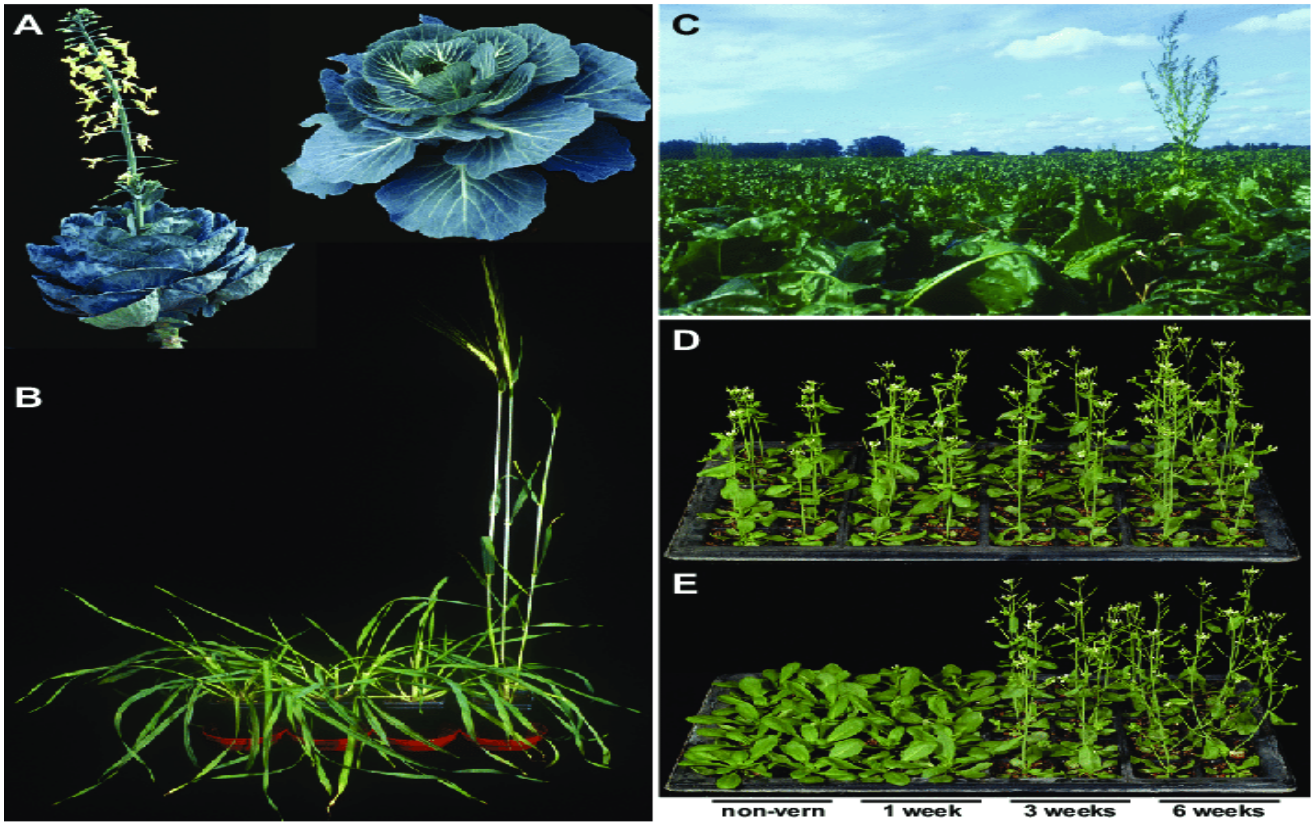
VERNALIZATION



Presented by:
Dr. Ankit Kumar Singh
Assistant Professor
Department of Botany
Marwari College
Lalit Narayan Mithila University
Darbhanga
ankitbhu30@gmail.com

For B.Sc. Part II (Sub.) Group C (Plant Physiology)

Lecture No. 40

Vernalization

Vernalization is the process whereby flowering is promoted by a cold treatment given to a fully hydrated seed (i.e., a seed that has imbibed water) or to a growing plant.

✓ Dry seeds do not respond to the cold treatment.

✓ Without the cold treatment, plants that require vernalization show delayed flowering or remain vegetative.

✓In many cases these plants grow as rosettes with no elongation of the stem.

