Plant Growth and Development

CHAPTER 15

NCERT FOCUS

ANSWERS

Topic 1

1. Growth is defined as a vital process which brings about an irreversible and permanent change in the shape, size, form, weight and volume of a cell, organ or whole organism, accompanied with increase in dry matter.

Differentiation is a localised qualitative change in size, biochemistry, structure and function of cells, tissues or organs, *e.g.*, fibre, vessel, tracheid, sieve tube, mesophyll, leaf, etc. Thus it is a change in form and physiological activity. It results in specialisation for particular functions.

Development may be defined as a process which includes growth, differentiation and maturation in a regular sequence in the life history of a cell, organ or organism *viz*. seed germination, growth, differentiation, flowering, seed formation and senescence.

Dedifferentiation is the process by which the differentiated cells which have lost the ability to divide under certain circumstances, become meristematic and regain the divisibility.

Redifferentiation is defined as maturation or differentiation of dedifferentiated cells to form cells which are unable to divide *e.g.*, secondary xylem elements, cork cells etc., are formed by redifferentiation of secondary cambial cells.

Determinate growth is the ability of cell, tissue or the organism to grow for a limited period of time.

Meristem is tissue consisting of unspecialised immature cells, possessing the power of continuous cell division and adding new cells to the body.

Growth rate is defined as the increased growth of an organism per unit time.

2. A flowering plant consists of a number of organs *viz*., roots, stem, leaves, flowers, fruits etc. growing differently under different stages of life cycle. These plant organs require different parameters to demonstrate their growth. In plant organs like fruits, bulbs, corms etc. fresh weight is used for measuring their growth. In case of fruits, increase in volume, diameter etc., are also used as other parameters for the measurement of their growth. For flat organs like leaves, increase in surface area is used as the parameter. Stem and roots primarily grow in length and then in girth, thus increase in length and diameter are used for measuring their growth. Consequently, the flowering plants exhibit several parameters to demonstrate growth.

3. (a) Arithmetic growth : If the length of a plant organ is plotted against time it shows a linear curve, the growth is called arithmetic growth. In this growth the rate of growth is constant and increase in growth occurs in arithmetic progression, *e.g.*, length of a plant is measured as 2, 4, 6, 8, 10, 12 cms at a definite interval of 24 hrs. It is found in root or shoot elongating at constant rate. Arithmetic growth is expressed as

$$L_t = L_0 + r_t.$$

Here, L_t = length after time *t*, L_0 = length at the beginning, r = growth rate.

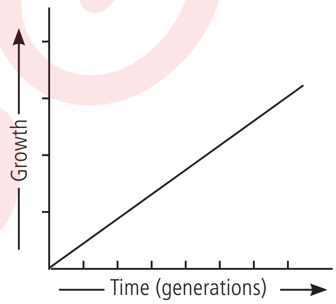

Fig. : Arithmetic growth curve

(b) Geometric growth : Geometric growth is the growth where both the progeny cells following mitosis retain the ability to divide and continue to do so. It occurs in many higher plants and in unicellular organisms when grown in nutrient rich medium. Number of cells is initially small so that initial growth is slow which is called lag phase. Later on, there is rapid growth at exponential rate. It is called log or exponential phase.

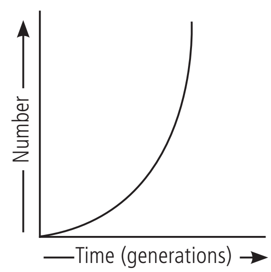

Fig. : Geometric growth curve

(c) Sigmoid growth curve : Geometric growth cannot be sustained for long. Some cells die. Limited nutrient availability causes slowing down of growth. It leads to stationary phase. There may be actually a decline. Plotting the growth against time will give a typical sigmoid or S-curve.

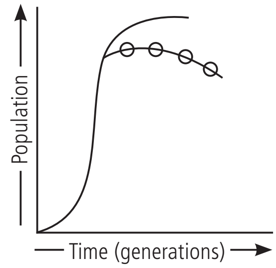

Fig. : Sigmoid growth curve

S-curve of growth is typical of most living organisms in their natural environment. It also occurs in cells, tissues and organs of plants.

(d) Absolute growth rate is the measurement of total growth per unit time.

Relative growth rate is growth per unit time per unit initial growth.

$$\text{Relative growth rate} = \frac{\text{Growth in given time period}}{\text{Measurement at start of time period}}$$

Suppose two leaves have growth by 5 cm^2 in one day. Initial size of leaf A was 5 cm^2 while that of leaf B was 50 cm^2. Though their absolute growth is the same (5 cm^2/day), relative rate of growth is faster in leaf A(5/5) because of initial small size than in leaf B(5/50).

