VIVEKANANDA COLLEGE
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NAAC ACCREDITED 'A' GRADE

Topic:	PLANT GROWTH REGULATORS
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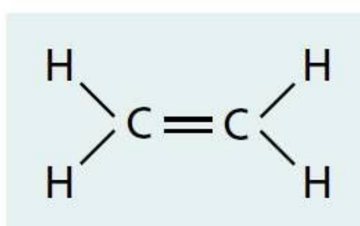
Ethylene:

It is a naturally occurring **gaseous hormone** which stimulates transverse or isodiametric growth but retards the longitudinal one.It decides fruit ripening, cause flower, senescence, and abscission, recovery of wound together with many aspects of normal growth and development of plants. Ethylene was recognised as a plant hormone by Crocker (1935).

Precursor: Ethylene is produced in plants from the amino acid methionine.

Occurrence: It is formed in almost all plant parts— roots, leaves, flowers, fruits, seeds. Maximum synthesis occurs during climacteric ripening of fruits and tissues undergoing senescence. Excess of auxin also induces ethylene synthesis. Many effects of excess auxin are actually the effects produced by ethylene.

Chemical structure of ethylene:



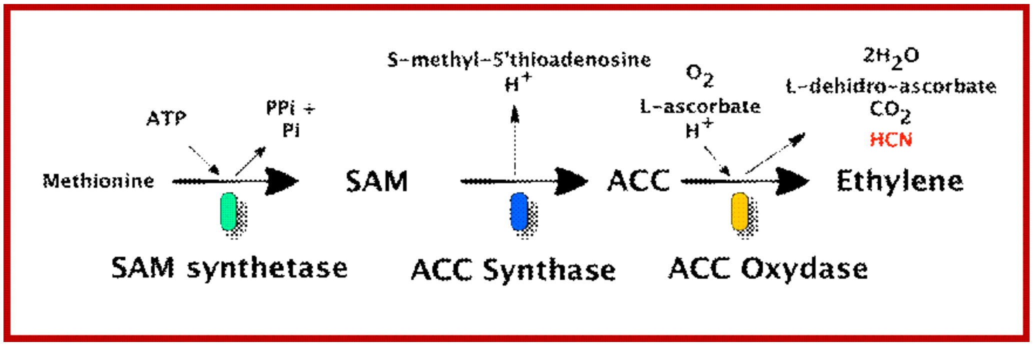
Ethylene

Biosynthesis of Ethylene:

All parts of the plant are capable of producing ethylene. Its production is induced during certain stages of growth, such as germination, ripening of fruits, abscission of leaves etc. Its production can also be induced by a variety of external factors like mechanical injury, environmental stresses and a few chemicals.

The biosynthesis of ethylene in plants starts with a sulfur containing amino acid, methionine.

1. In the first step, methionine is activated by ATP and is converted to S-adenosyl methionine (SAM) and pyrophosphate is liberated. The reaction is catalyzed by SAM-synthase.
2. In the second step the enzyme ACC-synthase converts S-adenosyl methionine to 1-amino cyclopropane carboxylic acid (ACC). This reaction is rate limiting. The activity of the enzyme ACC- synthase is affected by auxins, wounding stress or pathogens. These factors usually increase ACC-synthase activity and hence ethylene production.
3. In the third step, ACC is oxidized and cleaved to ethylene, CO2 and HCN. The reaction is catalyzed by the enzyme ACC-oxidase.



The shoot apex is the principal site of ethylene synthesis in seedlings. Nodes of dicot seedlings produce more ethylene than internodes. Roots produce comparatively much less amount. Other organs also produce ethylene in much less amount which increases during senescence and ripening.

The plants and micro-organism metabolize ethylene. It is converted to ethylene oxide which enters glyoxylate cycle as ethylene glycol. It may also form conjugate with glucose.

Physiological role of ethylene:

1. Fruit Ripening:

One of the most pronounced effects of ethylene is in ripening of fruits and therefore, ethylene is also known as **fruit ripening hormone**. Different types of fruits react differently with exogenous application of ethylene. Additional production of ethylene by ripening fruits is autocatalytic.

In **climacteric fruits** (such as apples, bananas, tomatoes etc.)

- ➢ exposure of mature fruits to ethylene result in respiration climacteric (marked increase in respiration during initiation of ripening) followed by additional production of ethylene leading to hastening of ripening process.

Three important changes take place in fruit ripening which is believed to be due to ethylene induced gene activation which produces a number of enzymes for fruit ripening.

(1) Enzymes such as polygalacturonase increase due to activation and causes softening of the fruit wall. Some cellulases also increase which may be involved in softening of fruit walls.

(2) The increase in phenyl-alanine ammonia lyase catalyzed deamination of 1-phenyl-alanine to trans cinnamic acid which can then be incorporated into anthocyanidins and produce pigments which impart bright colour to fruits.

(3) Hydrolyzing enzymes may convert complex carbohydrates into simpler forms (into some acids or sugars) which add sour/sweet taste to the fruits

But, in **non-climacteric fruits** (such as citrus fruits and grapes),

- ethylene treatment does not cause respiration, climacteric and additional ethylene production and the ripening process remains unaffected.

However, the minimum threshold level of endogenous ethylene is essential for all types of fruits for ripening.

2. Plumular Hook Formation:

In etiolated dicot seedlings, the plumular tip (i.e., shoot apex) is usually bent like a hook. This hook shape is advantageous to seedling for penetration through the soil, protecting the tender apical growing point from being injured.