✓ Due to vernalization the vegetative period of the plant is cut short resulting in an early flowering.

✓ Some of the characteristics of the cold requirement for flowering, includes the range and duration of the inductive temperatures, the sites of perception, the relationship to photoperiodism, and a possible molecular mechanism.

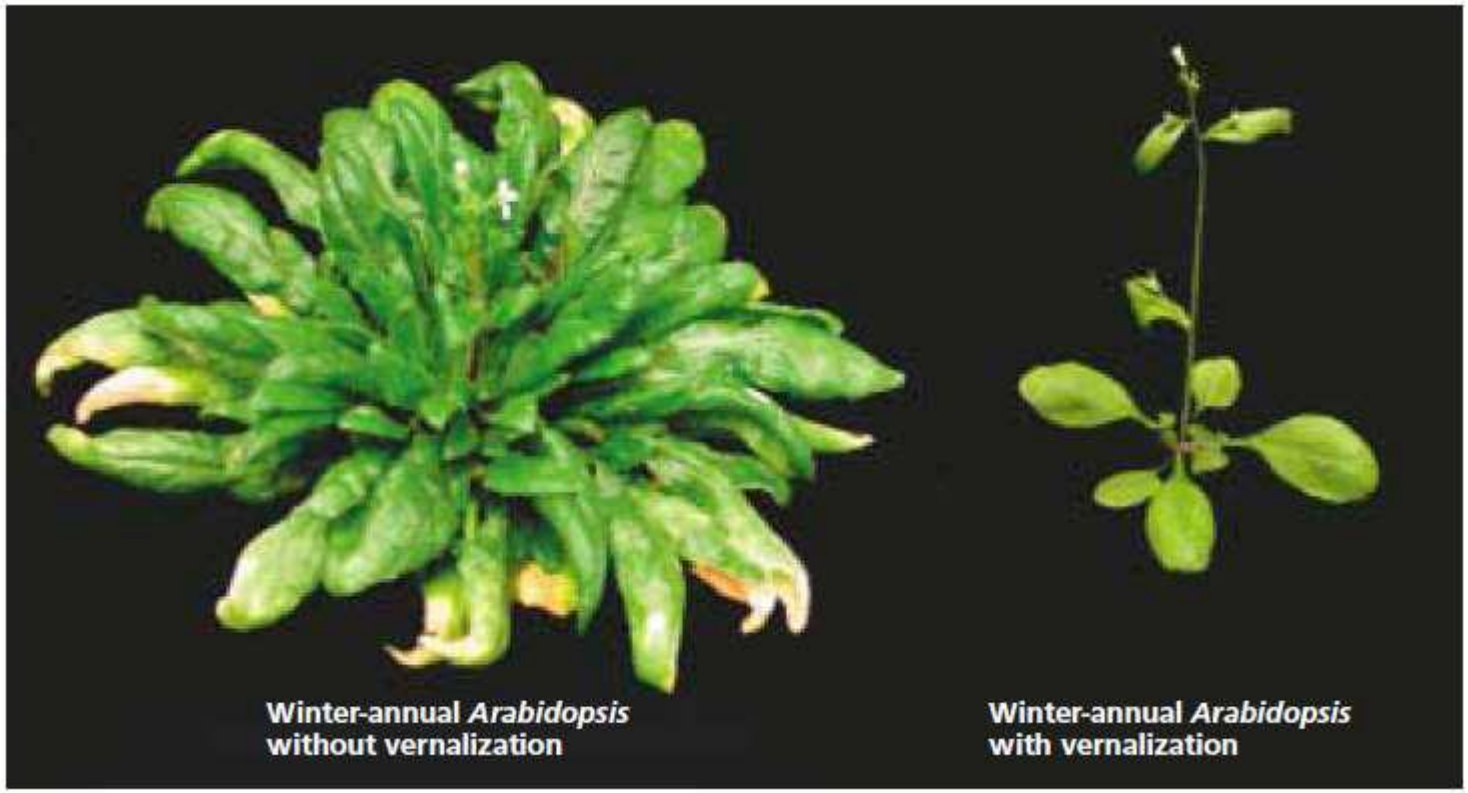


Figure: Vernalization induces flowering in the winter- annual types of *Arabidopsis thaliana.* The plant on the left is a winter-annual type that has not been exposed to cold. The plant on the right is a genetically identical winter annual type that was exposed to 40 days of temperatures slightly above freezing (4 °C) as a seedling. It flowered 3 weeks after the end of the cold treatment with about 9 leaves on the primary stem

History of vernalization

- Klippart,1857- first noticed the low temperature requirement for flowering while working with winter wheat and spring wheat.
- Lysenko,1938-used the term vernalization for a low temperature promotion of flowering in plants.
- Chourad ,1960- defined vernalization as “acquisition or acceleration of the ability to flower by a chilling treatment”.

