Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Second Year)

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Course Title: Plant Physiology

Unit 8: Plant growth regulators

Module Name: Discovery and physiological roles of ethylene

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Notes

PLANT GROWTH REGULATORS OR PHYTOHORMONES

Plant growth regulators or phytohormones can be defined as organic substances produced naturally in the higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute quantity.

TYPES OF PLANT GROWTH REGULATORS

Auxins: Indole-3-acetic acid (IAA)
Gibberellins: Gibberellic acid (GA)
Cytokinins: Kinetin, Zeatin, etc
Abscisic acid (ABA)
Ethylene

CHEMICAL NATURE OF ETHYLENE

Ethylene is the only plant growth regulator that occurs in the form of a gas.
Ethylene (C_2H_4) is a well known olefinic gas with a molecular weight of 28.

Highly volatile substance that readily undergoes oxidation to produce ethylene oxide.
Colourless, flammable gas with a faint "sweet and musky" odor when pure.
Lighter than air at room temperature and is sparingly soluble in water.
Readily absorbed by potassium permanganate ($KMnO_4$).

DISCOVERY OF ETHYLENE

Ethylene has been used since the ancient times.

Egyptians, gashed the figs in order to stimulate ripening.

Ancient Chinese, would burn incense in closed rooms to enhance the ripening of pears.

Russian scientist named Dimitry Neljubow, (1901) observed that dark-grown pea seedlings growing in the laboratory exhibited symptoms like inhibition of stem elongation, stem thickening and horizontal growth due to ethylene present in laboratory air but when grown in fresh air regained their normal growth.

A.F. Sievers and R.H. True, (1912), demonstrated that the combustion gases from the kerosene stove were beneficial in the ripening of lemons.

W.C. Crocker and L.I. Knight, (1908, 1913) identified ethylene as the active constituent of both, illuminating gas and Tobacco smoke.

H.H. Cousins first report that plants evolve ethylene, observed that when Oranges and Banana were stored together during shipping, some gas was emanated from oranges which caused ripening of Banana.

Sarah Doubt, (1917) discovered that ethylene stimulated abscission.

Frank E. Denny, (1924) discovered that it was the ethylene emitted by the kerosene lamps that induced the ripening in crops.

O.H. Elmer, (1932) reported that the sprouting of potatoes could be inhibited by keeping them in close proximity of mature Apples or Pears.

R. Gane, (1934) provided a chemical proof that ethylene was produced by ripe Apples.

Since than it has been shown that ethylene is produced from essentially all parts of higher plants and is induced during certain stages of growth such as germination, ripening of fruits, abscission of leaves and senescence of flowers.

PHYSIOLOGICAL ROLES OF ETHYLENE

FRUIT RIPENING

Most pronounced effect of ethylene is ripening of fruits (Apple, Banana, Tomatoes etc) and is also known as fruit ripening hormone.

Exposure of fruits to ethylene result in increase in respiration, additional production of ethylene and speedup of ripening process.

Different types of fruits react differently with exogenous application of ethylene.

In climacteric fruits such as Apples, Bananas, Tomatoes etc, exposure of mature fruits to ethylene result in respiration climacteric (increase in respiration during initiation of ripening) followed by additional production of ethylene leading to hastening of ripening process.

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.

Minimum threshold level of endogenous ethylene is essential for all types of fruits for ripening.

PLUMULAR HOOK FORMATION

Etiolated dicot seedlings, the plumular tip is usually bent like a hook.

The hook shape helps to penetrate through the soil and protects the tender apical growing point from being injured.

Ethylene causes asymmetric growth on two sides of plumular tip-more rapid growth of outer side.

Seedling exposed to white light, formation of ethylene decreases and 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 of plumular hook.

This effect can be reversed by exposing the seedling to far-red light.

Etiolated seedlings when exposed to light in presence of ethylene the plumular hook fails to open.

If seedlings are grown in dark along with an ethylene absorbant such as $KMnO_4$, the plumular hook opens.

TRIPLE RESPONSE

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

Inhibition of stem elongation.

Stimulation of radial swelling of stems.

Horizontal growth of stems with respect to gravity.

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 *Arabidopsis* ethylene treatment promotes initiation of root hairs.

INHIBITION OF ROOT GROWTH

Ethylene inhibits linear growth of roots of dicotyledonous plants.

LEAF EPINASTY

When upper side of the petiole of the leaf grows faster than lower side due to which leaf curves downwards this is called as epinasty. E.g. Tomato, Potato, Pea and Sunflower (only dicot plants).

Young leaves are more sensitive than the older leaves.

Monocots do not exhibit this response.

FLOWERING

Ethylene inhibit flowering in plants.

In Pineapple and Mango it induces flowering.

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.

SEX EXPRESSION

In some monoecious plants such as Cucurbits, Cucumber, Pumpkin, Squash and Melons, ethylene promotes formation of female flowers thereby suppressing the number of male flowers.

SENESCENCE

Ethylene enhances senescence of leaves and flowers in plants.

In senescence, concentration of endogenous ethylene increases with decrease in concentration of cytokinin’s and it is said that a balance between these two phytohormones controls senescence.

E.g. freshly cut Carnation flowers when kept in water.

Loose color of their petals and wither early.

When kept in water containing silver thiosulphate remain fresh for many weeks.

Silver thiosulphate is potent inhibitor of ethylene action.

ABSCISSION OF LEAVES

Ethylene promotes abscission of leaves in plants.

Older leaves are more sensitive than the younger ones.

Induces synthesis of wall degrading enzymes such as cellulases and pectinases which leads to leaf abscission.

E.g. Fumigating the wild type birch tree (*Betula pendula*) with 50 ppm ethylene results in rapid defoliation of the tree within few days.

However, in transgenic birch tree with a mutated version of *Arabidopsis* ethylene receptor ETR1-1, does not respond to ethylene treatment and therefore does not defoliate.

BREAKING DORMANCY OF SEEDS AND BUDS

Ethylene break dormancy and initiate germination of seeds in Strawberry, Apple and Cereals.

Non-dormant varieties of seeds produce more ethylene than those of dormant varieties.

Dormancy of buds can also be broken by ethylene treatment in many plants.

Potato tubers are exposed to ethylene in order to sprout the dormant buds.