

Lecture-5

GROWTH AND DEVELOPMENT

5.1 'Growth' - definition:

Growth and Development are the most fundamental and conspicuous characteristics of all living organisms. According to dictionary, growth is the advancement towards maturity and development is a gradual increase in size. The plant physiological definition of growth is 'an irreversible increase in mass, weight or volume of a living organism, organ or cell.

5.2 Growth Curve:

Typical growth pattern of an annual plant is represented in figure.3. This can be divided into three phases.

1. Lag period of growth:

During this period the growth rate is quite slow because it is the initial stage of growth.

2. Log period of Growth

During this period, the growth rate is maximum and reaches the top because at this stage the cell division and physiological processes are quite fast.

3. "Senescence period or steady state period :

During this period the growth is almost complete and become static. Thus the growth rate becomes zero.

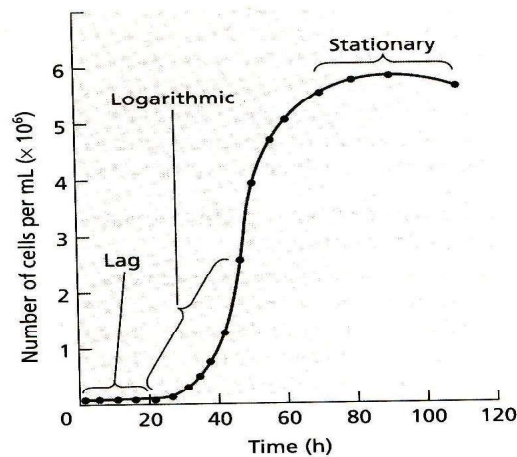


FIG.3 A TYPICAL 'S' SHAPED GROWTH CURVE

*Figure 3 is from reference 6

If the growth rate is plotted against time, an 'S' shaped curve is obtained which is called **sigmoid curve** or **grand period curve**.

The growth curve described above is seen in most cases, although there is a considerable difference due to variations in plant species as well as environmental factors. It is also apparent that growth in all parts of a multi cellular plant is not uniform. In higher plants, it is restricted only to the **meristematic zones** which are found near the root and the shoot tips, in the vascular cambium and in certain parts of young leaves.

Growth pattern of annual crops:

Here the first phase relates to the seed germination and seedling growth. Seeds germinating below ground are dependent on stored material in the cotyledons until the seedling emerge in to light and start photosynthesis. Hence, initial increase in weight is negligible. **(LAG PHASE)**

The second phase of growth is characterized by a rapid and often linear increase in dry matter production and terminates with flowering(anthesis). **(LOG PHASE)** It is associated with tillering, stem elongation and leaf expansion in cereals. In case of **indeterminate crops** such as Cotton, Pigeon pea etc. it is characterized by formation of branches with large number of leaves.

Initiation of flower buds signifies end of rapid growth phase **(grand period of growth)** and indicates onset of flowering.

The third phase of growth is marked by a reduction in growth rate until growth ceases at maturity. Assimilates stored in leaves and stems are translocated to partially sustain seed growth. At the end of this growth period, water is lost from aerial plant parts, photosynthesis stops and crop ripens **(STATIONARY PHASE AND DEATH)**.

5.3 TYPES OF GROWTH:

a) Determinate Organs :

Those organs that grow to certain size and then stop growing are called determinate organs. After their growth is completed they eventually senesce and die. Examples of such organs are leaves, flowers and fruits etc.

Determinate Growth:

If, reproductive growth starts only after completion of vegetative growth it is called as determinate growth habit.

Eg. Maize.

Indeterminate Organs:

Those organs which grow continuously with the activity of meristems are indeterminate organs. Examples are roots and vegetative stems of perennials. These structures always remain youthful, because of the meristematic activity.

Indeterminate Growth:

Here, vegetative and reproductive growth overlaps. This is shown in plants that have a capacity for both vegetative growth and flowering over an extended period.

Eg. Redgram, Soybean etc.,

5.4 Monocarpic and polycarpic species :

Monocarpic species flower only once and then die. Thus, in a sense monocarpic species are determinate as far as the entire plant is concerned.

