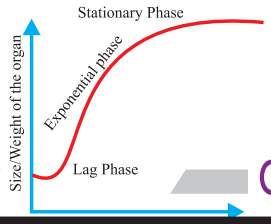

Chapter - 15

Plant Growth and Development

Plant Growth Regulators

Growth

An irreversible permanent increase in size of an organ or its parts or a cell

Growth is indeterminate and measurable. It is accompanied by metabolic process.

Phases of Growth

Meristematic : constantly dividing cells.

Elongation : Increased vacuolation, cell enlargement, new cell wall depositions.

Maturation : Cells attain maximum size in terms of well thickening & protoplasmic modifications.

Growth Rates

Arithmetic Growth : Linear curve on ploting length of organ against time $L_t = L_o + rt$.

Geometric Growth Rate : Shows leg phase, exponential phase and stationary phase in growth.

$W_1 = Woe^{rt}$

Important Processes

Differentiation

Dedifferentiation

Redifferentiation

Conditions of Growth

Need water, oxygen, nutrients, optimum temperature, light.

Development

Include all the changes that an organism goes during its life cycle.

Growth Promoters

Auxins: IAA, IBA, NAA & 2, 4-D. isolated by F W Went from tips of coleoptiles of oat seedling.

Main role apical dominance, initiate rooting for plant propagation, promote flowering, induce parthenocarpy.

Giberellins: GA_1 GA_2 G_3 Aetc isolated by E. Kurosawa, 1926.

Role : Increase in stem height, delay senescence, speed up malting process, promote bolting.

Cytokinins : Skoog & miller.

Role Rapid cell division, over come apical dominance, promote nutrient mobilisation delay leaf senescence.

Growth Inhibitors

Abscisic Acid : ABA discovered by F. T. Addicott.

Role Intibit sead germination, induce dormancy, closure of stomata, increase tolerance to stressful conditions.

Ethylene - neither promoter nor inhibitor stristly

Discovered by H. H. Cousins (1910), only gaseous PGR.

Role Ripening of fruits, apical hook formation in dicot seeding, promote senescence and abscission, break seed and bud dormancy, promote root growth and root hair formation, initate germination in peanut seeds, and sprouting of potato tubers.

Rate of light & temperature in flowering

Response of plants to period of day/night is called photoperiodism.

Plants can be LDP, SDP and DNL.

Vernalisation

Promotion of lowering by a period of low temperature. It affect flowring quantitatively or qualitatively.

Seed Dormancy

The period in which a seed fail to germinate even when external conditions are favourable.

Causes of seed dormancy.

Impermeable & hard seed coat, immature embryos' presence of chemical inhibitors like ABA, Phenelic Acid, Para- ascorbic acid.

Means to break seed dormancy:

- By mechanical abrasions.
- Microbial action as passing through digestive tract of animals.
- Subjecting to chilling conditions.
- Applying GA and nitrates.
- Changing environmental conditions like light & temperature.

Points To Remember

Seed Germination : The seed germinates only when favourable conditions for growth exists in the environment. In absence of favourable conditions it goes into a period of suspended growth or rest, called dormancy.

Abscission : Shedding of plant organs like leaves, flowers and fruits etc. from the mature plant.

Apical dominance : Suppression of the growth of lateral buds in presence of apical bud.

Dormancy : A period of suspended activity and growth usually associated with low metabolic rate. Some, seeds undergo a period of dormancy and can germinate only after dormancy period gets over.

Phytochrome : A pigment, found in plants which control the light dependent developmental process.

Phytohormone : Chemicals secreted by plants in minute quantities which influence the physiological activities.

Senescene : The last phase of growth when metabolic activities decrease.

Vernalisation : A method of promoting flowering by exposing the young plant to low temperature.

Growth : An irreversible permanent increase in size, volume and weight of an organ or its parts or even of an individual cell.

Quiescence : Non-germination of a viable seed due to non-availability of proper environmental conditions.

