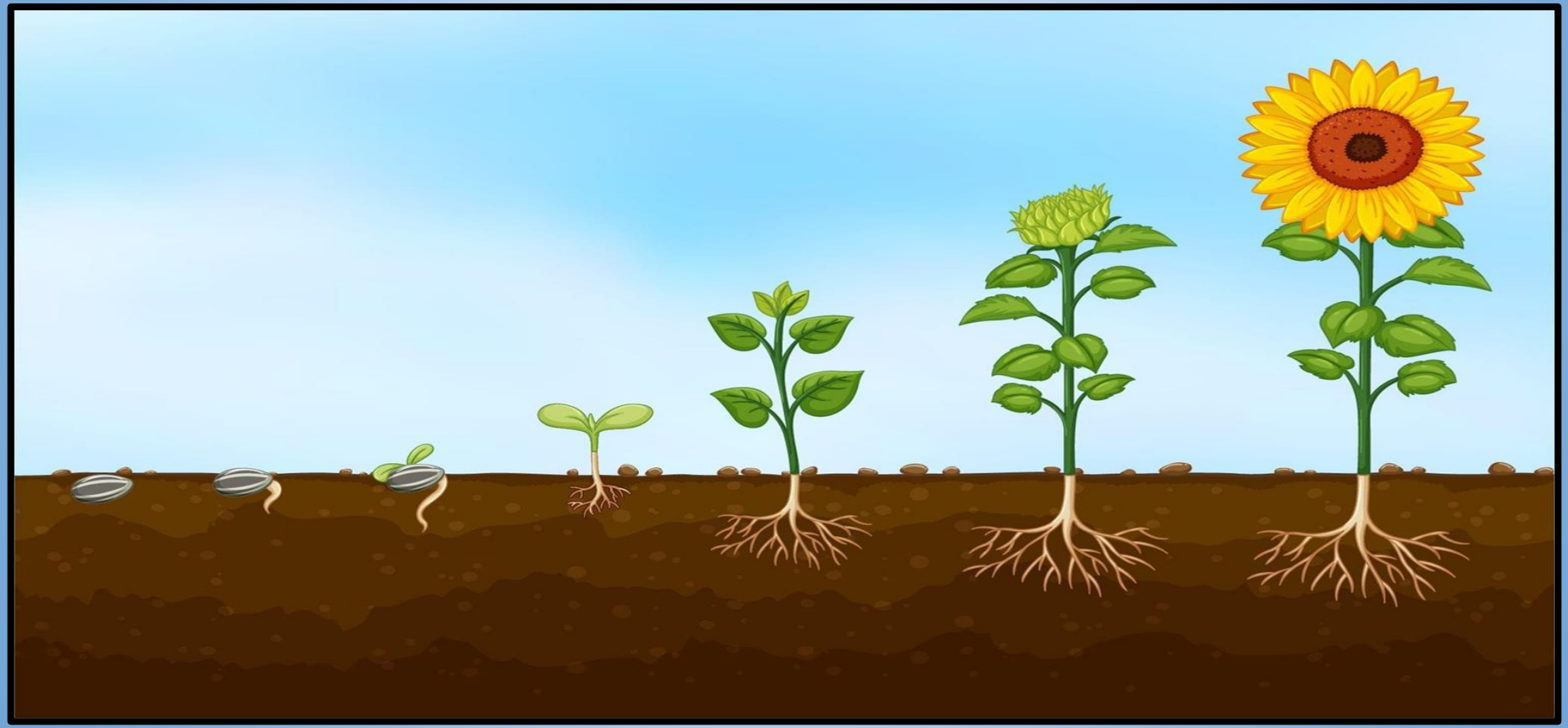
PLANT GROWTH & DEVELOPMENT



15.1 GROWTH

Growth is regarded as one of the most fundamental and conspicuous characteristics of a living being. What is growth? Growth can be defined as an irreversible permanent increase in size of an organ or its parts or even of an individual cell. Generally, growth is accompanied by metabolic processes (both anabolic and catabolic), that occur at the expense of energy. Therefore, for example, expansion of a leaf is growth. How would you describe the swelling of piece of wood when placed in water?

