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PLANT GROWTH AND DEVELOPMENT

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, that occur at the expense of energy.

Plant Growth Generally is Indeterminate

Plant growth is unique because plants retain the capacity for unlimited growth throughout their life. This ability of the plants is due to the presence of meristems at certain locations in their body. The cells of such meristems have the capacity to divide and self-perpetuate.

This form of growth wherein new cells are always being added to the plant body by the activity of the meristem is called the open form of growth.

root apical meristem and the shoot apical meristem are responsible for the primary growth of the plants and principally contribute to the elongation of the plants along their axis. These are the meristems that cause the increase in the girth of the organs in which they are active. This is known as secondary growth of the plant

Growth is Measurable

Growth, at a cellular level, is principally a consequence of increase in the amount of protoplasm.

Growth is, therefore, measured by a variety of parameters some of which are: 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

The constantly dividing cells, both at the root apex and the shoot apex, represent the meristematic phase of growth.

The cells in this region are rich in protoplasm, possess large conspicuous nuclei. Their cell walls are primary in nature, thin and cellulosic with abundant plasmodesmatal connections.

The cells proximal to the meristematic zone represent the phase of elongation. Increased vacuolation, cell enlargement and new cell wall deposition are the characteristics of the cells in this phase.

Further away from the apex, i.e., more proximal to the phase of elongation, lies the portion of axis which is undergoing the phase of maturation.

The cells of this zone, attain their maximal size in terms of wall thickening and protoplasmic modifications.

Growth Rates

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

The simplest expression of arithmetic growth is exemplified by a root elongating at a constant rate. On plotting the length of the organ against time, a linear curve is obtained.

$L_t = L_0 + rt$

L_t = length at time 't'

L_0 = length at time 'zero'

r = growth rate / elongation per unit time.

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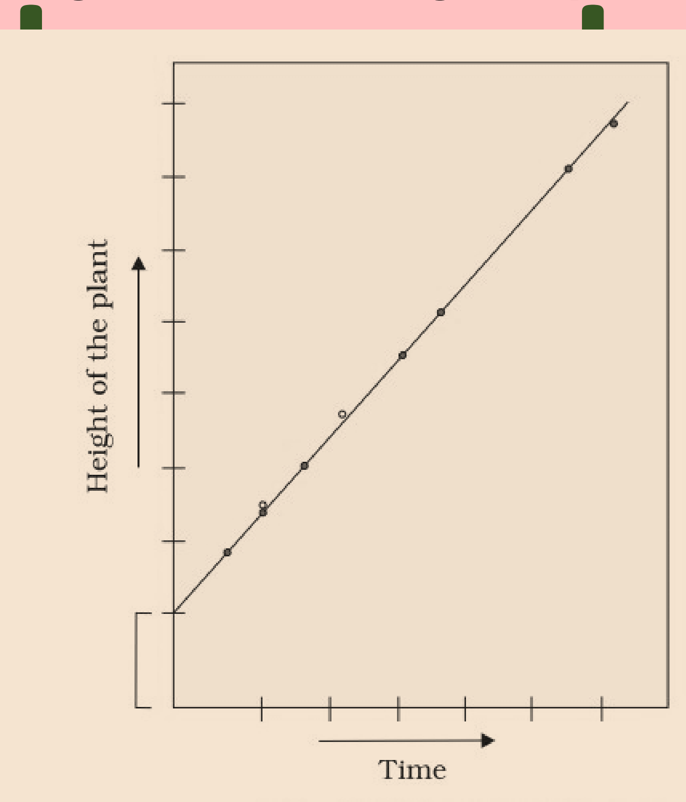

Constant linear growth, a plot of length L against time t

in geometrical growth. In most systems, the initial growth is slow (lag phase), and it increases rapidly thereafter – at

an exponential rate (log or exponential phase). If we plot the parameter of growth against time, we get a typical sigmoid or S-curve. A sigmoid curve is a characteristic of living organism growing in a natural environment.

The exponential growth can be expressed as

$W_1 = W_0 e^{rt}$

W_1 = final size

W_0 = initial size at the beginning of the period

r = growth rate

t = time of growth

e = base of natural logarithms

r is the relative growth rate and is also the measure of the ability of the plant to produce new plant material, referred to as efficiency index. Hence, the final size of W_1 depends on the initial size, W_0.

DIFFERENTIATION, DEDIFFERENTIATION AND REDIFFERENTIATION

DIFFERENTIATION

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

DEDIFFERENTIATION

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.

REDIFFERENTIATION

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

DEVELOPMENT

Development is a term that includes all changes that an organism goes through during its life cycle from germination of the seed to senescence

Plants follow different pathways in response to environment or phases of life to form different kinds of structures. This ability is called plasticity.

PLANT GROWTH REGULATORS

Characteristics

The plant growth regulators (PGRs) are small, simple molecules of diverse chemical composition. They could be indole compounds (indole-3-acetic acid, IAA); adenine derivatives (N_6 - furfurylamino purine, kinetin), derivatives

of carotenoids (abscisic acid, ABA); terpenes (gibberellic acid, GA_3) or gases (ethylene, C_2H_4).

The PGRs can be broadly divided into two groups based on their functions in a living plant body. One group of PGRs are involved in growth promoting activities, such as cell division, cell enlargement, pattern formation, tropic growth, flowering,

fruiting, and seed formation.

The PGRs of the other group play an important role in plant responses to wounds and stresses of biotic and abiotic origin.

Physiological Effects of Plant Growth Regulators

Auxins

The term 'auxin' is applied to the indole-3-acetic acid (IAA), and to other natural and synthetic compounds having certain growth regulating properties.

Auxins like IAA and indole butyric acid (IBA) have been isolated from plants. NAA (naphthalene acetic acid) and 2, 4-D (2, 4-dichlorophenoxyacetic) are synthetic auxins.

They help to initiate rooting in stem cuttings, an application widely used for plant propagation.

the growing apical bud inhibits the growth of the lateral (axillary) buds, a phenomenon called apical dominance.

Auxins also induce parthenocarpy.

Gibberellins

Gibberellins are another kind of promotory PGR. There are more than 100 gibberellins reported from widely different organisms such as fungi and higher plants. They are denoted as GA1, GA2, GA3 and so on.

All GAs are acidic. They produce a wide range of physiological responses in the plants.

Cytokinin's

Cytokinins have specific effects on cytokinesis, and were discovered as kinetin (a modified form of adenine, a purine) from the autoclaved herring sperm DNA.

Natural cytokinins are synthesised in regions where rapid cell division occurs.

Cytokinins help overcome the apical dominance. They promote nutrient mobilisation which helps in the delay of leaf senescence.

Ethylene

Ethylene is a simple gaseous PGR. It is synthesised in large amounts by tissues undergoing senescence and ripening fruits.

Ethylene promotes senescence and abscission of plant organs especially of leaves and flowers. Ethylene is highly effective in fruit ripening. It enhances the respiration rate during ripening of the fruits. This rise in rate of respiration is called respiratory climactic.

Abscisic acid

It acts as a general plant growth inhibitor and an inhibitor of plant metabolism. ABA inhibits seed germination. ABA stimulates the closure of stomata and increases the tolerance of plants to various kinds of stresses. Therefore, it is also called the stress hormone. ABA plays an important role in seed development, maturation, and dormancy. By inducing dormancy, ABA helps seeds to withstand desiccation and other factors unfavourable for growth. In most situations, ABA acts as an antagonist to GAs.