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B.Sc. Part- II
[BOTANY SUBSIDIARY]
GROUP- 'C'

(i) PHOTOPERIODISM

Group - 'c'

Photoperiodism

Photoperiodism [Photon: light. periodus = orbit, recurrence, course] →

" Photoperiodism is the response of the plant to the relative length and timings of light and dark conditions."

Garner and Allard (1920) were the first to use the term photoperiodism. They observed that Maryland Mammoth variety of tobacco failed to produce flowers during summer but when grown in green house during winter the plant flowered profusely. They further subjected Maryland Mammoth tobacco plant to short day lengths during summer by placing the plant in darkness after exposure to a daylength that would be equivalent to a winter day. Plants treated in this way produced flowers. Furthermore, they found that the plant can be kept in vegetative state during winter months by lengthening the days with artificial additional light. This variety of tobacco is called short day plant because its flowers only under short days. Later on it was found that some plants require longer photoperiods to induce flowering while others produce flowers under both long and short-day conditions. Still others some plants require a long photoperiod followed by short photoperiods to flower, while others are induced to flower when short photoperiods followed by long photoperiods.

On the basis of the lengths of photoperiods requirements of plants the plants have been classified into:-

(1) Short-day plants [SDPs]
(2) Long-day plants [LDPs]
(3) Day-neutral plants [DNPs]

(1) Short-day plants - For flowering of short day plants the day length must not exceed a certain critical value, the day length required is less than a certain critical length. Short day plants may be more correctly called long night plants as a certain minimum of uninterrupted dark period in 24 hours is necessary for their flowering. If the dark period is less than the critical length, flowering will not occur. Short day plants will not flower even if a flash of light or weak light is provided during the continuous dark period. However the light interruption is not very effective if it is nearing the beginning

or the end of dark period. These plants are also not capable of flowering if short dark or short light periods are not provided alternately.

Hillman (1959) showed that short day plants are capable of flowering even if kept continuously in dark but provided with sucrose. This shows that the short-day plants require light period only for carrying on photosynthesis. In short-day plants flowering can be induced even during long days by increasing the dark period by putting them in dark for sometime before sunset or after sunrise. In these plants cutting short of the light period up to 12 hours or less induces flowering in them. Some examples of short-day plants are - Soyabean, Poinsettia, cocklebur, Potato, Sugarcane, cosmos, chrysanthemum, Aster, Dahlia, Tobacco, Strawberry etc.

(2) Long-day plants → These plants require a photoperiod of more than a critical length which may very from 14 to 18 hours. The best flowering of long day plants usually occur in continuous light. For flowering they require either no dark period or a very short dark period. A flash of light given

to long-day plants during long dark periods can induce flowering in them even during short day periods. Here darkness has an inhibitory effect on flowering. The long day plants can flower even in short day periods if these short day periods are accompained with still shorter dark periods. A long-day plants requiring 16 hours of light period in 24 hours can be made to flower if it is provided with a cycle of eight hours of light period and four hours of dark period. The flowering in long day plants is inhibited not because of the short periods but because of too long dark periods. Because of this long day plants can also be called short-night plants.

Examples of long-day plants are- Spinach, Lettuce, Radish, Alfalfa, Sugar-beet, Opium, Poppy, Larkspur, Maize, Oat, Henbane, wheat etc.

③ Day-neutral plants or Indeterminate plants } → They can flower even if the light period provided is from few hours to continuous illumination. Their flowering is not affected by the length of the day.

Examples of day-neutral plants are - Tomato, cucumbers, cotton, pea, sunflower, dandelion etc.

