

Lecture: 24

GROWTH

Growth is an irreversible increase in size. It may be evaluated by measurements of mass, length or height, surface area or volume.

Growth is restricted only to living cells and is accomplished by metabolic processes involving synthesis of macromolecules, such as nucleic acids, proteins, lipids and polysaccharides at the expense of metabolic energy.

Growth at cellular level is also accompanied by the organization of macromolecules into assemblages of membranes, plastids, mitochondria ribosomes and other cell organelles. Cells do not definitely increase in size but divide, giving rise to daughter cells. An important process during cell division is synthesis and replication of nuclear DNA in the chromosomes, which is then passed into the daughter cells. Therefore, the term growth is used to denote an increase in size by cell division and cell enlargement, together with the synthesis of new cellulose materials and the organization of cellulose organelles.

Growth is also defined as a vital process which brings about a permanent change in any plant or its part in respect to its size, form, weight and volume.

Growth regions

Typical growth regions in plants are the apices of shoot and root. Such growing regions are known as apical meristemes, primary meristemes or regions of primary growth. These apical meristemes are responsible for the increase in length, differentiation of various appendages and formation of plant tissues.

Phases of growth

Growth is not a simple process. It occurs in meristematic regions where before completion of this process, a meristematic cell has to pass through the following 3 phases.

1. Cell formation phase
2. Cell elongation phase
3. Cell differentiation (cell maturation)

The cell formation phase is represented by meristematic zone and cell enlargement phase by cell elongation zone.

The dividing meristematic cells are thin walled and have dense protoplasm with a large nucleus and without or with very small vacuoles. The intercellular spaces are also absent. The newly formed cells after the first phase of cell division have to pass through the second phase of cell enlargement. During the second phase of cell elongation on account of large quantities of solutes inside the growing cell, water enters the cell due to osmotic effect resulting in the increased turgidity and expansion and dilation of the thin and elastic cell wall. This phase also results in appearance of large vacuoles.

In the last phase or cell maturation, second walls are laid down and cell matures and gets differentiated into permanent tissue.

Growth curve

Whether the growth rate of a cell, a plant organ, a whole plant or the whole life cycle of plant or the whole life cycle of plant is measured in terms of length, size, area, volume or weight. It has been found that different growth phases result in 'S' shaped curve or sigmoid curve. In initial stages during the phase of cell formation, the growth rate increases slowly while it increases rapidly during the phase of cell elongation or cell enlargement and again slows down during the phase of cell maturation.

The period during the growth shows increase is known as grand period of growth. Thus, in a standard growth curve three well marked regions can be observed, the initial growth stage (lag phase), the grand period of growth (exponential or log phase) and the steady stage (maturity stage or senescence or stationary phase). The overall growth may be affected by external or internal factors but the S- shaped curve of grand period of growth is never influenced.

This growth curve suits well to the entire life of an annual plant when measured interms of dry weight against time.

Early growth of the plant is limited by the amount of food reserves in the seed. When the emerged seedlings develops an adequate root system and enough leaf surface to support vigorous photosynthesis and anabolism, a period of rapid increase in size is possible.

High metabolic rates are not maintained indefinitely and eventually processes are set in motion that lead to cessation of growth. The factors responsible for the decrease in growth are competition for essential metabolites, growth substances, water, light or the accumulation of inhibitors, toxic substances or waste materials.

The English plant physiology is V.H. Blackman (1919) suggested that the growth of the plants can be represented by equation.

$$W_1 = W_0 e^{rt}$$

Where W_1 is the final size (W_t and h_t etc) after time t . W_0 is the initial size at the beginning of the time period. r is the rate at which plant substance is laid down during time 't' and is the base of natural laagering. Blackman pointed out that equation describes the way in which money placed at compound interest increases with time; the term compound interest law is used to describe such phenomenon. Bank usually apply compound interest quarterly or annually so that the increase in amount occurs as a jump. With plant system, compound interest is applied continuously and size increase follows a smooth curve.

From the equation, the final size of an organism (W_1) is sent to depend on the initial size (W_0). Larger seed give a larger plant.

In addition, equation shows that plant size also depends on the magnitude of r , the relative growth rate. Blackman suggested that r might be used as a measure of the ability of the plant to produce new plant material and called r the efficiency index. The plants with high efficiency index could be expected to outperform plants with low efficiency index.

Differentiation

- Process involved in the establishment of localized differences in biochemical and metabolic activity (specialized functions) and a structural organization that result in new patterns of growth.