Growth = Addition of cells + Increase in cell size

PHASES OF GROWTH

- **Meristematic (formative phase) growth:**
  - It is shown by apices of roots and shoots.
  - The meristematic growth is facilitated by a thin cellulosic cell wall, along with many plasmodesmata connections.
- **Elongation (phase of enlargement):**
  - It is characterised by deposition in the cell wall and increased vacuolation.
- **Maturation:**
  - It is characterised by cell wall thickening and lignification.
  - Cells attain maturity and their maximal size and undergo protoplasmic modifications.

TYPES OF GROWTH

- **Primary Growth:**
  - Apical meristems of roots and shoots is responsible for primary growth.
- **Secondary Growth:**
  - Secondary growth is due to lateral meristems, e.g. vascular and cork cambium.
  - The plant increases in the girth due to secondary growth.

Arithematic growth

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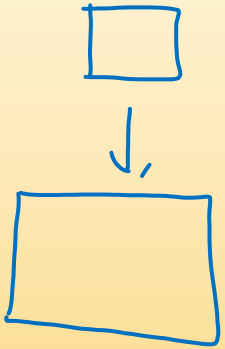
Cell growth/elongation



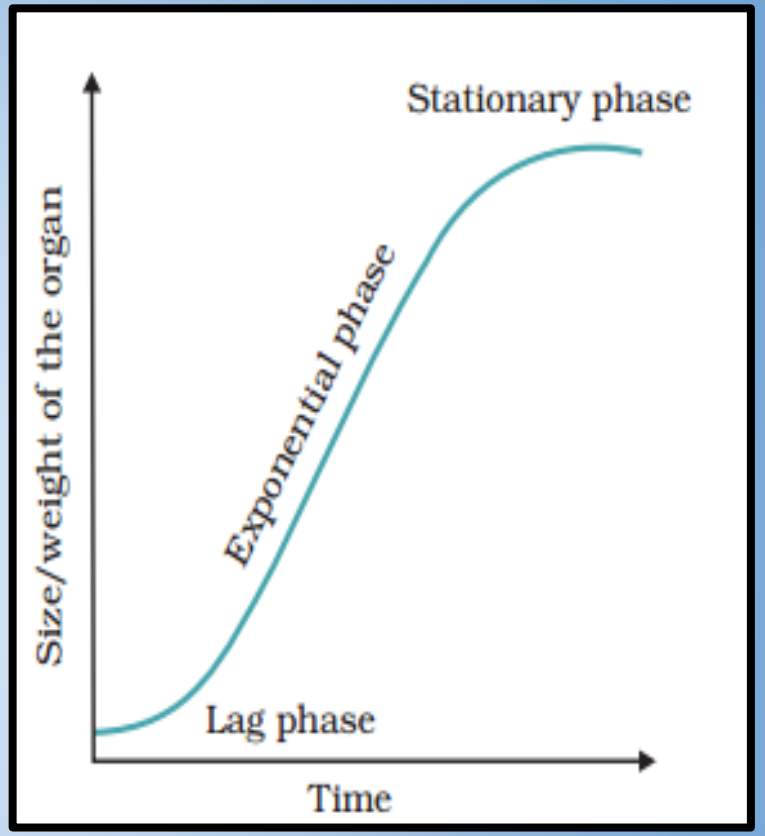
Geometric growth

↓

Cell division

GEOMETRIC GROWTH

- It is represented by
  - an initial lag phase of slow growth,
  - followed by an exponential or log phase of rapid growth
  - leads to a stationary phase, where growth slows down.
- We get a sigmoid curve.