Vivipary : It is the germination of seed while it is still attached to the parent plant and is nourished by it. *e.g., Rhizophora* and *Sonneratia*. As the germinating seed forms a seedling. It fall down into the mud due to increase in weights. In the mud, lateral roots develops for anchorage.

Heterophylly : Occurrence of more than one type of leaves in plants *e.g.,* larkspur, coriander leaves of juvenile plant are different in shape from mature plant.

Bolting : Elongation of internodes prior to flowering in plants like cabbage.

Photoperiodism : Response of Plants to relative periods of day/night to induce flowering.

According to duration of exposure of plants to light, plants are divided in 3 categories :

1. **Long Day Plants (LDP)—**Plants which need exposure to light for period exceeding critical duration *e.g.,* wheat, rice, cucumber.

2. **Short Day Plants (SDP)**—Plants which need exposure to light for period less than the critical length *e.g.,* Cabbage.
3. **Day Neutral Plants (DNP)**—There is no correlation between exposure to light duration & induction of flowering *e.g.,* Tomato.

Abbreviations

IAA	Indole acetic acid
NAA	Napththalene acetic acid
ABA	Abscisic acid
IBA	Indole-3 butyric acid
2,4-D	2,4 dichlorophenoxy acetic acid
PGR	Plant growth regulator

Seed Dormancy	Quiescence
It is the condition of seed when it is unable to germinate in spite of the availability of all environmental conditions suitable for germination. It can be due to immature embryo or pressure of growth inhibitors.	The condition of a seed when it is unable to germinate because the conditions for germination are not available, such as moisture, temperature etc.

Measurement of growth : Plant growth can be measured by a variety of parameters like increase in fresh weight, dry weight, length, area, volume and cell number.

Phases of growth : The period of growth is generally divided into three phases, namely, meristematic, elongation and maturation.

(i) **Meristematic :** New cell produced by mitotic division at root-tip and shoot-tip thereby show increase in size. Cells are rich in protoplasm and nuclei.

(ii) **Elongation :** Zone of elongation lies just behind the meristematic zone of roots and concerned with enlargement of cells.

(iii) **Maturation :** The portion lies proximal to the zone of elongation in roots. The cells of this zone attain their maximum size in terms of wall thickning and protoplasmic modification.

Growth rate : The increased growth per unit time is termed as growth rate. The growth rate shows an increase that may be arithmetic or geometrical.

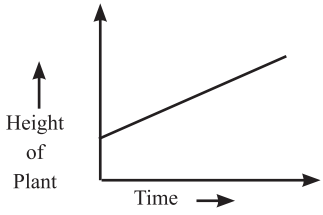

Fig. Linear growth curve

Growth	Mathematical expression	Curve
In Arithmetic growth : Only one daughter cell continues to divide mitotically while other differentiate and matures.	$L_1 = L_0 + rt$ L_1 = Length at time t L_0 = Length at time zero r = growth rate	Linear curve

Sigmoid Growth Curve

Geometrical growth	Formula	Shape of curve
The initial growth is slow (lag phase) and increase rapidly there-after at an exponential rate (log phase) In both, the progeny cells divide mitotically and continue to do so. However, with limited nutrient supply, the growth slow down leading to stationary phase.	$W_1 = W_0 e^{rt}$ W_0 = Initial size W_1 = Final Size r = growth rate t = time of growth e = base of natural logarithms	Sigmoid or S-curve

Sigmoid growth curve

Lag phase : Growth is slow in initial stage.

Exponential phase : Period of maximum growth

Stationary phase : When the nutrients become limiting, growth slows down.

