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Group-A, Plant Physiology

Topic- Photoperiodism

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Binod Kumar Pandey

Assistant Professor & HOD, Botany Department,

Ram Ratan Singh College, Mokama, Patna.

E.mail- binodkp14@gmail.com

Photoperiodism

Early twentieth century workers were of the belief that flowering in plants is a phenomenon effected by nutrition.

Kraus and Kraybill (1918) observed in the case of tomato plant, optimum nitrate and carbohydrates supply accelerated vegetative growth, but with a poor nitrate supply both reproduction and vegetative growth declined.

However, in the year 1906, a commercial variety of tobacco, Maryland narrow-leaved, gave rise to a new mutant called Maryland mammoth. This new variety showed vigorous vegetative growth during the summer, but the plants did not set seeds before the cold weather set in. W. W. Garner and H.A. Allard, plant physiologists, came forward to investigate the cause.

Finally they observed that these plants always bloomed during the short days of the winter months. The plants were made to flower even during the months of summer by cutting down the light period to seven hours a day (Fig. 5.1).

Gamer and Allard published their investigations in the year 1920. They, however, concluded that flowering was caused by exposure to days made up of short light and long dark periods. Since then it has been known that an environmental factor of great significance in controlling flowering is day length.

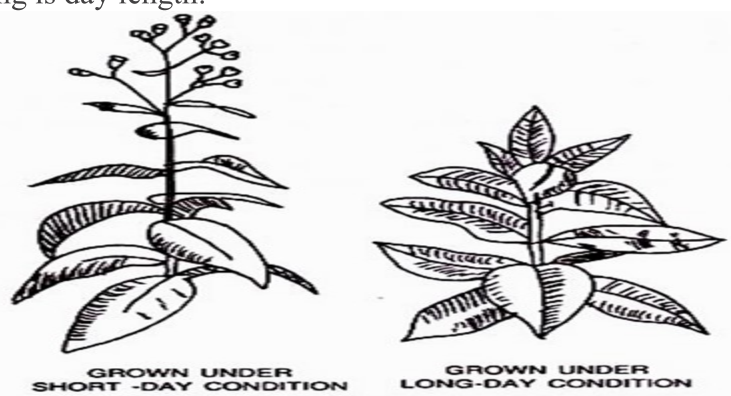

Fig. 5.1. The effect of day length on flowering of tobacco variety *Maryland mammoth*.

In tropical regions of earth there is very little change in day length throughout the year, and the days and nights are about equal. In temperate regions, day length changes from winter to summer, and the long days coincide with the warmer season. Many tropical species of plants when brought to temperate zone flower only when the days are short, continued long days prevent the formation of flower buds.

Plants native of temperate zone have a variety of flowering habits. Many temperate plants flower during spring when days are moderately short. Others flower during the summer when the days are long. Still others produce flowers during the short days of late summer and early fall. This mechanism that enables plants to respond to day length so that they flower at a specific time of the year is known as photoperiodism. The length of the daily period of light to which a plant is exposed is called photoperiod.

Plants are grouped according to their response to day length into what are called:

(i) Short-Day Plants
(ii) Long-Day Plants and
(iii) Day-Neutral Plants

(i) Short-Day Plants (SDP):

These plants flower when exposed to day lengths shorter than or below a certain critical maximum. The critical photoperiod, however, varies from species to species. If these plants are exposed to day lengths in excess of this critical point, they continue growing vegetatively (Fig. 5.2 A) Common examples of short-day plants are chrysanthemums, cock-lebur (Xanthium strumarium), tobacco (mutant. 'Maryland mammoth', Nicotiana, tabaccum), soyabean (Glycine max), and sugarcane (Sacchamm officinarum), etc. They normally flower in the early spring or autumn.

(ii) Long-Day Plants (LDP):

These plants begin flowering when exposed to day lengths longer than or above a certain critical minimum. Below the critical photoperiod, these plants continue their vegetative growth (Fig. 5.2 B). The critical photoperiod, in such plants also, varies from species to species. Some common examples of long day plants (LDP) are barley (Hordeum vulgare), spinach (Spinacea olemcea), radish (Raphanus sativus), henbane (Hyoscyamus niger), onion (Allium cepa) and carrot (Daucus carota), etc. They normally flower in late spring or early summer.