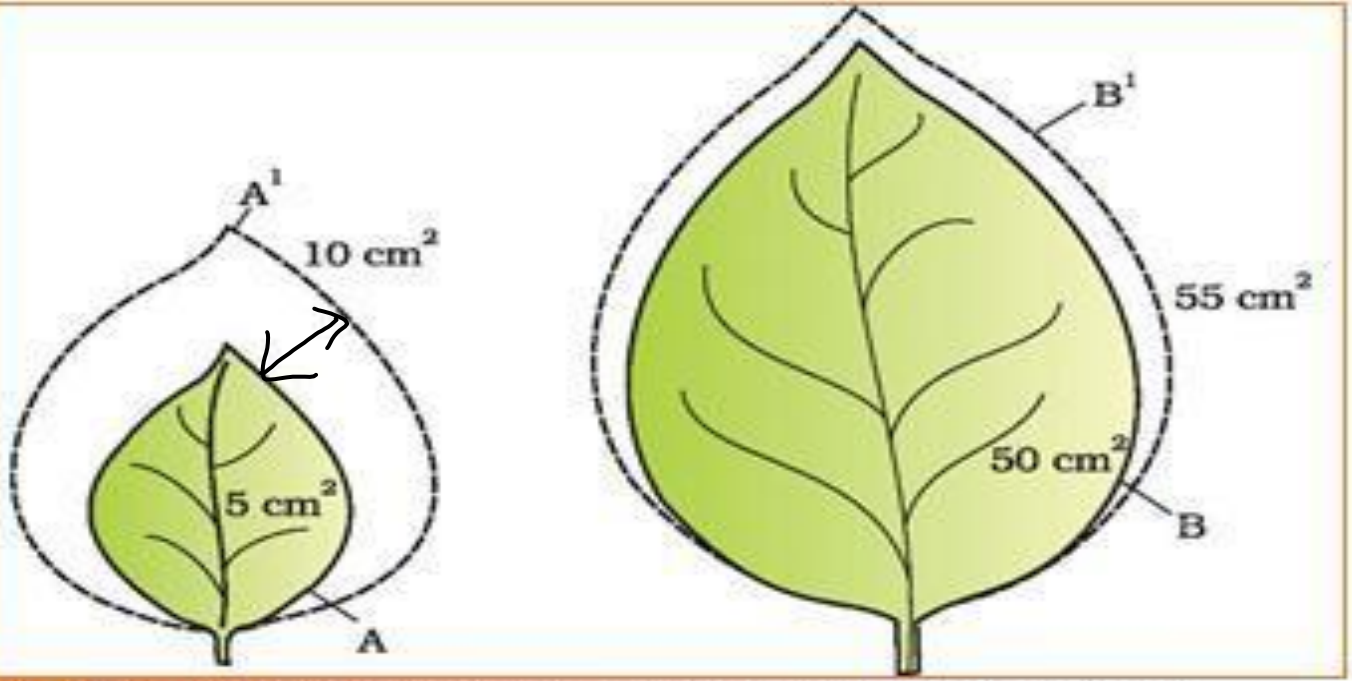


Fig: Diagrammatic comparison of absolute and relative growth rates. Both leaves A and B have increased their area by 5 cm^2 in a given time to produce A^1, B^1 leaves.

NEET QUESTION

Q) Fastest phase of S-shaped growth curve is

A. Lag Phase

B. Log Phase

C. Stationary Phase

D. Both A and B

NEET PYQ

Q) Typical growth curve in plants is

A. stair-steps shaped

B. parabolic

C. sigmoid

D. linear.

15.2 Differentiation, Dedifferentiation and Redifferentiation

The cells derived from root apical and shoot-apical meristems and cambium differentiate and mature to perform specific functions. This act leading to maturation is termed as **differentiation**. During differentiation, cells undergo few to major structural changes both in their cell walls and protoplasm. For example, to form a tracheary element, the cells would lose their protoplasm. They also develop a very strong, elastic, lignocellulosic secondary cell walls, to carry water to long distances even under extreme tension. Try to correlate the various anatomical features you encounter in plants to the functions they perform.

Plants show another interesting phenomenon. The living differentiated cells, that by now have lost the capacity to divide can regain the capacity of division under certain conditions. This phenomenon is termed as **dedifferentiation**. For example, formation of meristems – interfascicular cambium and cork cambium from fully differentiated parenchyma cells. While doing so, such meristems/tissues are able to divide and produce cells that once again lose the capacity to divide but mature to perform specific functions, i.e., get **redifferentiated**. List some of the tissues in a woody dicotyledenous plant that are the products of redifferentiation.

DEDIFFERENTIATION

- When living differentiated cells regain their ability to divide and differentiate, the process is called dedifferentiation.
- Example:
  - Parenchyma cells again differentiate into the cork and interfascicular cambium.

