

PHOTOPERIODISM AND FLOWERING

Light controls many physiological processes in the plant among them the process of flowering is important even in the life cycle of the plant. In case of annuals, floral induction signals the end of vegetative growth. In perennials, floral initiation is not accompanied by such changes and the vegetative and reproduction growth occur simultaneously. Reproductive growth is a complex process which includes anatomical, morphological, physiological and biochemical process. All these changes are finally manifested into transformation of vegetative to reproductive bud.

Before floral primordial can be initiated, the plant must complete a period of vegetative growth of attain some minimal leaf number. When this condition is attained the plant is said to be **ripe-to-flower**. In most plants, ripeness to-flower is attained after the plant has produced several leaves. In some annual grasses a minimum of 7 **leaves** must be developed before the plant is ripe to flower. On the other hand, a plant such as *pharabtis nil* is ripe to flower within a day after the cotyledons have emerged. The cotyledons presumably contain enough stored food to support subsequent reproductive development.

However, most of the commonly cultivated plants and weedy annuals attain the ripe-to-flower condition **2-3 weeks** after seedling emergence when a few leaves have fully developed.

22.1 IMPORTANCE OF PHOTOPERIODISM IN AGRICULTURE:

The knowledge of photoperiodism and its application has great economical potential as follows

- The yield of tubers, corns, bulbs and rhizomes can be increased substantially by increasing or decreasing the duration of day or night.
- Annuals may be grown twice or thrice in a year.
- Perennials might flower throughout the year.
- Hybridization experiments have got a fillip because different varieties growing in different areas with different durations and flowering at different times are made to grow and flower side by side by artificially controlling their photoperiods.
- Understanding the concept of photoperiodism has helped to choose photo insensitive varieties and cultivars. These cultivars are best suited in intensive agriculture.

22.2 CLASSIFICATION OF PLANTS BASED ON PHOTOPERIODIC RESPONSES

Garner and Allard (1920) observed that flowering in Maryland mammoth variety of tobacco (*Nicotiana tabacum*) and Biloxi soybean (*Glycine max*) can be controlled by artificially increasing or decreasing the natural duration of sunlight. They introduced the term photoperiodism and defined that as the **response of plant to the relative length of day and night**. However, the duration of dark period is also much important to understand the concept.

Garner and Allard classified the plants into 5 types based as their photoperiod response of flowering

- A. Short day plants (SDP) B. Long day plant (LDP) C. Day neutral plant (DNP)
D. Short –long- day plants (SLDP) E. Long- short- day plants (LSDP)

A) Short day plants (SDP)

Plants that readily flower when the day length is less than its critical day length (photoperiod required to induce flowering is critical day length). For example, critical day length for xanthium (SDP) is about 15.5 h and it flowers only when day length is 15.5 h or less. It was also shown that even a brief exposure to light during dark period inhibits flowering and therefore it requires a continuous and uninterrupted dark period for its flowering. On the other hand, a brief period of darkness during day time had no effect on flowering. Because of the importance of dark period in flowering, these are also called as **Long Night Plants**.

B) Long day plants (LDP)

These plants flower readily only when the photoperiods are longer than the critical photoperiod. For example annual *Hyoscyamus* has a critical photoperiod less than 10h.30m. As a result, this plant does not flower with a photoperiod less than 10h.30m but it promptly flower under any length of photoperiod above this limit and even within 24h of light. These plants are also called as **short night plants**.

C) Indeterminate or Day Neutral Plants

Indeterminate or DNP flowers readily over a wide range of day length from relatively SDL to continuous illumination.

D) SLDP

These plants require first short photoperiod and then long photoperiod for flowering.

E) LSDP

These plants require first long days and then short photoperiod for flowering

These plants do not flower when exposed to either SD or LD and need both LD and SD for its flowering

22.2.1 EXAMPLES OF PLANTS WITH DIFFERENT PHOTOPERIOD REQUIREMENT ARE GIVEN BELOW

1. Short day plants

A. Qualitative SDP (Plants specifically requiring SD)

1. Chrysanthemum
2. Tobacco
3. Xanthium
4. Rice (*Oryza sativa*)
5. Japanese morning glory (*Pharbatis nil*)

B. Quantitative SDP (Plants promoted by SD)

1. Cosmos
2. Cotton
3. Hemp

2. Long day Plants

A. Qualitative LDP (plant specifically requiring LD)

1. Barley (winter barley)
2. Wheat
3. Henbane (*Hyoscyamus Niger*)
4. Spinach
5. Sugar beet

B. Quantitative LDP (plants promoted by LD)

1. Lettuce
2. Blue grass
3. Clover

3. Day neutral plants

1. Cucumber
2. Balsam
3. maize
4. Tomato

4. LDSDP

1. Bryophllum
2. *Cestrum Nocturnum* (Night blooming Jasmine)

5. SDLDP

1. Winter rye
2. Candy tuft

22.3 PERCEPTION OF PHOTOPERIODIC STIMULUS

Knott (1934) first observe that photoperiodic induction is perceived by young expanded leaves. Later Knott's work was confirmed by Chailakhyan (1936) he divided chrysanthemum plants into four groups and varied the regime of light

and dark cycles in all the four groups by using light proof cases. The four groups of plants are as follows:

