

SENESCENCE

30.1 Definition: The term 'senescence' is derived from a Latin word "**Senescere**" which means to grow old'. The terms 'Senescence, Programmed Cell Death (PCD)', 'Apoptosis' and 'Ageing' are often used synonymously in plant or animal systems. All these terms generally refer to death of cells, organs or organisms.

In the life cycle of higher plants when they have reached a certain stage of maturity, they senesce and die. It should be clarified that the ageing is not the same as senescence. '**A degenerative and irreversible change in a plant which leads to death**' is called **senescence** whereas **ageing** is '**the process of attaining maturity with the passage of time**'.

30.2 CLASSIFICATION OF SENESCENCE (TYPES OF SENESCENCE):

Depending upon the part of the plant in senescence, **Leopold** (1961) has classified senescence into following four categories.

A. **Overall senescence:** (whole plant senescence): In this kind of senescence, there is senescence and death of the entire plant, which usually takes place at the end of reproductive phase.

Eg: Cereal crops like maize, wheat and rice and also in mustard and cabbage

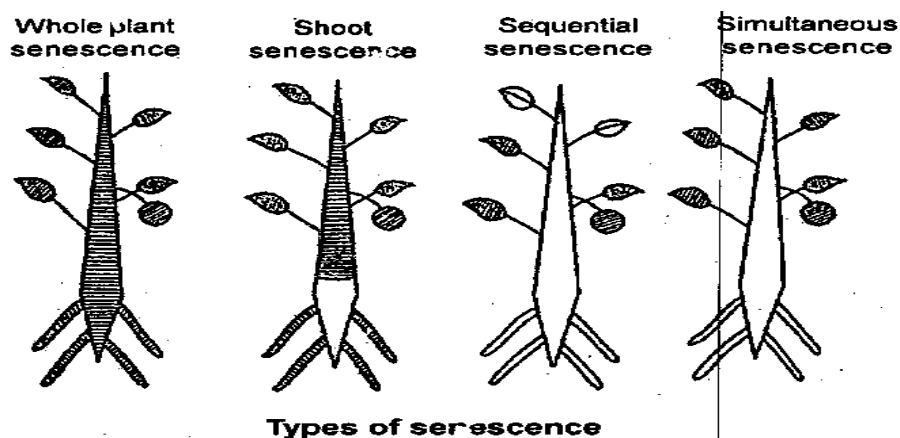
B. **Progressive senescence:** In normal development of most annual plants, there is progressive senescence, where the oldest leaves senesce and die first. The senescence moves from leaves to the stem and then to under ground parts.

Eg: Tobacco.

C. **Top senescence** (Shoot senescence) Here senescence and death of all above ground parts occurs, while the under ground root portions survive and give rise to new buds in the next season.

Eg: Sugar beet, Banana, Ginger

D. **Deciduous senescence** (simultaneous senescence): In this kind of senescence, all leaves senesce and die, leaving the stem and roots alive as in gulmohar (*Delonix regia*) and Raavi (*Ficus religiosa*), Eucalyptus.



The occurrence of senescence differs both in their causes and in its nature. Senescence of the entire plant after a single reproductive cycle is called **monocarpic senescence**. Senescence may be delayed when flowers and fruits are removed. Some monocarpic plants like *Agave americana* generally live and grow for many years before flowering. They die when they produce fruits. Thus senescence is an irreversible one. On the other hand in tobacco plant older leaves senesce as the plant grows. But the senescence can be reversed when the apical meristem of the plant is removed.

30.3 THEORIES OF MECHANISM OF SENESCENCE:

30.3.1 Nutritional theory: Molisch (1920) suggested that senescence was caused by nutritional deficiency. Different parts of the plants compete for nutrition. Fruit or growing tip for example, might form stronger sinks for translocation and thus accumulate much of nutrients, that the older leaves would be starved. This triggers off the senescence process in the older leaves and they start acting as a nutrient source for younger structures. One of his observations is that, if the fruit, seed or growing tip is removed, senescence is greatly delayed in the leaves. However, nutritional theory is not applicable to many situations. It is not possible to retard senescence in annual plants that have flowered or fruited even by application of fertilizers. Dioecious plants, which bear only male flowers and require no additional nutrients for fruit formation also undergo senescence.

30.3.2 Hormonal theory: It is observed that senescence is initiated as a result of change in hormonal content of the organ. Some believe that a hormonal signal is sent from developing fruits to leaves and other vegetative parts, where it triggers senescence. It is now well known that ABA produced in the developing fruits and seeds induce senescence in the leaves.

Nooden and Leopold (1978) proposed a term "**Death hormone**" for the causative agent of senescence in monocarpic species. The death hormone is a chemical substance which is supposed to be produced in developing seeds and translocated to vegetative parts through xylem and initiates senescence in leaves. This hypothesis is based on the observations that preventing flowering or fruiting retarded senescence in many cases.