Vernalization Results in Competence to Flower at the Shoot Apical Meristem

- Plants differ considerably in the age at which they become sensitive to vernalization.
- Winter annuals, such as the winter forms of cereals (which are sown in the fall and flower in the following summer), respond to low temperature very early in their life cycle.

They can be vernalized before germination if the seeds have imbibed water and become metabolically active.

- Other plants, including most biennials (which grow as rosettes during the first season after sowing and flower in the following summer), must reach a minimal size before they become sensitive to low temperature for vernalization.
- The effective temperature range for vernalization is from just below freezing to about 10°C, with a broad optimum usually between about 1 and 7°C (Lang 1965).
- The effect of cold increases with the duration of the cold treatment until the response is saturated.
- The response usually requires several weeks of exposure to low temperature, but the precise duration varies widely with species and variety. Vernalization can be lost as a result of exposure to devernalizing conditions, such as high temperature but the longer the exposure to low temperature, the more permanent the vernalization effect.
- Vernalization appears to take place primarily in the shoot apical meristem. Localized cooling causes flowering when only the stem apex is chilled, and this effect appears to be largely independent of the temperature experienced by the rest of the plant.

➢ In developmental terms, vernalization results in the acquisition of competence of the meristem to undergo the floral transition.

➢ Competence to flower does not guarantee that flowering will occur.

A vernalization requirement is often linked with a requirement for a particular photoperiod (Lang 1965).

➢The most common combination is a requirement for cold treatment followed by a requirement for long days a combination that leads to flowering in early summer at high latitudes .

➢Unless devernalized, the vernalized meristem can remain competent to flower for as long as 300 days in the absence of the inductive photoperiod.

✓ The vernalization is an aerobic process and requires metabolic energy.

✓ In the absence of oxygen cold treatment becomes completely inefficient.

✓ Sufficient amount of water is also essential.

✓ Vernalization of dry seeds is not possible.

Mechanism of vernalization

Two theories explains the mechenism of vernalization

1. Phasic development theory
2. Hormonal theories

1. Phasic development theory

Proposed by Lysenko in 1934.

- According to this theory there is a series of phases in the development of a plant.
- Each phase is stimulated by an environmental factor such as temperature,light,etc.
- Commencement of one phase will take place only after the completion of the proceeding phase.

There are two phases

1.Thermophase

2. Photophase

✓ Thermophase depends on temperature.vernalization accelerates thermophase.

✓ Thermophase should be followed by photophase which requires light.

2. Hormonal theories

✓ Harmonal theory proposed by Melcher (1939)

✓ He proposed that chilling treatment induces the formation of a new floral hormone called vernalin.

✓This hormone is transmitted to other parts of the plant.

✓ He graphted a vernalized plant with an unvernalized plant.

✓The unvernalized plant also initiates flowering.

✓ The hormone, vernalin diffuses from the vernalized plant to the unvernalized plant and induces flowering.

Epigenetic Changes in Gene Expression

✓ Vernalization May Involve Epigenetic Changes in Gene Expression.

✓ Changes in gene expression that are stable even after the signal that induced the change (in this case cold) is removed are known as **epigenetic regulation.**

✓One model for how vernalization affects flowering is that there are stable changes in the pattern of gene expression in the meristem after cold treatment

✓The involvement of epigenetic regulation in the vernalization process has been confirmed in the LDP *Arabidopsis.*

✓A gene that acts as a repressor of flowering has been identified: ***FLOWERING*** LOCUS C (FLC). FLC is highly expressed in nonvernalized shoot apical meristems (Michaels and Amasino 2000).