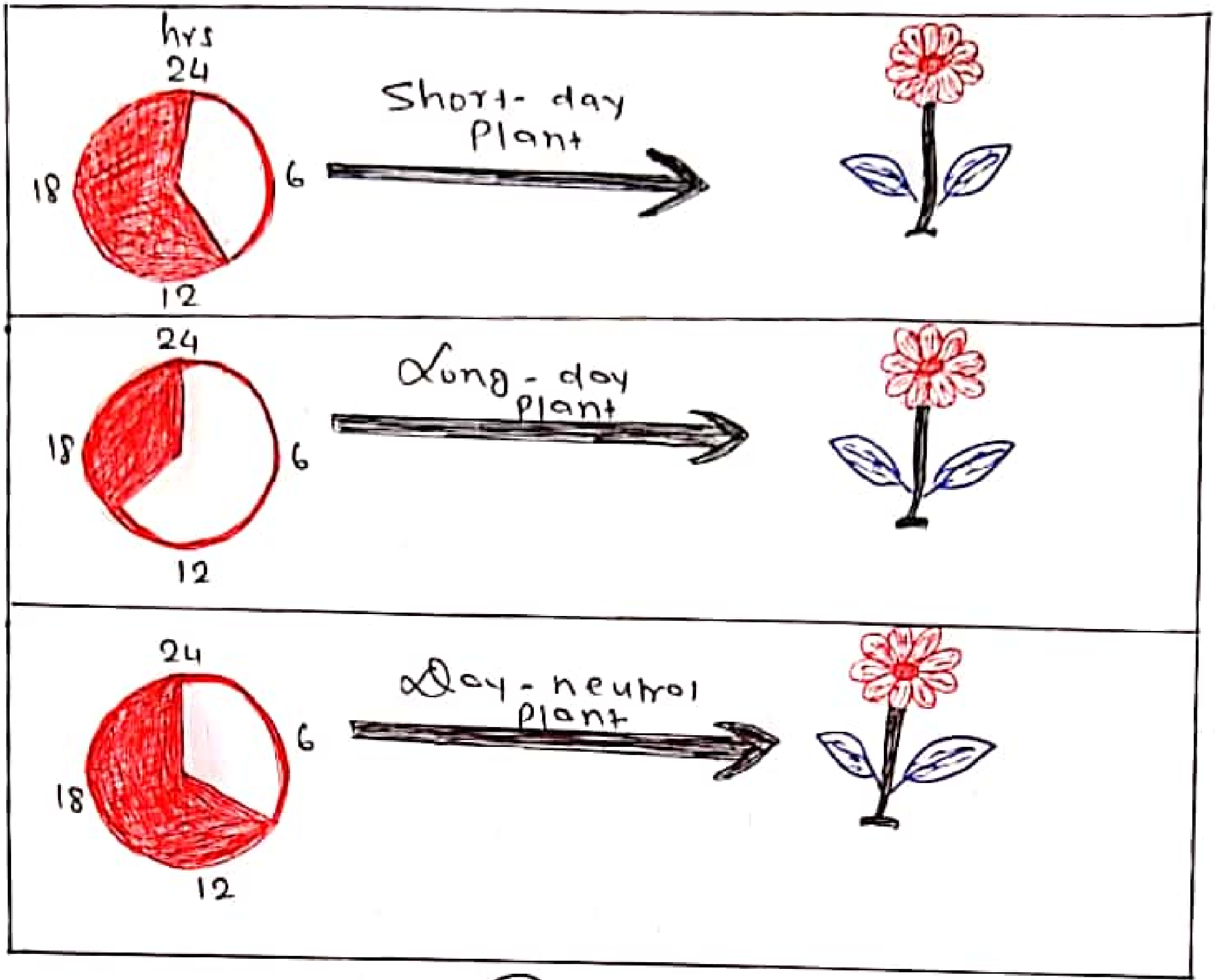

figure - Three categories of the plants

Photoperiodic Induction

Based on experimental findings it has been observed that a continued favourable photoperiods till blossoming is not essential, but a short and appropriate photoperiod exposure is required for the production of flowers. The kind of photoperiodic influence persists even when a plant is preceded and followed by unfavourable photoperiods or conditions.

This phenomenon of producing photoperiodic influence is known as "photoperiodic induction." An essential period capable to produce photoperiodic induction may be one day as in Xanthium pennysylvanicum, Pharbitis nil, Lolium etc. two days as in Soyabean, three days in henbane or 15 to 20 days as in beet or even more.

Besides the length of minimum photoperiod, a minimum vegetative growth is also essential, such as number of leaves. It varies from plant to plant.