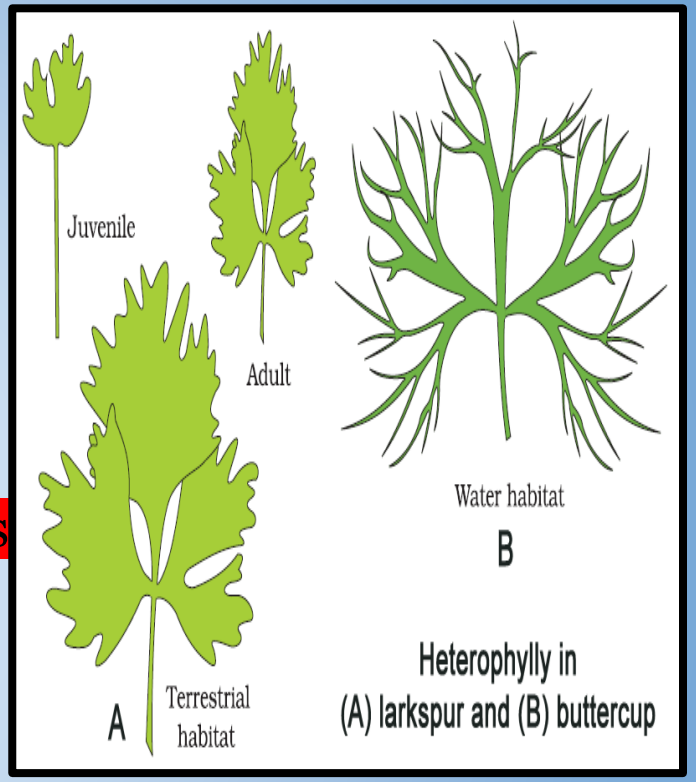
DEVELOPMENT

- Development refers to growth as well as differentiation. The development includes all the phases of the lifecycle from seed germination to senescence.
- Development is controlled by various intrinsic and extrinsic factors:
- **Intrinsic Factors:**
  - These include genetic as well as hormonal control
- **Extrinsic Factors:**
  - Environmental factors like oxygen, temperature, water, nutrients, etc.

Development
=> Growth
+
Differentiation

PLASTICITY

- Plants form different types of structures in response to various environmental conditions. This is termed as **plasticity.**
- **Heterophylly**:
  - It refers to the different shapes of leaves present at different stages of life or in different environmental conditions.
  - E.g. In coriander, cotton and larkspur, leaves are of different shapes at juvenile and mature stages.
  - In buttercup, the leaves of terrestrial and aquatic habitats are different.



NEET PYQ

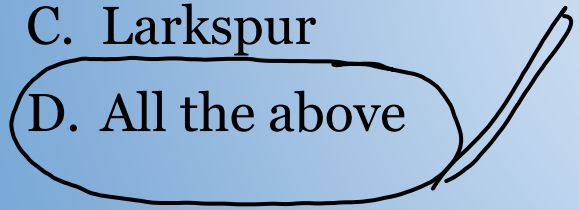
Q) Juvenile Heterophylly is seen in

A. Cotton

B. Coriander

C. Larkspur

D. All the above



PLANT GROWTH REGULATORS

- "Plant growth regulators function as chemical messengers for intercellular communication."
- They are chemical compounds and found naturally in plants.
- They are also synthesised commercially and used in agricultural practices.
- They are known as plant hormones or phytohormones.

CHARACTERISTICS

- Environmental factors influence gene expression and hormone production
- Plant hormones may show different effects at different stages and at different concentrations
- Plant hormones act by signal transduction, i.e. an external signal is converted to internal signal and which in turn causes one or more cellular responses.

CLASSIFICATION

- Plant growth promoters:
  - It induces cell division, elongation, differentiation and the formation of flowers, fruits and seeds.
  - e.g. auxins, gibberellins, cytokinins
- Plant growth inhibitors:
  - They are linked to dormancy, abscission and various stress responses,
  - e.g. Abscisic acid (ABA)
- Ethylene, the gaseous hormone has inhibitory as well as growth-promoting effects

The 'bakane' (foolish seedling) disease of rice seedlings, was caused by a fungal pathogen *Gibberella fujikuroi*. E. Kurosawa reported the appearance of symptoms of the disease in uninfected rice seedlings when they were treated with sterile filtrates of the fungus. The active substances were later identified as gibberellic acid.

