days. It is also definite that the gibberellins alone do not constitute the 'florigen', but it is usually held that the gibberellins are in some way connected with the overall process of flowering.

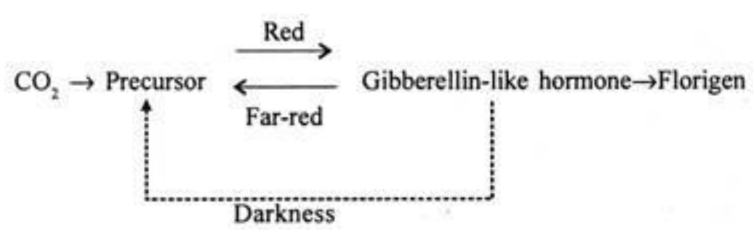
According to a scheme proposed by Brian (1958), a gibberellin like hormone is produced in the leaves during the photoperiod somewhat as follows:

CO_2 → Precursor (P) → Gibberellin-like hormone

The precursor may be slightly stimulatory or inactive or antagonistic to the gibberellin-like hormone. Red irradiations promote the conversion of the precursor to the gibberellin-like hormone. In the dark there is a slow reconversion of the gibberellin-like hormone to the precursor.

This reconversion is accelerated by far-red irradiations. It is further presumed that high concentration of the gibberellin-like hormone leads to the synthesis of florigen in long-day plants. In short-day plants the synthesis of florigen takes place when the level of gibberellin-like hormone is low. But, flowering eventually follows once the florigen synthesis has taken place in both the cases.

The whole scheme is diagrammatically shown below:



Importance of Photoperiodism:

(i) The knowledge of the phenomenon of photoperiodism has been of great practical importance in hybridisation experiments.

(ii) Although the floral hormone ‘florigen’ has not yet been isolated, the isolation and characterization of this hormone will be of utmost economic importance.

(iii) The phenomenon of photoperiodism is an excellent example of physiological preconditioning (or after-effect) where an external factor (i.e., the photoperiodic stimulus) induces some physiological changes in the plant the effect of which is not immediately visible. It lingers on in the plant and prepares the latter for a certain process (i.e., flowering) which takes place at a considerably later stage during the life history of the plant.

Some Phytochrome Mediated Photo responses in Plants are following:

1. Photoperiodism. 2. Seed germination.3. Elongation of leaf, petiole, stem.

4. Hypocotyl hook unfolding. 5. Unfolding of grass leaf. , 6. Sex expression.

7. Bud dormancy. 8. Plastid morphology. 9. Plastid orientation.

11. Rhizome formation. 12. Bulb formation. 13. Leaf abscission. 14. Epinasty.

15. Succulency, 16. Enlargement of cotyledons. 17. Hair formation along cotyledons. 18. Formation of leaf primordia.

****