Mechanism of Photoperiodism

Mechanism of photoperiodism is studied under following headings -

1 Site of photo-inductive Perceptions

There kinds of observations were made by Knott (1934) and confirmed by Chailakhyan (1936) that photo-induction is perceived by the leaves, while working on Xanthium pennysylvanicum (cocklebur) isolated leaves and a single leaf in the plant capable to receive photo-inductive influenceshave been observed. The sensitivity of perceiving influence increases with the growth of leaf till full expansion and decreases in the older leaves. Thus, it depends on the age of plant.

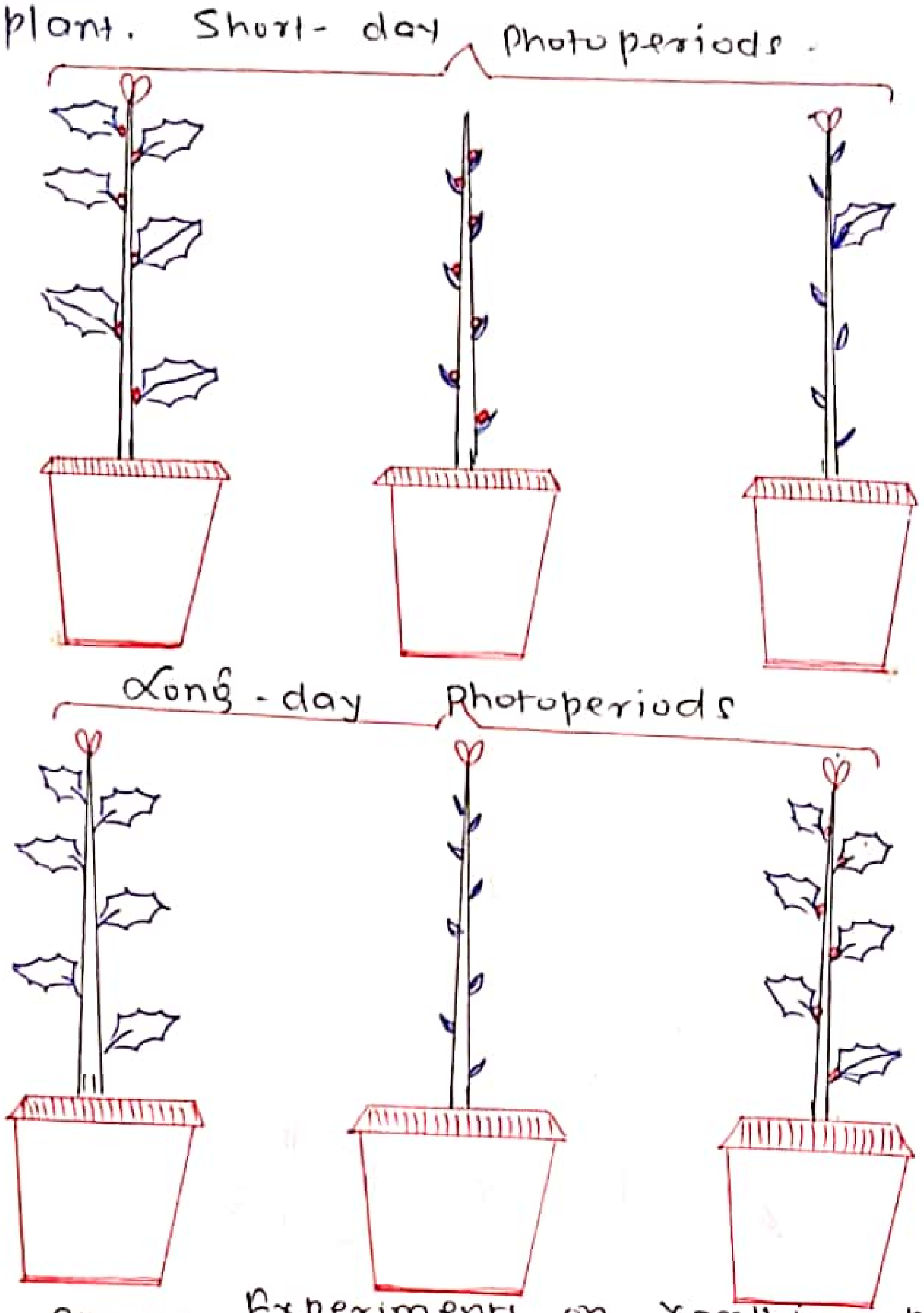

figure → Experiments on Xanthium plants indicate that photoperiodic stimulus is perceived by leaves.