F. Skoog and his co-workers observed that from the internodal segments of tobacco stems the callus (a mass of undifferentiated cells) proliferated only if, in addition to auxins the nutrients medium was supplemented with one of the following: extracts of vascular tissues, yeast extract, coconut milk or DNA. Skoog and Miller, later identified and crystallised the cytokinesis promoting active substance that they termed kinetin.

During mid-1960s, three independent researches reported the purification and chemical characterisation of three different kinds of inhibitors: inhibitor-B, abscission II and dormin. Later all the three were proved to be chemically identical. It was named abscisic acid (ABA).

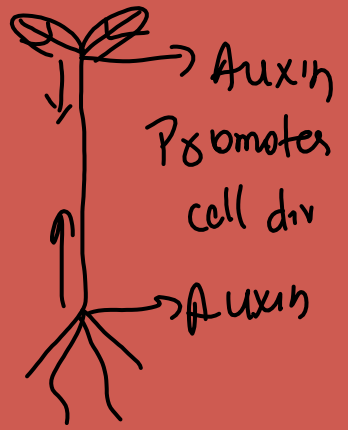
Cousins confirmed the release of a volatile substance from ripened oranges that hastened the ripening of stored unripened bananas. Later this volatile substance was identified as ethylene, a gaseous PGR.

DISCOVERY

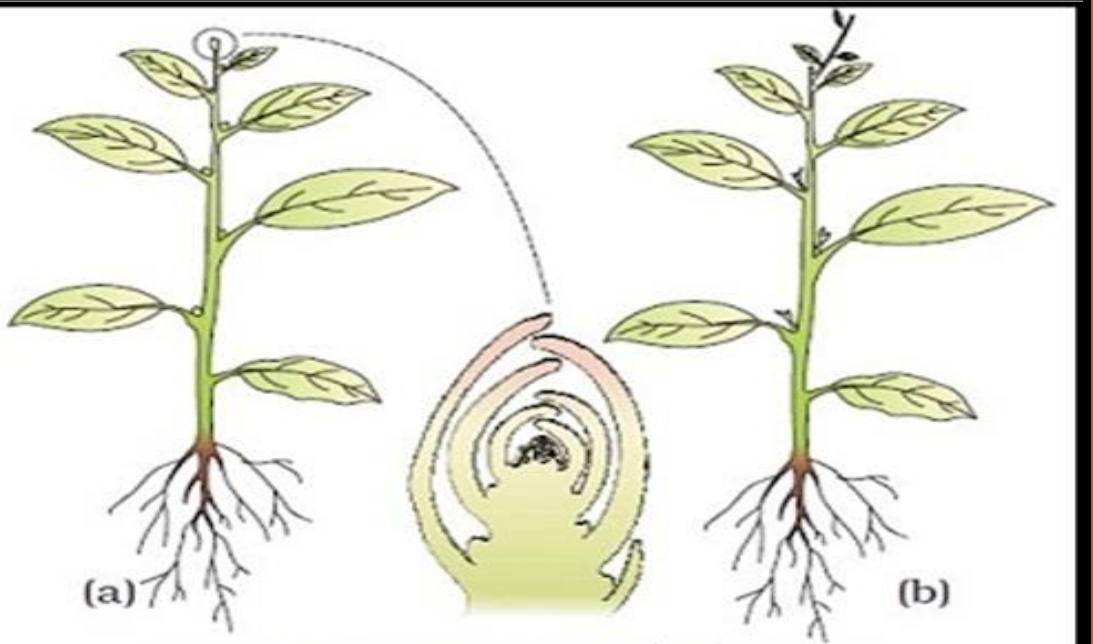
- Skoog discovered that callus proliferation in the internodal region takes place, only if auxin was supplemented with coconut milk or DNA, yeast or vascular tissue extract
- Miller et al later identified and crystallised cytokinin and termed as kinetin from herring sperm DNA.
- H.H. Cousins discovered the presence of a gaseous substance in ripened oranges, which hastened the ripening of bananas

AUXIN

- Produced in root and shoot apices.
- It gets transported to various parts.
- The transport of auxin is polar or unidirectional.
- **Natural auxins:**
  - IAA (Indole acetic acid)
  - IBA (Indole butyric acid)
- **Synthetic auxins:**
  - 2,4-D (2, 4-Dichlorophenoxyacetic acid)
  - NAA (naphthalene acetic acid).