Ex. Rice, Maize, Sunflower, Sugarcane, sorghum etc.

Polycarpic species flower more than once in life cycle. Here, the vegetative and reproductive periods overlap each other. This is seen in most of the tree species.

Most monocarpic species are annuals. However, some of them are biennials and perennials also. Many varieties of bamboos may grow and live for over 50 years and then they flower and die. Thus bamboos are perennial but monocarpic. All polycarpic plants are perennials.

5.5 Development :

Growth leads to the development. Development is defined as ordered change or progress often (but not always) towards a higher, more ordered or more complex state. However, these two processes are often linked together and occur in sequence. Growth is a quantitative change in contrast to development which is more of a qualitative change.

5.5.1 INITIATION AND DEVELOPMENT OF VEGETATIVE STRUCTURES:

5.5.1.1 Root growth: Radicle is the embryonic root. During the seed germination and seedling formation, it grows to form primary root of the seedlings. A growing root usually has 4 distinct regions,

1. Root cap
2. Meristematic region
3. The region of cell elongation and
4. The region of differentiation and maturation.

The root cap protects the root tip. The meristematic region in young root is situated just below the root tip. The cells in this region are responsible for growth in the root. The meristematic region consists of numerous small, compactly arranged thin walled cells almost completely filled with cytoplasm. They have very small vacuoles and comparatively large nuclei. Inter cellular spaces are absent. Only a few cells in the meristem may actually be involved in the longitudinal growth of the root.

F.A.L. Clowes and B.E. Jupiner (1968) demonstrated that there is a **quiescent center** in the meristematic region, where no cell division takes place. This center is located just above the root tip. It is surrounded by a group of actively dividing cells, which give rise to the column of cells forming roots.

The region of cell elongation is made up of column of newly derived cells. It is the elongation of these cells, which causes the root tip to project forward and push through. Most cells in this region elongate at least 15 folds and increase in diameter which results in the development of considerable pressure by the elongation of root.

The region of differentiation and maturation:

The cells in the region of differentiation and maturation differentiate into various tissues, characteristic to the mature root; the epidermis, cortex and stele.

In roots xylem and phloem differentiate only acropetally and as continuation of the older xylem and phloem in the more basal part of the root.

During differentiation most cells increase in size and vacuolation.

5.5.1.2 Stem growth : The life of stem starts as a plumule. It grows to form the shoot of the seedling. The longitudinal growth of stem and formation of various organs like branches, leaves, flowers is the function of stem meristem.

Tunica Corpus Theory:

To explain the cellular organizations of stem meristem, **A.Schmidt** (1924) first proposed a **tunica corpus theory**. Accordingly , most apical meristems contain two zones, an outer tunica and an inner Corpus. Tunica consists of one to several layers of cells at the surface of the meristem while corpus cells are beneath the tunica layer. The cells in tunica divide by anticlinal division i.e in a plane perpendicular to the surface of the stem, whereas the corpus cells divide in many different ways.

The formation of branches leaves or outer appendages on the stem are initiated in the formation of a primordium or out growth at the surface of the meristem, just below the tip. In the formation of aerial organs both tunica as well as corpus layers are involved. The tunica normally forms the epidermis of the organ derived from the

meristem, while corpus cells produce majority of the internal tissues of the new organ.

Auxins normally promote the elongation of stem. They induce the elongation of cells. Gibberellins also promote stem elongation and they do this by promoting cell division as well as cell elongation.

5.5.1.3 Leaf initiation and Growth: Elevations appear on the periphery of the meristem in a regular pattern. Leaf primordia appear as dome shaped on the periphery of the stem. They appear at nodal positions of the stem, which have an **intercalary meristem** when the leaves are to be produced in pairs; each pair usually appears to right angle to the preceding pair, the two leaves in a pair generally opposite to each other.

The growth of individual leaf also follows the typical sigmoidal pattern, just like the growth of the entire plant. In most plants, the shape and form of leaves are fixed and little variation found among them.