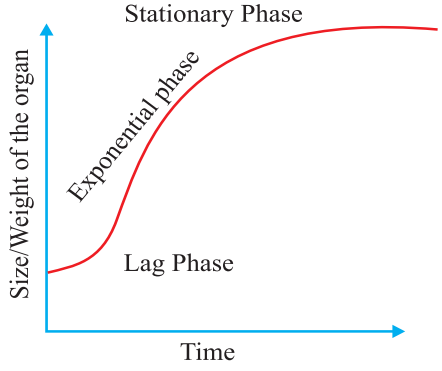

Fig. Sigmoid growth curve

Relative Growth : The growth per unit time as percentage of initial size

$$\text{RGR} = \frac{\text{Growth per unit time}}{\text{Initial size}} \times 100$$

Differentiation : A biochemical or morphological change in meristemic cell (at root apex and shoot apex) to differentiate into permanent cell is called differentiation. e.g. loss of protoplasm by tracheary elements.

Dedifferentiation : The phenomenon of regeneration of permanent tissue to become meristematic is called dedifferentiation. eg. formation of interfascicular cambium and cork combium from parenchymatous cells.

Redifferentiation : Meristems/tissue are able to produces new cells that once again lose the capacity to divide but nature to perform specific functions. e.g. secondary cortex, secondary xylem etc.

Conditions or factors influencing Growth

1. Nutrition 2. Availability of water 3. Temperature 4. Oxygen 5. Light 6. Gravity 7. Stress factors like minerals, water or temperature etc.

Phytohormone or Plant Growth-Regulator

Growth promoting hormones : These are involved in growth promoting activities such as cell division, cell enlargement, flowering, fruiting and seed formation. *e.g.,* Auxin, gibberellins, cytokinins.

Growth inhibitor : Involved in growth inhibiting activities such as dormancy and abscission. *e.g.,* Abscisic acid and Ethylene.

Hormones	Functions
1. Auxins (Growth Promoters) e.g. Indole 3-Acetic Acid, 2, 4-D and 2, 4, 5,-T etc.	1. Apical dominance, cell elongation, Promote flowering prevent premature leaf and fruit falling, initiate rooting in stem cutting, as weedicide, induce parthenocarpy.
2. Gibberellins $GA_3 (C_{19}H_{22}O_6)$ e.g, GA_4, GA_7, GA_{19} and GA_{20} etc.	2. Delay senescence, speed up malting process, increase in length of axis (grape stalk), increase in length of stem (sugarcane), bolting in beet, cabbages and many plants with rosette habit.

3. Cytokinins (Growth Promoters) *e.g.* Zeatin (trans 6-purine) DMAA-Dimethylalyl adenine and Isopentyl adenine (IP) etc.	3. Promote cell division, induce cell enlargement, reduce apical dominance, induce growth in auxiliary bud, chlorophyll preservation, lateral shoot growth, adventitious root formation.
4. [Ethylene ($H_2C = CH_2$) A gaseous PGR which acts as growth promoters as well growth inhibitor (mainly as growth inhibitor)	4. Promotes senescence and abscission of leaf and fruits, promotes ripening of fruits, break seed and bud domancy, initiate germination in peanut, sprouting of potato tuber, promotes root growth and root hair formation.
5. Abscisic acid (ABA) eg. (Abscisin II, Dormin)	5. Inhibit seed germination, stimulate closer of stomata, increase tolerance to various stress, induce dormancy in seed and bud, promotes ageing of leaf (senescence). Can delay the ripening of stored fruits as it absorbs the ethylene.

Vernalisation : The phenomenon in which flowering is either quantitatively or qulitatively dependent on exposure to low temperature. eg wheat, barley, rye, bi-ennial plants like sugarbeet cabbage, carrots. It prevents precocious reproductive development late in the growing season and enables the plant to have sufficient time to reach maturity

Questions

(SRT) Select Response Type Question (1 mark each)

1. The cause of 'BAKANE' disease of rice
   (a) Gracilaria (b) Gibberella fujikuroi
   (c) Geledium (d) Anabena
2. Which plant hormone was first isolated from human urine.
   (a) Ethylene (b) ABA
   (c) Auxin (d) Cytokinin

3. The only gaseous plant hormone is

(a) Gibberllins (b) Dormin

(c) Zeatin (d) Ethylene

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer Question (1 mark each)

4. How does abscisic acid acts as stress hormone in drought condition ?
5. A farmer observed some broad-leaved weeds in a wheat crop farm. Which plant hormone would you suggest remove them ?
6. Name the plant growth regulators you should use to (a) Increase the yield of sugarcane (b) Promote lateral growth (c) Cause sprouting of potato tuber (d) Inhibit seed germination.
7. Why do lateral buds start developing into branches when apical bud is removed ?
8. Flowering in certain plant occur only when they are exposed to low temperature for a few weeks. Name this phenomenon.
9. A hormone released by an over ripe apple in a wooden box will cause ripening of all other apples too. Name the hormone, and to which class it belongs to?

