Photoperiodism:

The plants in order to flower require a certain day length i.e., the relative length of day and night which is called as photoperiod. The response of plants to the photoperiod expressed in the form of flowering is called as photoperiodism.

The phenomenon of photoperiodism was first discovered by Garner and Allard (1920, 22) who observed that the Biloxi variety of Soybeans (Glycine max) and 'Maryland Mammoth' variety of tobacco (Nicotiana tabacum) could be made to flower only when the daily exposure to the light was reduced below a certain critical duration and after many complex experiments concluded that 'the relative length of the day is a factor of the first importance in the growth and development of plants'.

Depending upon the duration of the photoperiod, they classified plants into three categories.

(1) Short Day Plants (SDP):

These plants require a relatively short day light period (usually 8-10 hours) and a continuous dark period of about 14-16 hours for subsequent flowering . Some examples of these plants which are also known as long-night-plants are tobacco (Nicotiana tabacum) Soybeans (Glycine max), Cocklebur (Xanthium pennsylvanicum).

i. In short day plants the dark period is critical and must be continuous. If this dark period is interrupted even with a brief exposure of red light (660-665 mμ wavelength), the short day plant will not flower .

(2) Long Day Plants (LDP):

These plants require a longer day light period (usually 14-16 hours) in a 24 hours cycle for subsequent flowering. Some examples of these plants which are also called as short night plants are Spinacea (spinach) Beta vulgaris (Sugar beet).

i. In long day plants the light period is critical.

ii. A brief exposure in the dark period or the prolongation of the light period stimulates flowering in long day plants.

(3) Day Neutral Plants:

These plants flower in all photoperiods ranging from 5 hours to 24 hours continuous exposure. Some of the examples of these plants are tomato, cotton, sunflower, cucumber and certain varieties of peas and tobacco.

During recent years certain intermediate categories of plants have also been recognised. They are,

Long Short Day Plants:

These are short day plants but must be exposed to long days during early periods of growth for subsequent flowering. Some of the examples of these plants are certain species of Bryophyllum.

Short-Long Day Plants:

These are long day plants but must be exposed to short days during early periods of growth for subsequent flowering. Some of the examples of these plants are certain varieties of wheat (Triticum) and rye (Secale).

Photoperiodic Induction:

Plants may require one or more inductive cycles for flowering. An appropriate photoperiod in 24 hours cycle constitutes one inductive cycle. If a plant which has received sufficient inductive cycles is subsequently placed under un-favourable photoperiods, it will still flower. Flowering will also occur if a plant receives inductive cycles after intervals of un-favourable photoperiods (i.e., discontinuous inductive cycles). This persistence of photoperiodic after effect is called as photoperiodic induction. i. An increase in the number of inductive cycles results in early flowering of the plant. For instance Xanthium (a short day plant) requires only one inductive cycle and normally flowers after about 64 days. It can be made to flower even after 13 days if it has received 4-8 inductive cycles. In such cases the number of flowers is also increased.

ii. Continuous inductive cycles promote early flowering than discontinuous inductive cycles.

Perception of the Photoperiodic Stimulus and Presence of a Floral Hormone:
It is now well established that the photoperiodic stimulus is perceived by the leaves. As a result, a floral hormone is produced in the leaves which is then translocated to the apical tip, subsequently causing the initiation of floral primordia.

That the photoperiodic stimulus is perceived by the leaves can be shown by simple experiments on cocklebur (Xanthium pennsylvanicum), a short day plant. Cocklebur plant will flower if it has previously been kept under short-day conditions (A). If the plant is defoliated and then kept under short day condition, it will not flower (B). Flowering will also occur even if all the leaves of the plant except one leaf have been removed (C).