Group A Entire plant continuously received long day treatment

Group B Lower leaf portion received short day treatment while upper defoliated portion received long day treatment

Group C Lower leafy portion received long day treatment while upper defoliated portion received short day treatment

Group D Entire plant continuously received short day treatment

He observed that flowering occurred in those plants where the leaves received short day treatment (Group B&D) but it failed in those plants where the leaves received long day treatment (Group A&C). On the basis of above observation he concluded that short day stimulus is perceived by the leaves.

Floral stimulus

The flowering stimulus produced in the photo induced leaves is translocated to the shoot apices for flower evocation. It has been observed that floral stimulus is similar in long and short day plants by grafting experiments. If a leaf from a photo induced plant is removed and then grafted on a non induced plant, then this plant flowers. Apparently a chemical substance is produced during photo inductive cycle, which is transmitted during grafting to non induced plants and evokes flowering. **Chailakhyan** (1936) named this flower inducing chemical substance as Florigen. The flowering stimulus travels through phloem but independent to the transport of photosynthates.

22.4 Biological clocks:

Study of Biological clocks is also known as chronobiology. The best understood biological clock is the circadian rhythm.

The various physiological processes do not occur at a constant rate during the different times of the day and night. The rate fluctuates showing peaks and dips at regular intervals. In other words the occurrence of the process is rhythmic. At first glance it may appear that such rhythms may be because of different external factors like temperature, light and humidity which fluctuate during the different times of the 24 hrs day. However, the plants continue to exhibit such rhythms even when held at constant conditions. It means that the occurrence of such rhythms is not because of variations in the external conditions (not exogenous) but appears to be controlled by the plant itself (endogenous). They are called as **endogenous rhythms**.

Most of the endogenous rhythms that occur in plants have a periodicity of frequency of about 24 hrs. That is, this process is repeated once in about 24 hrs and called **circadian rhythms**. Some properties of these diurnal rhythms are demonstrated by the sleep movement of the primary leaves of bean (*Phaseolus multiflorus*). (Fig.)

During the day the leaves are horizontal, while during the night the leaves assume a more vertical position. The plant is exposed to normal light and dark period for 2 days and was subsequently kept under light. The primary leaves continue to open and close once in about 24 hrs even continuous light.

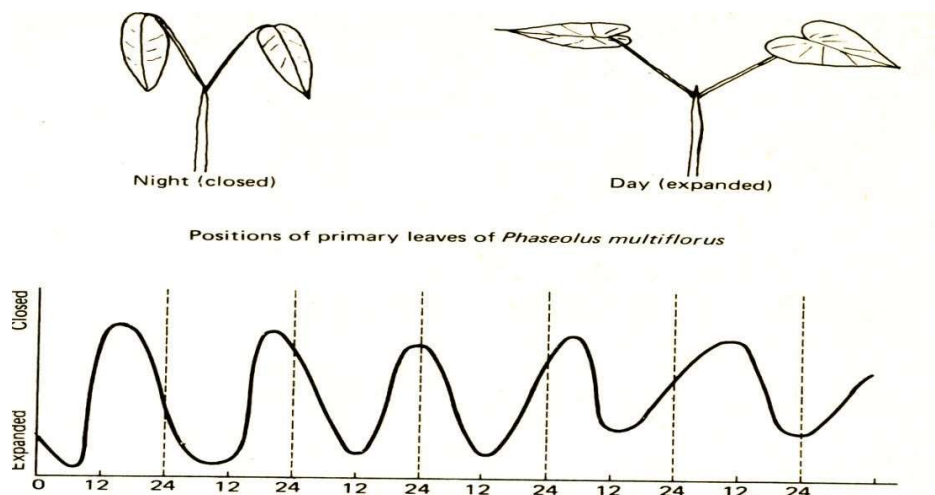


figure 18-8 Leaf movements of *Phaseolus multiflorus* in continuous dim light. 20° C

*Figure is from reference.7

The other examples of circadian movement in higher plants are cell mitosis, respiration, CO₂ fixation in Bryophyllum, enzymes activity, nectar odor and flower petal movement.

Experiments conducted by De Mairan, Pfeffer, Bunning and Stern and others have clearly shown the existence of an internal (endogenous) time measurement system in plants. The biological clock, as it is called, is believed to be very accurate as it measures the rhythms of a small period as one minute to as large a period as one year. Though the nature of the biological clock or the endogenous factor controlling it is not known, it is suggested to be located within the cell apparatus of even unicellular organisms.