APICAL DOMINANCE



Apical dominance in plants :
(a) A plant with apical bud intact
(b) A plant with apical bud removed
Note the growth of lateral buds into branches after decapitation.

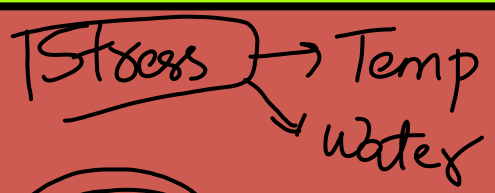
CYTOKININ

- There are many naturally occurring cytokinins, e.g. zeatin.
- They influence cytokinesis and are produced in the rapidly dividing cells, e.g. growing buds, young fruits and root apices

Kinetin

ABSCISIC ACID

- It is known as the stress hormone.
- It acts as an inhibitor of plant growth.
- It is produced in all the cells containing plastids.
- It is an antagonist of GAs



PHYSIOLOGICAL EFFECTS OF ABA:

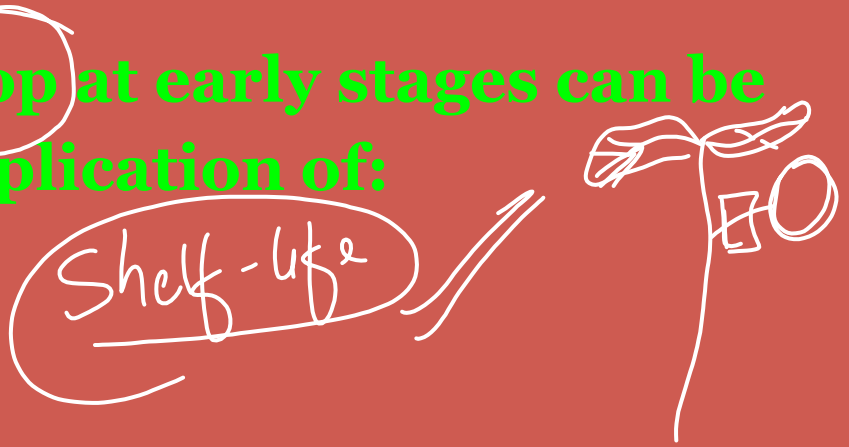
- Seed dormancy
- Closure of stomata and tolerance to various stresses
- Seed development and maturation

PHYSIOLOGICAL EFFECTS OF ETHYLENE

- Fruit ripening, e.g. tomatoes, apples,
- Senescence and abscission of leaves, flowers and fruits, e.g. cotton, walnut, cherry
- Maintenance of apical hook on seedlings
- Breaks seed and bud dormancy and initiates seed germination, e.g. peanut seeds, potato tubers
- Root initiation
- Internode and petiole elongation in water plants
- Promotes flowering and femaleness, e.g. cucumbers, mangoes
- Initiate germination in peanut seeds sprouting of potato tubers