Development

- The term is used to encompass the activities resulting from growth and differentiation.

- During development an orderly progression of transformations resulting in a characteristic form and chemical composition of plants takes place.

Totipotency

- Isolated plant cells have the inherent capacity to give rise to a whole plant
- The ability of every living plant cell to produce the entire plant is called totipotency

Morphogenesis

- Development of form or shape of cells and organs
- Direction of cell expansion (decided by orientation of cellulose deposition)
- Control of cell division

Measurement of Growth

- Plant height, leaf size (length, width, area), fresh weight, dry weight of different organs (stem, girth, leaves and fruits).
- Cell number in tissues, organs.
- Conc. of chemicals constituent DNA, RNA, soluble protein, CH₂O, lipids etc.

Vegetative growth

Genetical makeup, Nutrients (16 elements), Environment
 Hormonal regulation, Tropic movement, Apical dominance

Reproductive growth

Genetical makeup

Light – Photoperiodism

Temp – Thermoperiodism Vernalization

Moisture

Hormonal regulation - External & Internal

Nutrients - C: N - Ratio

Primary meristem

Apical meristem are formed during embryo
 development on the seed forms

Secondary meristem - The vascular cambium and meristematic zones are found near root and shoot tips in the vascular cambium.

Determinate growth - Germination → Leaves → flowers → fruits
the growth of particular organ is determined.

Indeterminate growth - Root tips, shoot tips, apical meristem cells have capacity to regenerate

Determinate plants - Apical bud ends with inflorescence - Monocarpic senescence

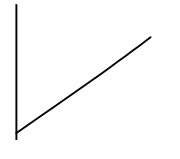
Indeterminate plants- Apical buds always vegetative - Floral buds in axils
Polycarpic senescence

Allometric Growth

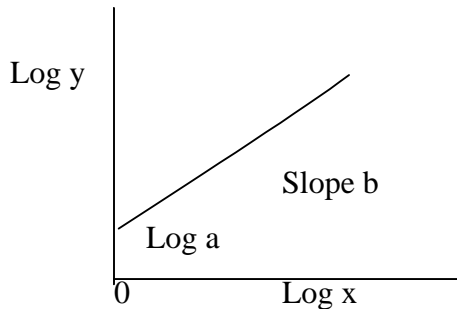
Growth of one part of plant may be closely related to growth of another part of the same plant, even though individual rates are different.

Linear $y = ax^b$
 Curvilinear $y = ax^{(b+c \log x)}$

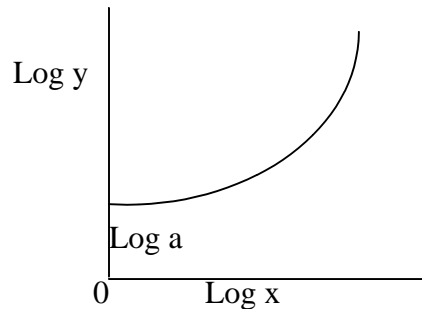
$\log y = \log a + b \log x$



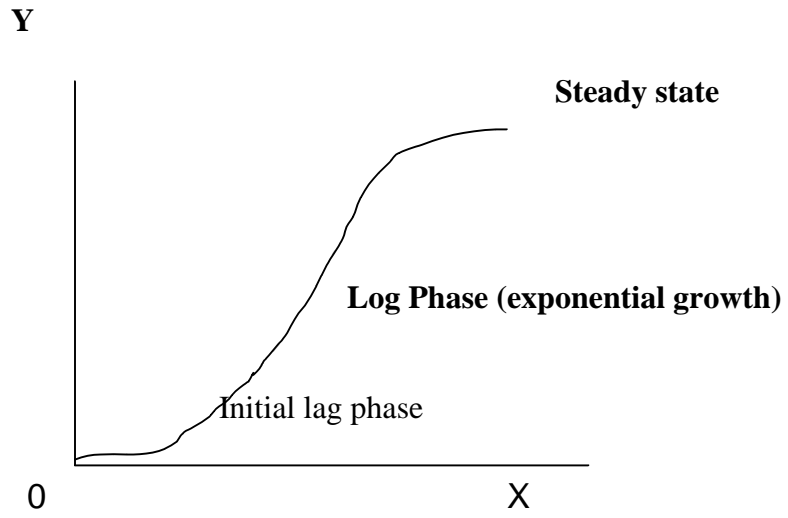
Linear



Curvilinear



Phases of growth - Sigmoid Curve



S – Shape or Wine cup shape