✓After vernalization, this gene is epigenetically switched off by an unknown mechanism for the remainder of the plant's life cycle

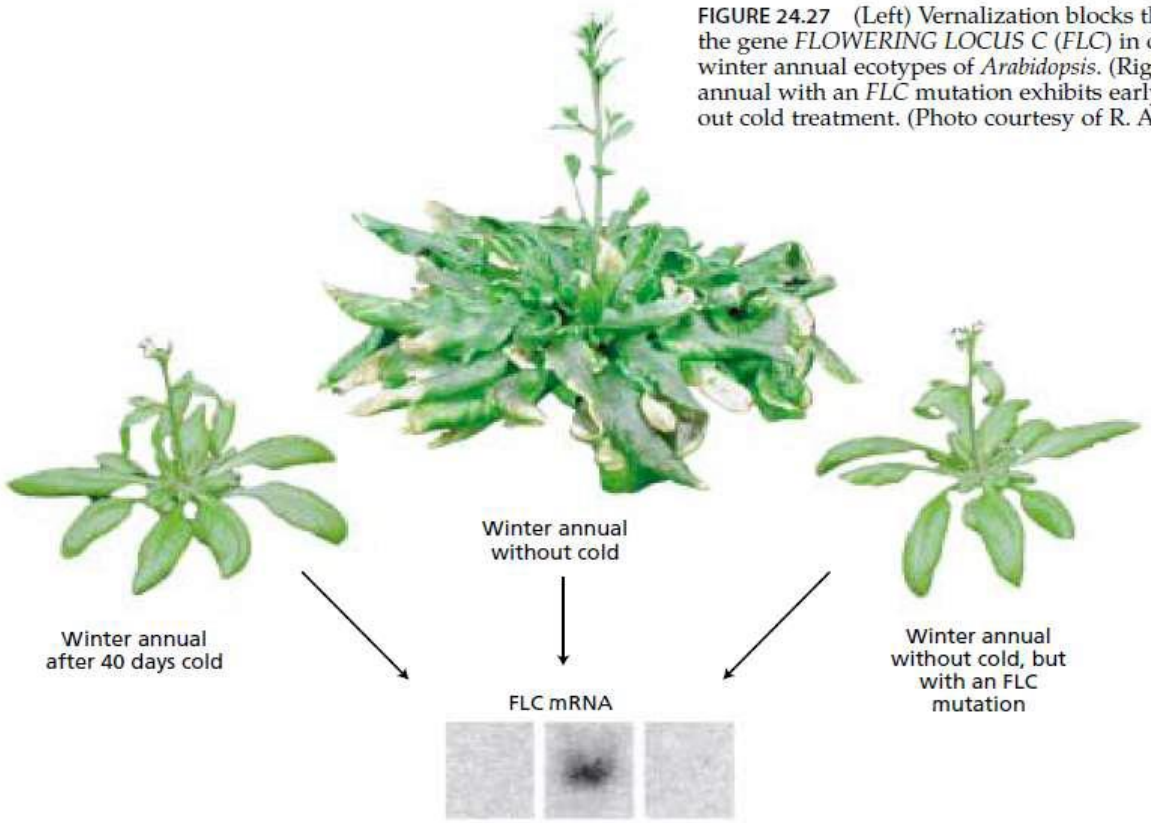


FIGURE: (Left) Vernalization blocks the expression of the gene *FLOWERING LOCUS C (FLC) in cold-requiring* winter annual ecotypes of *Arabidopsis. (Right) A winter* annual with an *FLC mutation exhibits early flowering without* cold treatment. (Photo courtesy of R. Amasino.)

Devernalization

✓The reversion of vernalization by high temperature treatment is called devernalization.

✓ Devernalization is effected by treating the vernalized seeds or buds with high temperature.

✓ Lang et al (1957) demonstrated that application of gibberlins can replace the cold treatment for vernalization in certain biennial plants

Practical applications of vernalization

✓ Due to vernalization the vegetative period of the plant is cut short resulting in an early flowering.

✓ Vernalization increases the resistance of plants to fungal diseases.

✓ It increases the cold resistance of plants.

✓ In the biennials, vernalization induces early flowering and early fruit setting.

✓ Flowering can be induced by graphting and this feature is used in horticulture.

✓ It also helps in crop improvement.

Dr. Ankit Kumar Singh
Assistant Professor
Department of Botany
Marwari College
Lalit Narayan Mithila University
Darbhanga
ankitbhu30@gmail.com

Thank You!!!