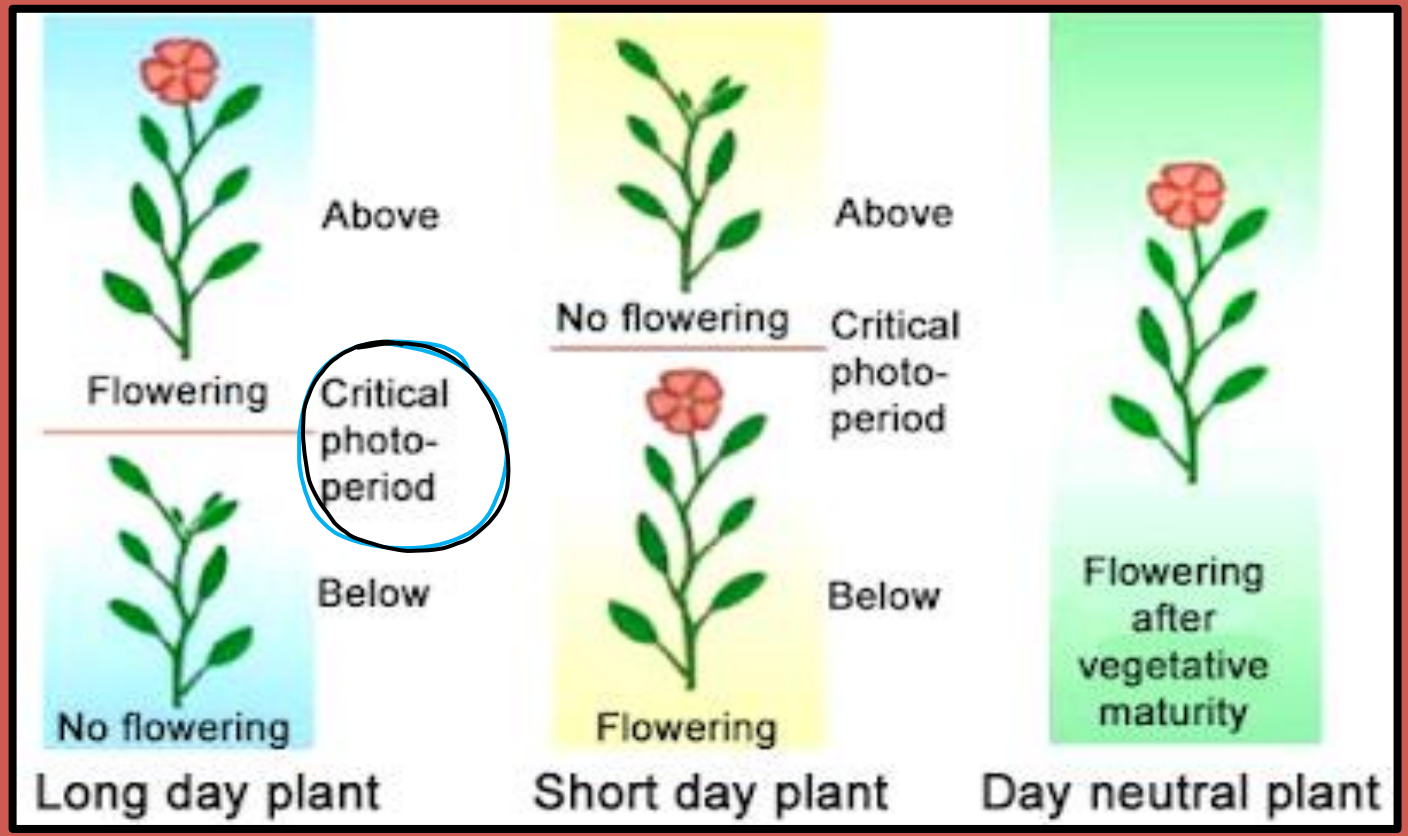
NEET PYQ

Q. Fruit and leaf drop at early stages can be prevented by the application of:



A. Ethylene
B. Auxins
C. Gibberellic acid
D. Cytokinins

PHOTOPERIODISM



VERNALISATION

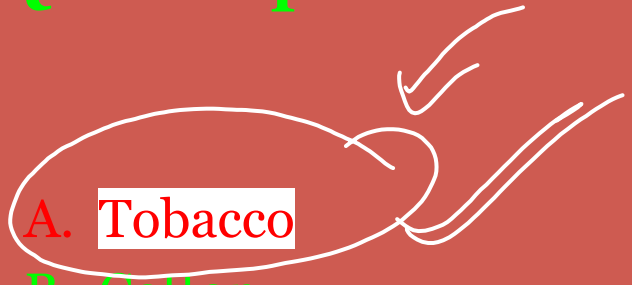
- Winter varieties are planted in autumn and harvested in mid-summer.
- Winter varieties will not flower within the growing season if planted in spring.
- Biennial plants need a period of low temperature to flower in subsequent months, e.g. cabbage, sugarbeet, carrots

CAUSES OF SEED DORMANCY

- Hard and impermeable seed coat
- Chemical inhibitors, e.g. ABA, para-ascorbic acids, phenolic acids, etc.
- Immature embryo
- The seed coat is broken by natural abrasions such as microbial action and digestive tract enzymes in animals, which eat seeds. This can also be induced artificially by knives, vigorous shaking and sandpaper.
- The effect of hormones can be overcome by cold temperatures, nitrates and gibberellic acids.

NEET PYQ

Q.Photoperiodism was first characterised in



A. Tobacco
B. Cotton
C. Tomato
D. Potato

NEET PYQ

Q. Treatment of seed at low temperature under moist conditions to break its dormancy called

A. Scarification
B. Stratification
C. Vernalisation
D. Chelation