- The plumular hook formation and its maintenance in etiolated (dark grown) seedling are due to formation of ethylene in that region which causes asymmetric or unequal growth on the two sides of plumular tip.
- Ethylene causes more rapid elongation of the outer side of plumular tip than on its inner side.
- When the seedling is exposed to white light, formation of ethylene decreases, the inner side of the hook also elongates rapidly equalising the growth on two sides and the hook opens.
- Red light is more effective in opening a plumular hook.

- ➢ This effect is reversed by exposing the seedling to far-red light. This red/far-red reversibility is indicative of the role of the pigment phytochrome in it.
- ➢ When etiolated seedlings are exposed to light in presence of ethylene, the plumular hook fails to open. On the other hand, if seedlings are grown in dark along with an ethylene absorbent such as $KMnO_4$, the plumular hook opens.
- ➢ It is believed that asymmetric growth on two sides of plumular tip resulting in hook formation and its maintenance in etiolated dicot seedlings is probably due to an ethylene dependent auxin gradient similar to that which develops during phototropic curvature.

3. Triple Response:

Ethylene causes 'triple response' of etiolated seedling such as in pea which consists of:

(i) Inhibition of stem elongation,

(ii) Stimulation of radial swelling of stems and

(iii) Horizontal growth of stems with respect to gravity (i.e., diageotropism)

Triple response effects of etiolated seedlings were the first to be related to the beginning of discovery of ethylene as a natural plant growth hormone.

4. Formation of Adventitious Roots and Root Hairs:

Ethylene induces formation of adventitious roots in plants from different plant parts such as leaf, stem, peduncle and even other roots. In many plants especially Arabidopsis, ethylene treatment promotes initiation of root hairs

5. Inhibition of Root Growth:

Ethylene is known to inhibit linear growth of roots of dicotyledonous plants.

6. Leaf Epinasty:

When the upper side (adaxial side) of the petiole of the leaf grows faster than the lower side (abaxial side), the leaf curves downward. This is called as **epinasty**.

Ethylene causes leaf epinasty in tomato and other dicot plants such as potato, pea and sunflower. Young leaves are more sensitive than the older leaves. However, monocots do not exhibit this response.

- ➢ Higher concentration of auxin, stress conditions such as salt stress, water-logging and pathogen infection also induce leaf epinasty indirectly through increased ethylene formation.
- ➢ In tomatoes and other plants, water-logging creates anaerobic condition around the roots resulting in accumulation of ACC (the immediate precursor of ethylene formation) in roots. ACC is then trans located to shoots along with a transpiration stream where it is

converted into ethylene in presence of oxygen and induces leaf epinasty.

7. Flowering:

Ethylene is known to inhibit flowering in plants. However, in pineapple and its allies (Family Bromeliaceae) and also mango, it induces flowering. Ethylene is used commercially to synchronize flowering and fruit set in pineapple. *Plumbago indica* (a Short Day Plant) can be made to flower even under non-inductive long days with the application of ethylene.

8. Wound response:

When plants are wounded and exposed to stress conditions, ethylene production rapidly increases and so ethylene acts as a **wound hormone.** Ethylene can also lead to production of phytoalexin in wound plants, to overcome fungal infection. A number of secretory processes like gum production and latex flow are stimulated by ethylene.

9. Sex Expression:

In monoecious species (with separate male and female flowers on the same plant) especially some cucurbits like cucumber, pumpkin, squash and melon; ethylene strongly promotes formation of female flowers thereby suppressing the number of male flowers considerably.

10. Senescence:

Ethylene enhances senescence of leaves and flowers in plants. In senescence, concentration of endogenous ethylene increases with decrease in conc. of cytokinins and it is now generally held that a balance between these two phytohormones controls senescence.

11. Abscission of Leaves:

Ethylene promotes abscission of leaves in plants. Older leaves are more sensitive than the younger ones. Fumigating the wild type birch tree *(Betula pendula*) with 50 ppm ethylene results in rapid defoliation of the tree within a few days. Contrary to this, transgenic birch tree with a mutated version of *Arabidopsis* ethylene receptor ETR1-1, does not respond to ethylene treatment and therefore, does not defoliate.

The relative conc. of auxin on two sides of the abscission layer has regulatory influence on the production of ethylene that stimulates leaf abscission.

At the time of abscission, conc. of auxin in the laminar region decreases with simultaneous increase in ethylene production. This also increases sensitivity of cells of the abscission zone to ethylene which now synthesize cell wall degrading enzymes such as cellulases and pectinases.

Activity of these enzymes results in cell wall loosening and cell separation ultimately leading to leaf abscission. (Besides auxin and ethylene, ABA has also been implicated in the process of leaf abscission. It's conc. increases in leaf at the time of abscission).

12. Breaking Dormancy of Seeds and Buds:

Ethylene is known to break dormancy and initiate germination of seeds in barley and other cereals. Seed dormancy is also overcome in strawberry, apple and other plants by treatment with ethylene. Non-dormant varieties of seeds produce more ethylene than those of dormant varieties.

In many plants, the rate of seed germination is increased by ethylene and a close correlation has been found between ethylene formation and seed germination in peanuts (Arachis hypogaea). In many plants, dormancy of buds can also be broken by ethylene treatment. Sometimes, potato tubers are exposed to ethylene in order to sprout the dormant buds.

13.Degreening of fruit:

It is noted that the color of fruit changes from green to yellow during ripening. Exogenous application of ethylene (5-10ppm) on fruits like banana or lemon exert a high rate of chlorophyllase activity resulting in degreening of fruit wall color.

14. Internodal growth of aquatic plants:

In some dicotyledonous aquatic plants like *Nymphoides peltata* ethylene influences internodal growth resulting in elongation of stem, enabling the leaves to float on the upper surface of water.