Plant growth regulators

*Guinny; with thanks to _lynx_*

Auxins

- *Promote cell elongation*
- *Inhibit growth of side-shoots*
- *Inhibit leaf abscission*

Auxins are produced at the apex; they travel to other parts of the plant via diffusion or active transport. They cause cells in the zone of elongation to elongate and the extent to which the cells elongate is proportional to the concentration of auxin.

Auxins act by increasing the stretchiness of the call walls - this is done via the active transport of hydrogen ions into the cell wall (by an ATPase enzyme on the cell membrane). The resulting low pH disrupts the hydrogen bonds in cellulose and it provides the optimum conditions for expansins (wall loosening enzymes) to work. This process makes the wall less rigid, allowing for increased water uptake which in turn makes the cell expand.

Auxins are also responsible phototropic responses in plants. The auxins are transported to the shaded side of the shoot, causing it to elongate more that the illuminated side and the overall effect of this is the shoot bending towards the light. An enzyme gradient is thought to be responsible for causing this redistribution of auxins.

Auxins usually inhibit leaf abscission by acting on cells in the abscission zone (found at the base of the leaf petiole – where the leaf connects to the stem). Leaf senescence causes the auxin production at the tip of the leaf to drop. The lack of auxins in the abscission zone makes the cells there for susceptible to ethene, in addition to that the drop in auxin levels cause a direct increase in ethene production. This leads to shedding leaves.

Auxins are indirectly involved in the phenomenon of apical dominance. High levels of auxins in the plant shoots keep abscisic acid levels high in the lateral buds, thus inhibiting their growth. This large amount of auxins also makes the apex a sink for cytokinins which encourages growth there. One the apex is removed, the cytokinin will move around to the rest of the plant and the abscisic acid concentration in the lateral buds will also drop. Hence the lateral bud growth that follows.

<u>Commercial uses:</u>

- *Preventing leaf and fruit abscission in low concentrations*
- *High concentrations promotes fruit drop*
- *Treating unpollinated flowers promotes parthenocarpy (growth of seedless fruit)*
- *Herbicide to kill weeds (death via excess shoot growth)*
- *Promoting root growth of cuttings*

Gibberellins

- *Promote seed germination*
- *Promote growth of stems*

Gibberellins cause growth in the internodes by stimulating cell division and cell elongation; this is done by stimulating the production of a cell cycle control protein and loosening the cell walls respectively. It causes mitosis in the intercalary meristems.

Commercial uses:

- *Elongating grape stalks, allowing more space for fruit growth*
- *Delay senescence in citrus fruits*
- *Acting together with cytokinins to elongate apples*
- *Speeding up amylase production in germinating barley – increases maltose production*
- *Elongating the inter-nodes in sugar canes so they store more sugar*
- *Speeding up seed formation in young coniferous trees and biennial plants*

Gibberellin inhibitors can be used to make flowers short and stock; a desirable trait in some flowers. Inhibitors are also used to prevent lodging – where the stems bend due to large amounts of water collecting in the ripened seed heads – which makes harvesting harder.

Cytokinins

- *Promote cell division*

Cytokinins stop the leaves of deciduous trees from senescence. It does so by encouraging the leaf to act as a sink for phloem transport – thus guaranteeing a good supply of nutrients. A drop in the leaf cytokinin level will cause leaf senescence (ageing).

Cytokinins promote bud growth. They are found at the apex because high auxin concentration acts as a sink for them. Applying cytokinins to lateral buds can override apical dominance.

Commercial uses:

- Delays leaf senescence for vegetables such as lettuce
- Used in tissue culture promoting bud and shoot growth from small pieces of tissues
- Producing shoots with lots of side branches – which can be split to grow separately

Ethene

- *Promotes fruit ripening*

Ethene causes in increase in the concentration of the enzyme cellulose in the abscission. The enzyme digests the walls of the cells in the abscission zone, causing eventual separation of the petiole from the stem. This effect is amplified by the absence of auxins – this is an example of synergy.

Ethene is applied by spraying as a solution of 2-choroethylphosphonic acid, which is easily absorbed and releases ethene inside the plant.

Commercial uses:

- Ripen apples, tomatoes and citrus fruits
- Promote female sex expression in cucumbers – reducing the chance of self-pollination and increasing yield
- Promote fruit drop in cotton, cherry and walnut
- Promote lateral growth in some plants – creating more compact flower stems

Ethene inhibitors are also useful. Storing fruits in low temperatures, low oxygen level and high carbon dioxide levels inhibits ethene production (and fruits from ripening). This allows fruits to be stored for longer and allowing them to be transported. Other inhibitors (such as silver salts) increase cut flowers' shelf life.

Abscisic acid

- *Inhibits seed germination and growth*
- *Causes stomatal closure during low water levels*

Abscisic acid inhibits growth, this is apparent in apical dominance. The high levels of abscisic acid in the lateral buds means only the shoot tip grows.