② Translocation of photoperiodic Stimulus

A Xanthium (SDP) grown with two main stems of which one is exposed to short days and the other to long days will bear flowers not only on short day branch but also on long day branch. Flowering also occurs if one branch is kept under long day conditions and other branch from which all leaves except one have been removed is exposed to short day conditions. However if one branch is exposed to long photoperiod the other which has been defoliated under short day conditions, flowering will not occur in any of the branches. The reaction can be explained by assuming that a flower inducing substance is produced in the leaves during short days and transported upwards and downwards through the stem. Under long days these substance is not produced. ⑧

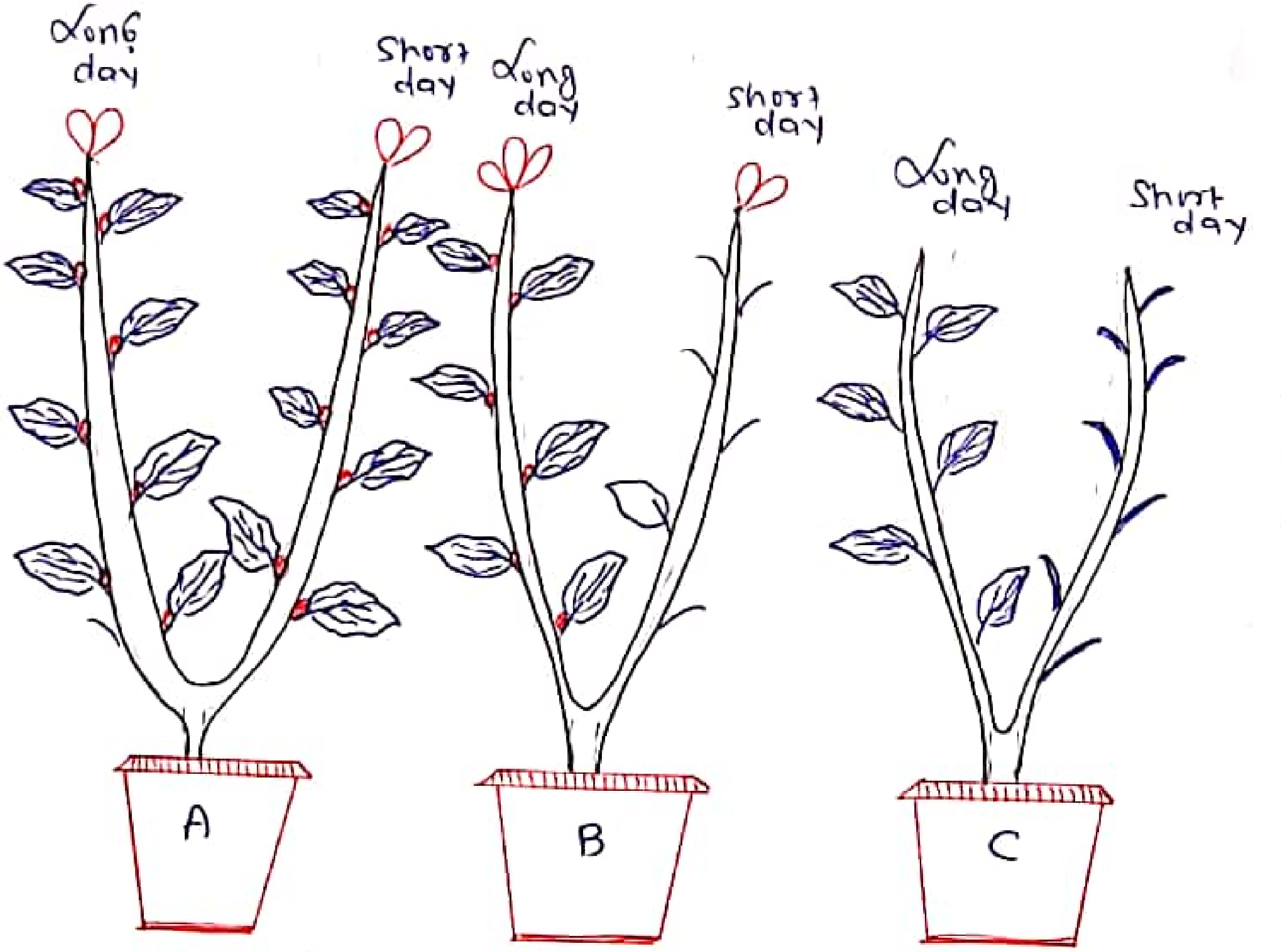

Figure- Experiment (xanthium) to show that photoperiodic stimulus can be translocated from one branch of the plant to another-