Short Answer Question-I (2 marks each)

10. How will you induce lateral branching in a plant which normally does not produce them ? Give reason.
11. What induces ethylene formation in plants ? Give any two different action of ethylene on plants.
12. What is meant by abscission ? Name phytohormone involved in it.
13. What is meant by apical dominance ? Which hormone control it ?
14. Differentiate between photoperiodism and vernalization.
15. Name a hormone which is :

    (a) gaseous in nature (b) responsible for phototropism (c) used for killing dicot weeds (d) Induces flowering in long day plants.

Short Answer Questions-II (3 marks each)

16. A primary root grows from 5 cm to 19 cm in a week. Calculate the growth rate and relative growth over the period.

17. Where are the following hormones synthesised in plants (a) IAA (b) gibberellins (c) cytokinins.
18. What would be expected to happen if :
    (a) GA_3 is applied to rice seedling?
    (b) a rotten fruit get mixed with unripe fruits?
    (c) you forget to add cytokinin to the culture medium?
19. Which growth hormone is responsible for the following :
    (a) induce rooting in a twig
    (b) quick ripening of a fruit
    (c) delay leaf senescence
    (d) 'bolt' a rosette plant
    (e) induce immediate stomatal closure in leaves
    (f) Induce growth in axillary buds.
20. Define differentiation, dedifferentiation and redifferentiation.
21. Where are auxins generally produced in a plant ? Name any one naturally occurring plant auxin and any one synthetic auxin.
22. Define growth rate. Name two types of growth. Draw the growth curves for these two types.
23. Mention various parameters taken into consideration for measuring the growth.

Long Answer Question (5 marks each)

24. Enlist the five categories of phytohormone. Write atleast two uses of each.

Answers

(SRT) Select Response Type Question (1 mark each)

1. (b) *Gibberella fujikuroi.*
2. (c) Auxin.
3. (d) Ethylene.

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer (1 mark each)

4. ABA cause rapid closure of stomata, preventing loss of water by transpiration.
5. 2.4-D.
6. (a) Gibberellin (b) Cytokinin
   (c) Ethylene (d) Abscisic acid
7. Due to inhibition of the activity of auxin the apical dominance is removed.
8. Vernalisation.
9. Ethylene, plant growth inhibitor.

Short Answers-I (2 marks each)

10. When apical bud is removed, lateral branches are produced. Du to removal of apical bud, the auxin is destroyed, thus inducing the lateral buds to grow rapidly.
11. Refer NCERT Book
12. - Premature fall of leaf and fruit is called abscission.
    - Abscisic acid
13. Refer NCERT Book
14. Refer NCERT Book
15. (a) Ethylene C_2H_2 (b) Auxin (c) 2, 4-D (d) Gibberellin

Short Answers-II (3 marks each)

16. (a) Growth = 19 – 5 = 14 cm, Period = 7 days

    Growth rate = $\frac{14}{7}$ = 2cm/day

    (b) Inititial growth = $\frac{7}{5}$ cm

    Growth rate per day $\frac{19-5}{7}$ = 2 cm

    Relative growth rate = $\frac{2}{5} \times 100 = 40\%$

17. (a) IAA = Shoot apex

    (b) Gibberellin – young leaves of buds, root tips

    (c) Cytokinins – Root apical meristan

18. (a) Hyper elongation of internodes of rice seedlings will occur.