(iii) Day-Neutral Plants (DNP):

These plants flower after a period of vegetative growth, regardless of the photoperiod. In other words, they are unaffected by the day or night lengths, and flower around the year (Fig. 5.2-C). Some common examples of day-neutral plants are cucumber (Cucumis sativus), cotton (Gossypium hirsutum), tomato (Lycopersicum esculentum), sunflower (Helianthus annuus), Maize (Zea mays) and some varieties of pea, etc.

Table showing Photoperiodic responses of some common plants.

Short Day Plants	Long Day Plants	Day Neutral Plants
Chrysanthemums (*Chrysanthemum spp.*)	Barley (*Hordeum vulgare*)	Balsam (*Impatiens balsamina*)
Cocklebur (*Xanthium strumarium*)	Cabbage (*Brassica oleracea*)	Beans (*Phaseolus spp.*)
Cosmos (*Cosmos sulphureus*)	Carrot (*Daucus carota*)	Chillies (*Capsicum annuum*)
Dahlias (*Dahlia variabilis*)	Henbane (*Hyoscyamus niger*)	Cotton (*Gossypium hirsutum*)
Goosefoot (*Chenopodium rubrum*)	Larkspur (*Delphinium ajacis*)	Cucumber (*Cucumis sativus*)
Hemp (*Cannabis sativa*)	Lettuce (*Lactuca sativa*)	Dandelion (*Taraxacum spp.*)
Morning Glory (*Ipomoea purpurea*)	Onion (*Altium cepa*)	Jerusalem artichoke (*Helianthus tuberosus*)
Poinsettia (*Euphorbia pulcherrima*)	Petunia (*Petunia spp.*)	Maize (*Zea mays*)
Rice (*Oryza sativa*)	Poppy (*Papaver somniferum*)	Potato (*Solanum tuberosum*)
Soya beans (*Glycine max*)	Radish (*Raphanus sativus*)	Rhododendrons (*Rhododendron* spp.)
Tobacco (*Nicotiana tabaccum*)	Spinach (*Spinacea oleracea*)	Tobacco (*Nicotiana tabaccum*)
Violets (*Viola papilionacea*)	Wheat (*Triticum aestivum*)	Tomato (*Lycopersicum*)

Photoperiodic Responses are Under the Control of Genes:

It is a matter of common observation that the critical day length of both long-day and short- day plants tends to fall within a range of 12—14 hours. Commercial flower growers can induce or delay flowering by controlling the photoperiodic and temperature conditions in glasshouses to meet the demands of the market. The photoperiodic responses of plant are now considered to the under the control of genes.

These can be modified by various methods to yield varieties responding to required day lengths. For instance, scientists at the National Botanical Research Institute, Lucknow have been able to develop varieties of Chrysanthemum which can bloom in different months of the year including summer.

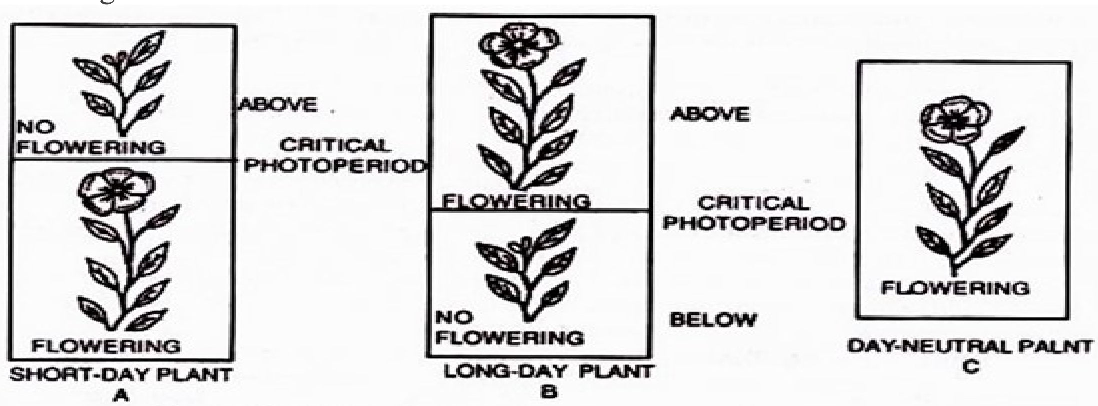

Fig. 5.2. (A-C). Showing the effect of day length on flowering.
A, Short-day plant ; B, Long-day plant ; C, Day-neutral plant.