However, many plants have leaves of different shape. The phenomenon is termed as heterophylly, which is quite common in aquatic plants.

5.5.2 INITIATION AND DEVELOPMENT OF REPRODUCTIVE STRUCTURES

5.5.2.1 Initiation and Development of Flower:

Once the biochemical requirements for evocation of flowering are completed and the meristem has reached the point of no return, it develops either into an inflorescence (a cluster of flowers) or solitary flowers. In most plants, the pattern of flower initiation and development is almost similar. As an example of flower initiation in *Capsicum annum* (Green pepper) the first microscopically visible change in the shoot apex is the change in its shape. The apex almost becomes flat from conical, due to the inhibition of growth in the central portion of the meristem. Some protuberances develop from this meristem in a whorled manner. Floral parts (sepals, petals etc) are formed due to the development of the protuberances. The outermost whorl of the protuberances forms the sepal and next to it forms petals and so on.

Most plants produce bisexual flowers containing functional male (stamens) and female (pistils) parts. Other species contain staminate (male) and pistillate (female) flowers only on different individual plants.

Auxins and Ethylene stimulates the formation of female flowers, where as gibberellins increase the ratio of male to female flowers in the cucumber.

Initially, the floral parts are tightly enclosed with in the outer most part, the sepals, constituting a floral bud. Subsequently expansion of the flower bud in to an open flower occurs. The cause of the flower opening is usually due to the differential growth of the inner and outer sides of the sepals and petals.

5.5.2.2 Fruit and Seed Development:

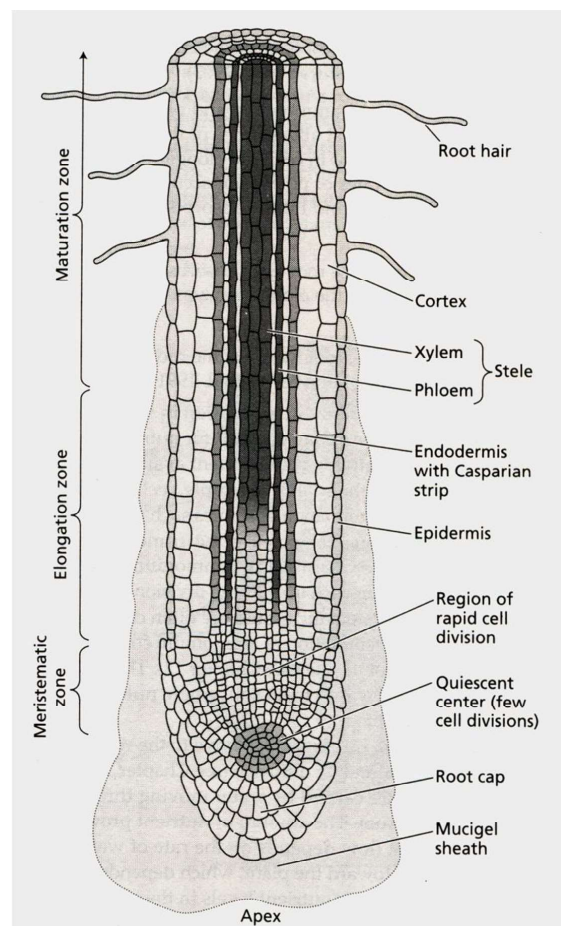
The first stage in fruit and seed development is rapid cell division without much enlargement due to cytokinin production by the endosperm which is growing at this stage. Various tissues of the parent plant *viz*, the ovary, receptacle and sometimes parts of the floral tube may be involved in the formation of fruits.

Following the cell division stage cell enlargement phase of growth proceeds and this is by auxins produced in the seeds. If the seeds are removed from a developing fruit, development stops, however it can be restarted again by the application of auxins.

It was observed that fruit development in cucumber is dependent on auxins which originate from the ovule, while some fruits respond rather to gibberellins than to auxin treatment.

At this stage in the development of fruits the concentration of organic acids and sugars begin to increase followed by decrease in osmotic potential. This is related to the increasing absorption of water and growth by enlargement of cells.

ANNEXURE



*Figures are from reference 6