Further evidence that both Short day long day plants produce a flower promoting hormone was provided by grafting experiment. In 1936 Kuyper and Wiersum and also Choilakhyan found that if a shoot from a plant conditioned for flowering (donor) is grafted to another plant kept in non-flower inducing conditions (receptor) the latter will flower in spite of adverse day length. Even grafting of single leaf produced flowering (The receptor should be defoliated before flowering)

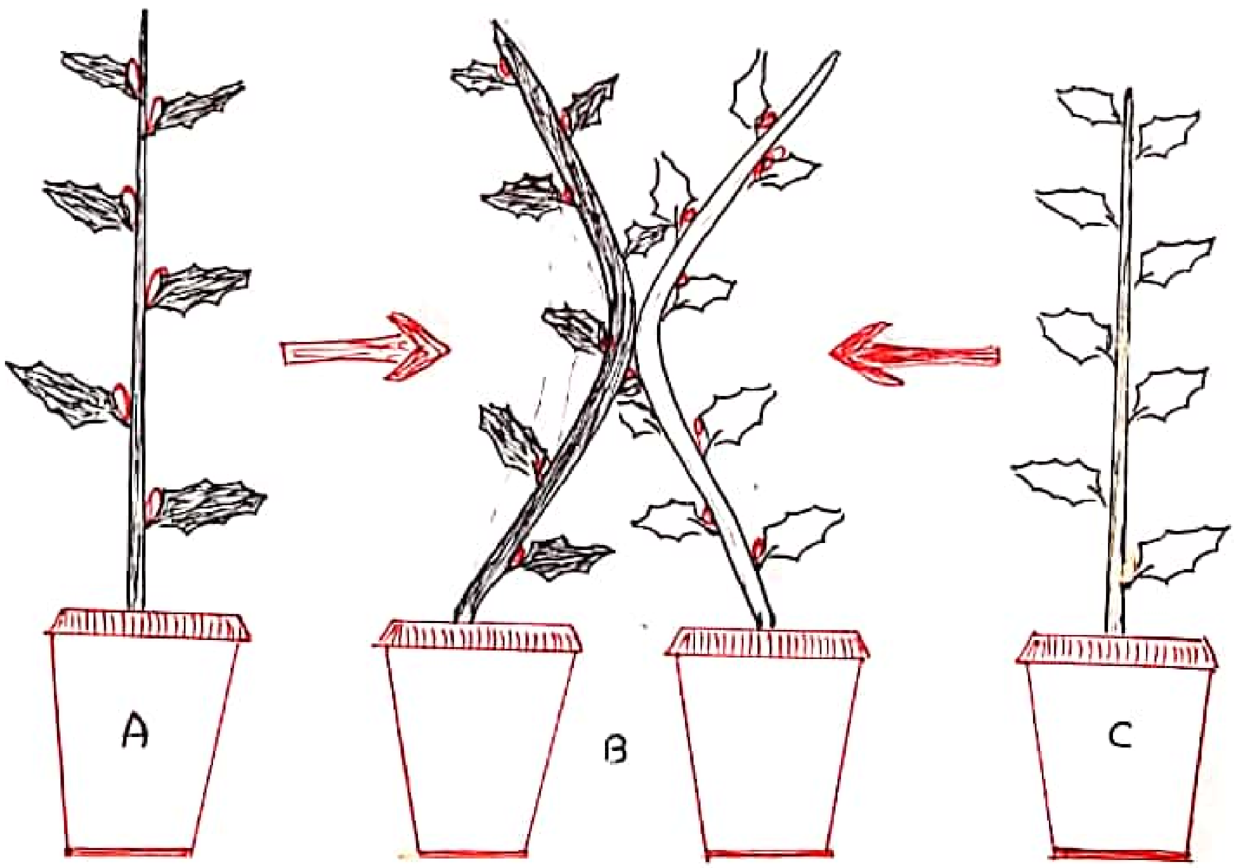

figure- The stimulus can translocate from one plant to another plant through graft union.