Critical Photoperiod:

The critical photoperiod for long and short day plants greatly varies from species to species. For instance. Chrysanthemum and Poinseltias are both short-day plants, but Chrysanthemum form flowers when the days are shorter than 14.5 hours, whereas Poinsettias produce flower buds only when the days are less than 12.5 hours.

Spinach and rose mallow are long-day plants, but spinach flowers when the days are longer than 14 hours, the rose mallow flowers when they are longer than 13 hours. In other words, the short-day plants flower only when the days are shorter than a critical photoperiod, and the long-day plants flower only when the days are longer than the critical duration.

Induction Period:

Induction period is the minimum period of exposure to a long day or a short day which is required to induce flowering. Induction period differs in different plants. For instance, Xanthium requires only one cycle of day plus night, but most plants require about ten such cycles.

Long-Night and Short-Night Plants:

The Terms Long-Day and Short-Day Plants are actually misnomers. Earlier when the photoperiodism was discovered, the duration of the light period i.e. photoperiod was thought to be critical for flowering. However, later researches, noted that in short-day plants (SOP), when the long night period was interrupted by a brief exposure to light, the plants failed to flower (Fig. 5.3).

From this observation, scientists concluded that what is critical or essential for these plants to flower is long and un-interrupted dark period rather than a short day length. A brief interruption of the dark period with light nullified the effect of long night. So to be more precise and appropriate, short day plants may be regarded as long-night plants.

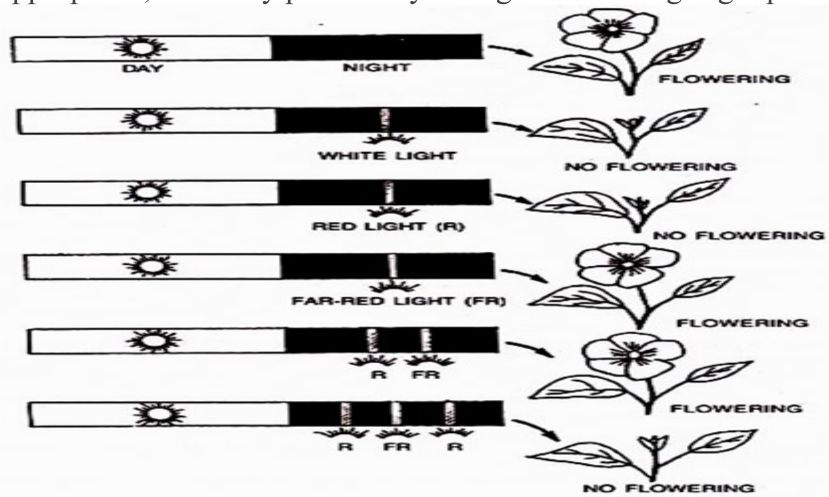

Fig. 5.3. Effect of night (dark) interruption on flowering in a short-day plant. vegetative but into flower bud.

Similarly long-day plants (LDP) respond to nights shorter than the critical dark period. Curiously long day plants do not need an uninterrupted dark night. Long-day plants are also regarded as short-night plants.

Theory of Photoperiodic Action:

Attempts have been made to understand as to how day (or night) length affects the plant so as to change the normal leaf primordia of the stem apex into flowering primordia? As written above, in short-day plants it is the dark period rather than the light period which affects induction of flowering, but in long-day plants, dark period is not at all important and they can flower even in continuous day light. This clearly indicates that there must be two different systems operating in two groups of plants for the induction of flowering.

Significance/Practical Importance of Photoperiodism:

1. Photoperiodism determines the season in which a particular plant shall come to flower. For example, short-day plants develop flowers in autumn-spring period (e.g., Dahlia, Xanthium) while long-day plants produce flowers in summer (e.g., Amaranthus).

2. Knowledge of photoperiodic effect is useful in keeping some plants in vegetative phase (e.g., many vegetables) to obtain higher yield of tubers, rhizomes etc., or keep the plant in reproductive phase to yield more flowers and fruits.

3. A plant can be made to flower throughout the year by providing favourable photoperiod.

4. Helps the plant breeders in effective cross-breeding in plants.

5. Enable a plant to flower in different seasons thus fruits can be produced during their off-season by controlling photoperiod.