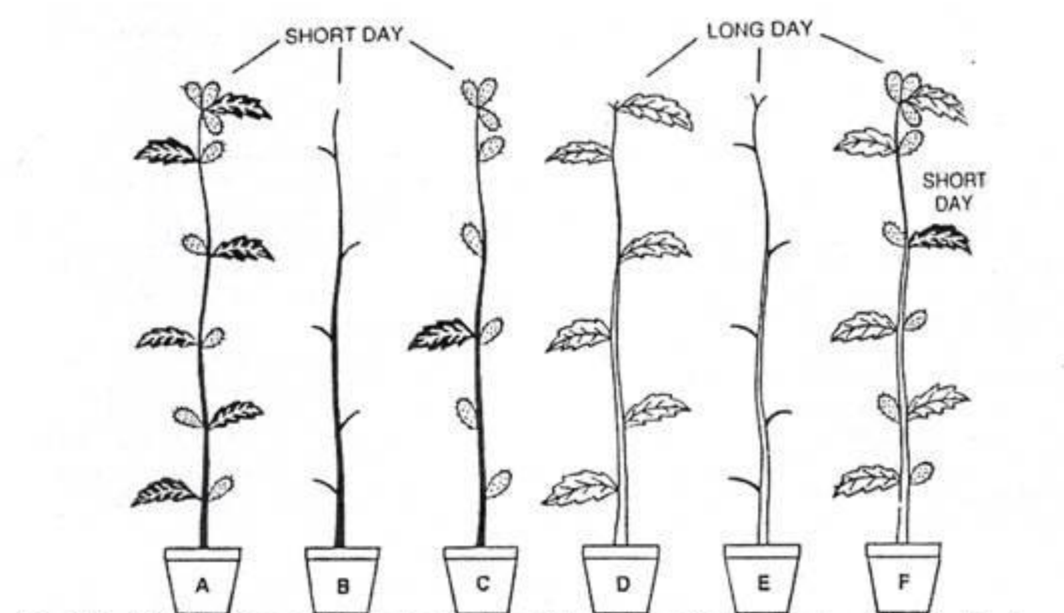


Fig. 18.2. Experiment on cocklebur plants to show that photoperiodic stimulus is perceived by the leaves. Flowering occurs even if a single leaf is exposed to appropriate photoperiod. See text

If a cocklebur plant whether intact of defoliated, is kept under long day conditions it will not flower (D, E). But, if even one of its leaves is exposed to short day condition and the rest are under long day photoperiods, flowering will occur (F).

The photoperiodic stimulus can be transmitted from one branch of the plant to another branch. For example, if in a two branched cocklebur plant one branch is exposed to short day and other to long day photo period, flowering occurs on both the branches (Fig. 18.3 A).

Flowering also occurs if one branch is kept under long day conditions and other branch from which all the leaves except one have been removed is exposed to short day condition (Fig. 18.3 B). However, if one branch is exposed to long photoperiod and the other has been defoliated under short day condition, flowering will not occur in any of the branches (Fig. 18.3 C).

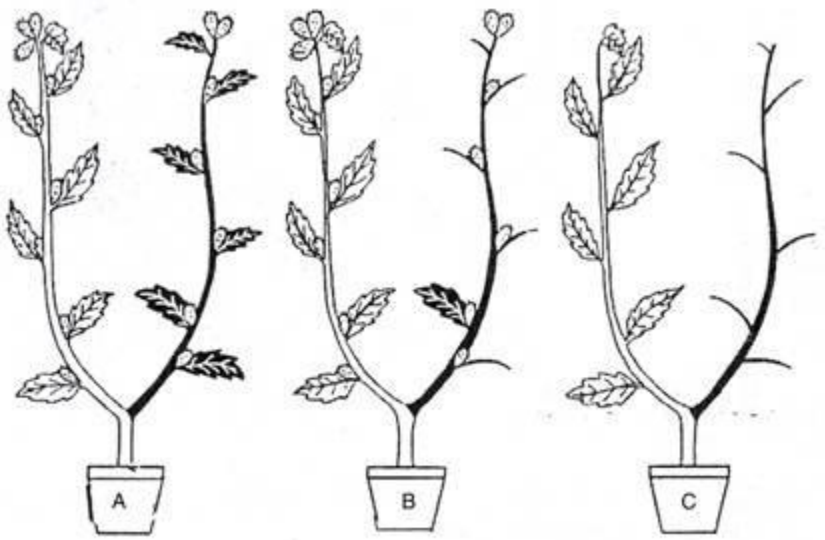


Fig. 18.3. Experiments on cocklebur plants to show that the photoperiodic stimulus can be transmitted from one branch of the plant to another.

Nature of the Floral Hormone:

Although there are firm evidences for the existence of a floral hormone but it has not yet been isolated. Therefore, the nature of this hormone which has been named as florigen is not very clear. But it is quite evident that this hormone is a material substance which can be translocated from leaves to the apical tips situated at other parts of the plant resulting in flowering.