    (b) Unripe fruits will lead to early ripening and ultimately it will result in rottening.

    (c) Shoot but formation will not occur.

19. Refer Points to Remember of Support Material

20. Refer Points to Remember of Support Material

21. Refer Points to Remember of Support Material

22. Refer Points to Remember of Support Material

23. Refer Points to Remember of Support Material

Long Answers (5 marks each)

24. Refer NCERT Text Book.

Assertion Reasoning (1 mark each)

The following question consists of 2 statements - Assertion (A) and Reason (R). Answer the question by selecting the appropriate option below :

(a) Both A and R are true and the reason is a correct explanation of the assertion

(b) Both A and R are true and the reason is not a correct explanation of the assertion

(c) The assertion A is true but the reason R is false

(d) Both the assertion A and reason R are false

(e) The assertion A is false but the reason R is true

25. **Assertion (A) :** Plant growth regulators are phytohormones, they are required for various metabolic activities for growth in plants.

    Reason (R) : Auxins, if applied on *Pinus*, will not induce flowering.

26. **Assertion (A) :** Plant growth is measurable.

    Reason (R) : Growth only means addition of dry weight in the plant.

(a) Both A and R are true and the reason is a correct explanation of the assertion

27. **Assertion (A) :** 'r' in logistic growth means exponential growth.

Reason (R) : It is also known as the efficiency index.

28. **Assertion (A) :** Heterophylly in larkspur is due to dedifferentiation.

Reason (R) : There is no role of environment in plasticity.

29. **Assertion (A) :** Cytokinin is produced in actively dividing cells.

Reason (R) : It helps in producing new leaves and shoots in plants.

Solution:

Assertion Reasoning

25. (b) (Plant growth regulators regulate growth but will not induce flowering)
26. (c) (Growth is measured by a variety of parameters some of which are: increase in fresh weight, dry weight, length, area, volume and cell number)
27. (e) ('r' is relative growth rate)
28. (d)
29. (a)

Source-based/Case-based/Passage-based/Integrated assessment questions

(4 marks each)

Read the following and answer any **four** questions from (i) to (v) given below :

30. The process by which prolonged exposure to cold temperatures. 4°C or less, promotes flowering is called vernalisation. It was first studied in 1918 by Gassner. It is believed that due to prolonged cold treatment, a hypothetical hormone like substance vernalin is produced in meristematic regions which induce flowering. Some monocarpic plants, which die when they flower, require vernalisn to flower, mostly requiring two seasons to complete the life cycle. Such plants are biennials or winter annuals. Cold exposure is a most for such plants to flower. Some monocarpic plants that are annuals but they do not require any cold treatment for flowering, such plants are called summer annuals. Many perennial such as stone fruit plants also require cold treatment to flower. Winter cereals such as autumn wheat also require cold

treatment to flower. If such wheat is grown in spring, it will continue growing vegetatively and will flower only after the upcoming winter season. Vernalisation can be reversed. It is done for sowing seeds of onions which are stored in cold storage for long. Applying plant growth regulators which cause bakanae disease can also help some seeds to germinate and skip prolonged cold periods.

(i) Which hypothetical precursor hormone is believed to be produced in meristematic regions of plants after vernalisation?

(a) Photolin (b) Vernalin

(c) florigen (d) morphactin

(ii) The plants which die after flowering are called _____?

(a) Polycarpic plants (b) Bicarpic plants

(c) Monocarpic plants (d) Plietesialic plants

(iii) Spring wheat does not require prolonged cold treatment for flowering. (T/F)

(iv) Name any two monocarpic plants that require vernalisation.

(v) Which of the following plant growth regulators can replace vernalisation?

(a) Gibberellin

(b) Auxin

(c) Cytokinin

(d) Ethylene

Solutions:

Source-based/Case-based/Passage-based/Integrated assessment questions

30. (i) (b) Vernalin

(ii) (c) Monocarpic plants

(iii) True

(iv) Sugarbeet, cabbage, carrots (any two)

(v) (a) Gibberellin