If one branch of a two branched Xanthium plant is grafted in series to five other Xanthium plants, was given photoinductive cycle, the second branch of first plant and other five plants kept in non-photoinductive cycle, all plants flowered.

During further observation it was determined that stimulus moves at the rate of 2.4/hr in short-day plants and 20 cm/hr in long day plants.

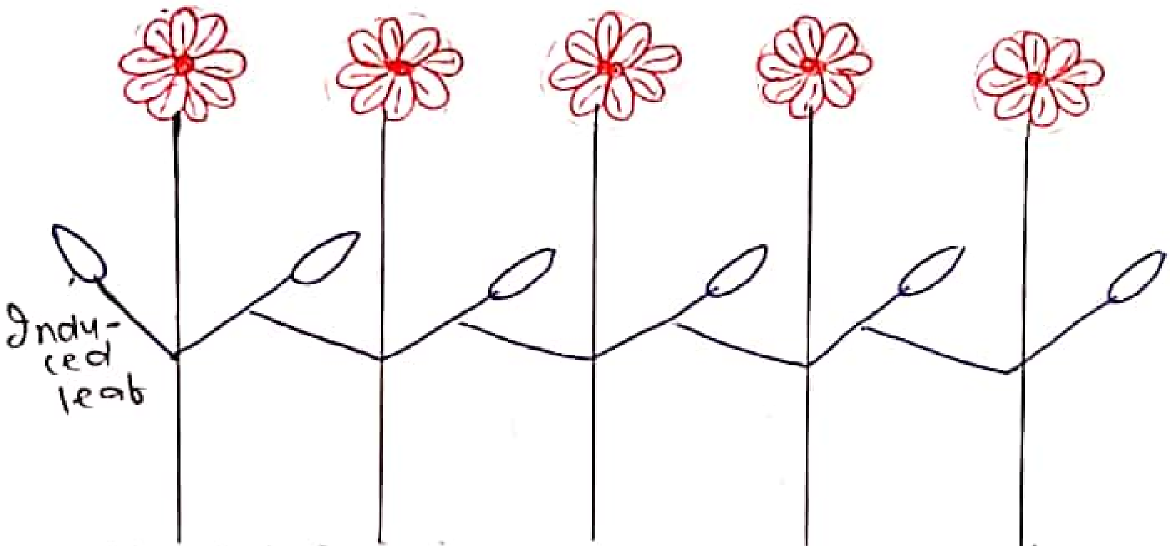

figure → Diagram to illustrate Chailakhyan's grafting experiment which demonstrates the translocation of the floral stimulus from one induced leaf to five grafted plants

(3) Nature of Stimulus → The transmission of stimulus indicates that it is in the form of some chemical. Chailakhyan (1936) named this flower inducing chemical as "florigen complex." According to him (1958) the "Florigen complex" the true flowering hormone includes two groups of substances formed in leaves.

(a) Gibbrellins → which are necessary for formation and growth of stem. (11)

(b) Anthesins → which are necessary for flower formation.

In LDP growing on short days, there is sufficient amount of anthesin but insufficient gibbrellin. Hence in increase in gibbrellin, either by endogenous synthesis when plants are transferred to long days or by application of a solution to leaves leading to flower.

The situation is reversed in short-day plants growing in long days, because gibberellin is at high level and anthesin at a low level.

Quality of light in relation to Photoperiodism

Phytochrome concept → Borthwick and Hendricks were of the view that there was present in plant tissues a receptor pigment, which they called phytochrome. It was first isolated by Butler (1954). Phytochrome is a bright blue or bluish-green protein having two interconvertible forms referred to by code numbers. P660, which has a light absorption peak in red light (660 m) and P730, which has a light absorption peak in far red (730 m). If P660 is exposed either to

Sunlight or to red light, it changes to P730. If P730 is then exposed to far-red light, it changes quickly back to P660. This changes also occurs slowly in darkness.