30.3.3 Alternations in nucleic acid and protein contents with senescence and usually it will decline in senescing plants (Carr and Pate, 1967)

30.3.4 Increase in enzymatic activities of ribonuclease and proteases with the onset of senescence in plant (Martin and Thimann, 1972)

30.3.5 Structural alterations particularly evidence of **deteriorative changes in membranes** and organelles (Poovaiah and Leopold , 1973)

30.3.6 Increased accumulation of free radicals with ageing (Choudhri, 1988)

No hypothesis is fully satisfactory or complete and various criticisms can be put forward for and against of these hypothesis.

30.4 METHODS OF PREVENTING LEAF AND FLOWER SENESENCE:

All the plants do not exhibit same response to growth hormones. Cytokinins appear to be more effective in delaying senescence in many herbaceous plants. GA's are effective in preventing senescence of ash (Fraxinus) because the endogenous GA content of the leaves decrease during leaf senescence. Auxins (IAA and 2,4-D) have been found to retard senescence in certain trees. Delaying the leaf senescence is a desirable phenomenon in annual crops like rice for better grain filling. Premature senescence of panicle also affects the grain yields in rice. By the use of growth regulators like Kinetin and triactontenol, the panicle senescence can be retarded by maintaining high succinic dehydrogenase activity (SDH) in the panicle components. High rate of N application at booting stage will maintain High SDH activity and retard panicle senescence.

30.5 PHYSIOLOGICAL AND BIOCHEMICAL CHANGES DURING SENESENCE:

Physiological

1. Yellowing of leaves because
Of decline in chlorophyll content
2. Decrease in photosynthetic rate
This may be due to
 - a. Ultra structural changes in chloroplasts
 - b. Decrease in chlorophyll content
 - c. Increase in stomata resistance and
 - d. Decrease in the activity of Rubisco enzyme
3. Decrease in rate of respiration
However in some species there is increase in respiration
4. Increased membrane permeability
5. Membranus subcelular inclusions are
Disrupted
6. Cells undergo reduction of their structure

Biochemical

1. Decrease in starch synthesis
2. Loss of ATP synthesis
3. Decrease in DNA and RNA
Synthesis
4. Decrease in protein
Synthesis. This decline is both
due to their accelerated
degradation as well as
decreased Synthesis
5. Increase in contents of
hydrolytic enzymes such as
Protease and nuclease.
6. Decrease in inorganic ions
and Various nutrients.

30.6 SIGNIFICANCE OF SENESCENCE: The main purpose of leaf senescence is to recover the nutrients, specially nitrogen and carbon for the growth of younger leaves and other developing organs on the plant. The senescence of leaves in deciduous trees is also a mechanism of avoiding extreme environmental conditions such as severe cold. Of late scientists are trying to develop ‘**stay green varieties**’ which can retard the process of leaf senescence and can maintain green leaves for a longer period.

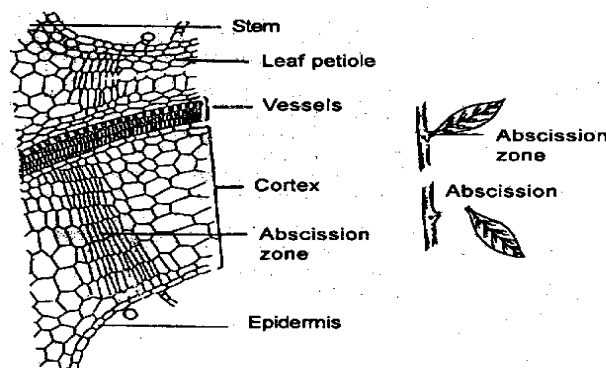
30.7 ABSCISSION AND ITS RELATION TO SENESCENCE:

The term **abscission** is used to describe ‘**the processes involved in the shedding of plant structure, characterized by the degradation of cell walls at the point of weakening**’. Cells surrounding the fracture line produce and secrete cell wall degrading enzymes which hydrolyze the central region of the wall allowing the cells to separate for fracture to occur. This fracture occurs in “**Separation layer**” which is 1-3 cells wide. Plants do not have the ability to produce separation layer anywhere. They are genetically limited to specific locations called “**Abscission Zones**” which are 5-50 cells wide.

Cells of abscission zone are somatic and have more persistent meristematic activity. Lignified structural elements like fibers and sclereids are absent in abscission zone and are replaced by collenchymas. Lignified walls are extremely resistant to enzymatic hydrolysis while collenchymas walls are readily degradable.

Absciscic acid was originally isolated as an “**abscission causing factor**”. However it is evident that ABA stimulates abscission of organs in only few species and that the primary hormone causing abscission is ethylene. On the other hand ABA is clearly involved in senescence, and through promotion of senescence it might indirectly increase ethylene formation and stimulate abscission. Senescence acts as a signal for inducing abscission and senescence of plant parts usually precedes the abscission.

But there are examples where leaf senescence occurs in the autumn and abscission does not occur until the following spring. Thus, the linkage between senescence and abscission can be broken since, both processes occur independently.



A leaf petiole showing the abscission zone