Recent researches are indicative of 'florigen' to be a macromolecule unlike other plant growth hormones which are rather small molecules. This macromolecule may possibly be a RNA or protein molecule which is trans located from the leaf to the apical tips (or meristems) via phloem in photo-induced plants.

Grafting experiments in cocklebur plants have even proved that the floral hormone can be trans located from one plant to another. For example, if one branched cocklebur plant (Fig. 18.4 A) which has been exposed to short day conditions is grafted to another cocklebur plant kept under long day conditions, flowering occurs on both the plants (Fig. 18.4 B).

Obviously the floral hormone has been transmitted to the receptor plant through graft union. But if a cocklebur plant is grafted to another similar plant both of which have been kept under long day conditions, flowering will not occur on either of the two plants (Fig. 18.4 C).

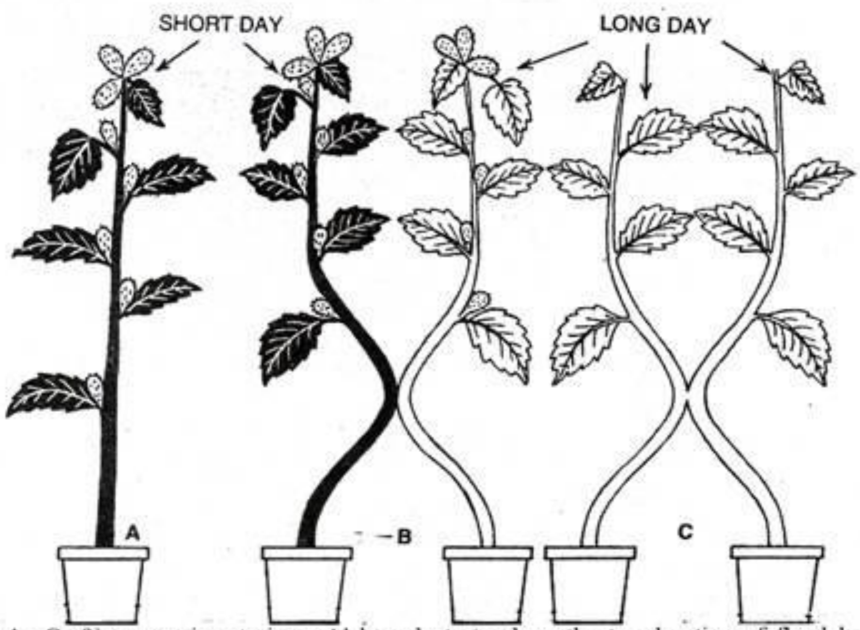


Fig. 18.4. Grafting experiments in cocklebur plants to show the translocation of floral hormone from one plant to another through graft union.

It has also been indicated that the floral hormone may be identical in short-day and long- day plants. For example, grafting experiments between certain long-day plants and short-day plants have shown that flowering occurs on both the plants even if one of them has been kept under non-inductive photoperiods.

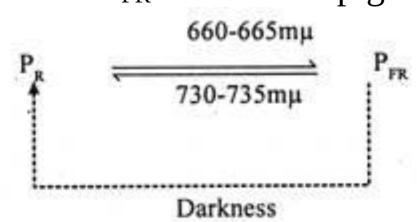
Phytochrome:

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 involves the operation of a proteinaceous pigment called as phytochrome.

i. The pigment phytochrome exists in two different forms:

(i) Red light absorbing from which is designated as P_R and
(ii) 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.
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:

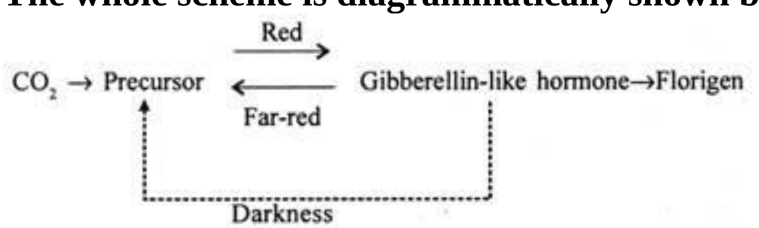
It is now well known that the gibberellins can induce flowering in long-day plants even under non-inductive short days. It is also definite that the gibberellins alone do not constitute the 'florigen', but it is usually held that the gibberellins are in some way connected with the overall process of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