4. Plant growth is generally indeterminate. Higher plants possess specific areas called meristems which take part in the formation of new cells. The body of plants is built on a modular fashion where structure is never complete because the tips (with apical meristem) are open ended - always growing and forming new organs to replace the older or senescent ones. Growth is invariably associated with differentiation. The exact trigger for differentiation is also not known. Not only the growth of plants are open-ended, their differentiation is also open, the same apical meristem cells give rise to different types of cells at maturity, *e.g.*, xylem, phloem, parenchyma, sclerenchyma fibres, collenchyma, etc. Thus, both the processes are indeterminate, unlimited and develop into different structures at maturity *i.e.*, both are open.

Topic 2

1. There are five main groups of natural plant growth regulators which are very much recognised as natural hormones in plants.

These are :

(i) Auxins
(ii) Gibberellins
(iii) Cytokinins
(iv) Abscisic acid
(v) Ethylene

Discovery of auxin : In 1880, Charles Darwin and Francis Darwin worked with the coleoptile of canary grass (*Phalaris* sp.) and found the existence of a substance in coleoptile tip, which was able to perceive the light stimulus and leads to the bending of tip towards light. Boysen and Jensen (1910-1913) worked on the substances secreted in the tip that are soluble in water (gelatin).

Paal (1919) reported that the substances secreted in the tip are translocated downwards and cause cell elongation in half portion which was on the dark side and hence bending was observed in opposite direction.

F.W. Went (1928) further refined this experiment and supported the observations of Paal. He was the first person to isolate and name these substances of tip as auxins (Greek *Auxein* - means 'to grow').

In 1931, Kogl and Haagen-Smith isolated crystalline compounds from human urine. These were named as auxin-a, auxin-b and heteroauxin.

Physiological functions of auxins :

(i) Auxins induce cambial cell divisions, shoot cell elongation and early differentiation of xylem and phloem in tissue culture experiments.

(ii) In general, auxins initiate rooting but inhibit the growth of roots. IBA is the most potent root initiator.

(iii) Auxins inhibit the growth of axillary buds (apical dominance) but enhance the size of carpel and hence earlier fruit formation.

(iv) Application of auxins retards the process of senescence (last degradative phase), the abscission of leaves, fruits, branches, etc.

(v) Auxins induce feminisation, *i.e.*, on male plant, female flowers are produced.

Agricultural/horticultural application of auxins :

(i) Application of auxins like IAA, IBA, NAA induce rooting in stem cuttings of many plants. This method is widely used to multiply several economically useful plants.

(ii) Normally, auxins inhibit flowering however in litchi and pineapple, application of auxin promotes flowering thus used in orchards.

(iii) Auxin induces parthenocarpy in some plants including tomato, pepper, cucumber and *Citrus*, thus, produces seedless fruits of more economic value.

(iv) Auxins like 2, 4-D and 2, 4, 5-T are commercially used as weedicides, due to their low cost and greater chemical stability. They are selective herbicides (killing broad-leaved plants, but not grasses).

(v) For checking premature fruit drop, auxins are applied which prevent the formation of abscission zone in the petiole or just below the fruit. Auxin regulates maturing fruit on the trees of apples, oranges and grape. High doses of auxins can cause fruit drop. Thus, heavy applications of synthetic auxins are used commercially to promote a coordinated abscission of various fruits to facilitate harvesting.

(vi) Auxin, produced in the apical bud, suppresses the development of lateral buds, *i.e.*, apical dominance. Thus practically used in prolonging the dormancy period of potato tubers.

(vii) Naphthalene acetamide is used to prevent the lodging (excessive elongation and development of weak plants, specially in Gramineae) or falling of crops.

(viii) Auxin (2, 4-D) promotes callus formation in tissue culture. Complete plantlets are regenerated from callus tissue, using auxins and cytokinin which are then transplanted into the soil. Now-a-days, this is a widely practised method of propagation in the field of agriculture and horticulture.

2. A fairly high concentration of abscisic acid (ABA) is found in leaves of plants growing under stress conditions, such as drought, flooding, injury, mineral deficiency etc. It is accompanied by loss of turgor and closure of stomata. When such plants are transferred to normal conditions, they regain normal turgor and ABA concentration decreases. Since the synthesis of ABA is accelerated under stress condition and the same is destroyed or inactivated when stress is relieved, it is also known as stress hormone.

3. (a) Auxins like IBA, NAA.
(b) Ethylene
(c) Cytokinins
(d) Cytokinins
(e) Gibberellins
(f) Abscisic acid (ABA)

4. (a) The coleoptile will elongate rapidly, as GA_3 helps in cell growth.
(b) The development of callus (mass of undifferentiated cells) will take place.
(c) The unripe fruits will ripe quickly because of the increased rate of respiration due to emission of ethylene from rotten fruit.
(d) Cell division will retard and shoot formation will not initiate from the callus.