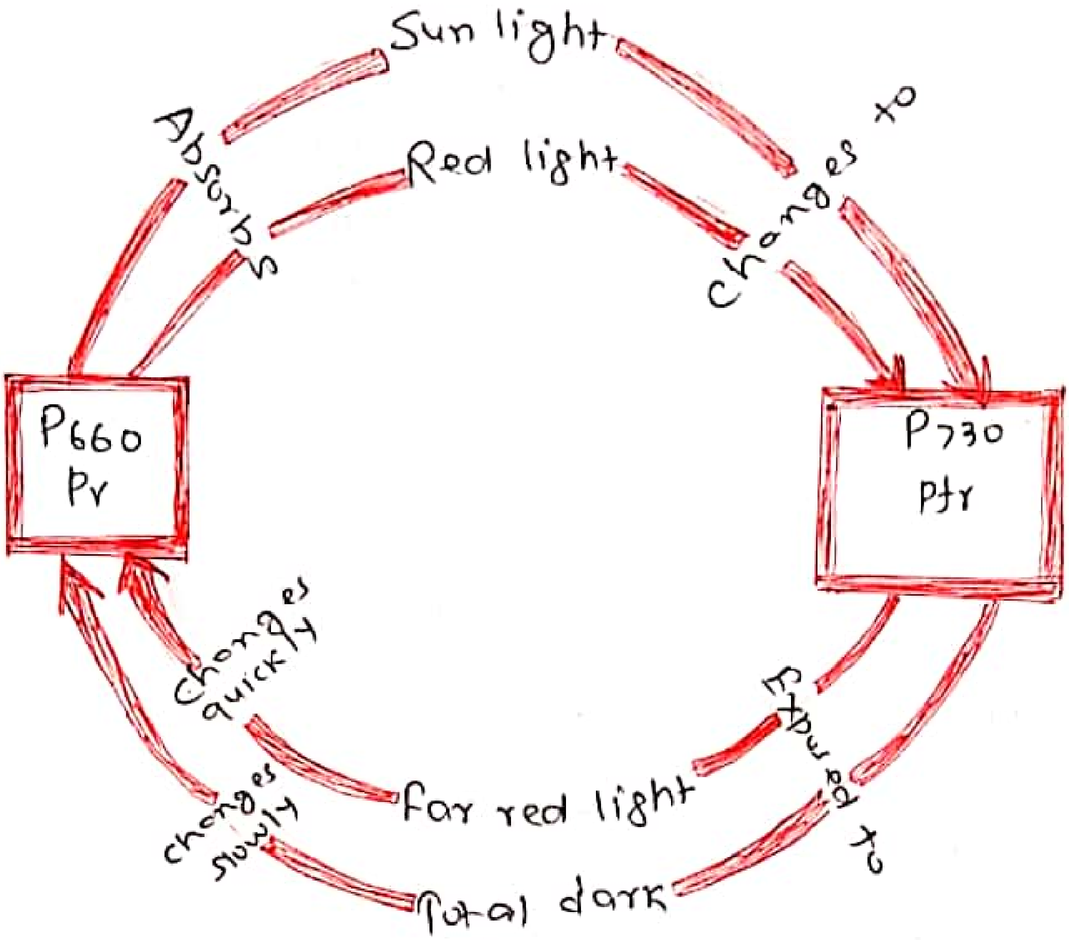

Figure - The phytochrome concept

It appears that during the day time (white light) the far-red absorbing form of phytochrome is accumulated in the plant. This form of the pigment is inhibitory to flower in short days plants and simultaneously to flower in long day plants. At the onset of dark period, the far-red form is subjected to thermal and spontaneous decay, creating the red absorbing form of phytochrome. The interruption of the dark period with red light will return the accumulating red absorbing form to the far-red absorbing form of phytochrome, thus inhibiting flowering in short day plants. If the red light break is followed by far-red break the red light effect is ceased.

Treatment dark control	mean stage of floral development in Xanthium
R	6.0
R-FR	0.0
R-FR-R	5.6
R-FR-R-FR	0.0
R-FR-R-FR-R	4.2
R-FR-R-FR-R-FR	0.0
R-FR-R-FR-R-FR-R	2.4
R-FR-R-FR-R-FR-RFR	0.0

R = Red
FR = Far-red

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