Plant Propagation PLS 3221/5222

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Chapter 2

Introduction to the Biology of Plant Propagation
-A review-

5. Plant Hormones and Plant development

Phytohormones

- Naturally occurring organic compounds
- Relatively low molecular weight
- Active in small concentrations
- Synthesized at a given site and translocated to the site of action

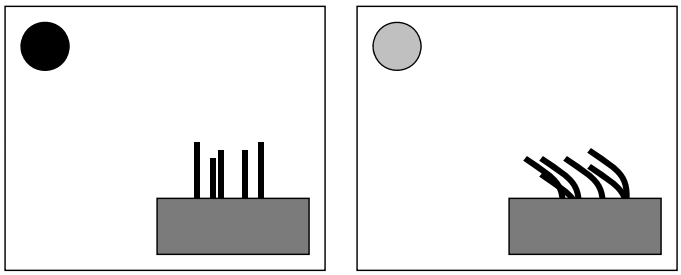
5 Major Phytohormones

Auxin
Cytokinin
Gibberellin
Abscisic acid
Ethylene

Plant Growth Regulators - Chemicals (natural or synthetic) which show hormonal effects to plants.

Auxins

- a plant growth hormone that controls adventitious root initiation and micropropagation stages.



Auxins (IAA)
indole-3-acetic acid

- Synthesized from the amino acid

L-tryptophane

  - –leaf primordia
  - –young leaves
  - –developing seeds
- Moves from cell to cell in a polar gradient (from tip to base)

Auxin (IAA)

- Coleoptile bending toward light (cell elongation)
- Inhibition of lateral buds by terminal buds (apical dominance)
- Formation of abscission layer on leaves and fruit
- Activation of cambial growth.

Synthetic Auxin

- Same functions in the plant as IAA but do not disintegrate (not metabolized) as readily when applied to living tissue.

indole-3-butyric acid (IBA)

α-naphthalene acetic acid (NAA)

Primary uses of Auxin in Propagation

- To induce adventitious rooting in cuttings
- To control morphogenesis in micropropagation

Cytokinin

- Cytokinin = a plant growth hormone that stimulates cell division and initiates shoot sequences in tissue cultures.

Cytokinins

- Natural cytokinin
  - Kinetin
  - Zeatin
  - isopentenyladenine (2IP)
- Synthetic cytokinin
  - benzyladenine (BA or BAP)

Cytokinin

- The interaction among cytokinin, gibberellin, and abscisic acid controls dormancy.
- Promotes cell division of galls and nodules produced from *Rhizobium* or *Rhizobactor*, nematodes, and infection by *agrobacterium tumefaciens*.

Cytokinin

- Acts in intact plants to delay or reduce senescence, slowing down the breakdown of chlorophyll and cellular protein.

Primary uses of Cytokinin in propagation

- High auxin/ cytokinin ratio favors rooting
- High cytokinin/ auxin ratio favors shoot formation
- High levels of both favors callus development

Gibberellins

- Gibberellins = plant growth hormones that stimulate shoot elongation and control germination and dormancy.

Gibberellins

- Synthesized in-
  - Leaf primordia
  - Roots
  - Fruits
  - Tubers
- Transported in the xylem and phloem
- Promote shoot elongation through increased cell division and cell elongation

Abscisic acid (ABA)

- Abscisic acid (ABA) = plant growth hormone that plays a role in plant stress, controlling water relations, embryo development, germination and dormancy.

Abscisic acid

- ABA is synthesized from mevalonic acid either directly or from the breakdown of carotenoid pigments.
- Biosynthesis occurs in the chloroplasts.

Abscisic acid

- Has a major function in controlling water relations through the stomates
- Has a role in food storage reserves

Abscisic acid

- Involved in the dormancy of buds and seeds, abscission, and plant response to stress, particularly moisture.
- Regulates stomatal closure, controls water and ion uptake by roots, and affects leaf senescence and abscission.

Abscisic acid

In propagation, ABA is involved in

- germination and dormancy of seeds
- embryogenesis and production of seeds

Ethylene

Ethylene = natural plant growth hormone involved with fruit maturity and stimulation of adventitious roots

Ethylene is a gas with a very simple structure.

Ethylene

- epinasty at high concentrations
- senescence and abscission in leaves and fruit
- Flowering
- lateral bud stimulation
- latex production, and flower induction

Ethylene

- Naturally occurring ethylene is involved in the maturity of fruits and is widely used to induce ripening in commercial storage.
- Wounding and stress consistently result in an increase in ethylene.

Ethylene In propagation

- Ethylene is involved in
  - Induction of adventitious roots
  - Stimulation of germination
  - Overcoming dormancy

Ethephon

- (2-chloroethylphosphoric acid)
- a liquid chemical absorbed by plant tissue where it breaks down to ethylene
- Used on some crops to promote ripening, act as a thinning agent, or to promote flowering.

Ancillary compounds

- Other naturally occurring substances are considered by some to show hormonal action.
- Polyamines - putrescine, spermidine, and spermine
  - synthesized from amino acids -arginine and ornithine

Ancillary compounds

- Jasmonate
- Brassinosteroids
- Phenolics
- Salicylate
- Myo-inositol is usually classed as a vitamin (used in tissue culture)

Plant Growth Regulators

- Some Plant Growth Regulators are used as growth retardants to inhibit synthesis of gibberellins in plants.

Chlormequat

Cardavan

Ancymidol

Paclobutrazol

Uniconazole

6. Biological life cycles in Plants

Totipotency

Competence

Determinism

Epigenetic Change

Phenology

Ontogeny

Totipotency

Totipotency = the concept that a single cell has the necessary genetic factors to reproduce all of the characteristics of the plant.

Any Parenchymal cell

Meristematic cells

zygote

Competence

Competence = a term that describes the potential of a cell to develop in a particular direction, such as forming adventitious roots.

Determinism

Determinism = describes the degree that a cell is committed toward a given developmental direction at a given time.

At some point in development, the process becomes irreversible and the cells are said to be determined.

See Figure 2-16 in your text.

Epigenetic factors in development

- Epigenetic change – describes changes in the way a plant looks (phenotype) without a mutation that changes the genetics of the plant.

Epigenetic factors in development

1. Formation of specific structures such as stems, roots, leaves, and flowers

   The basic growth, enlargement, and differentiation of specialized cells to produce the morphological and physiological variation that makes up the whole plant.

e.g. changes from vegetative to reproductive

Epigenetic factors in development

2. Induction of adventitious roots, buds, shoots, or embryos

   These processes take place if specific cells retain the potential for regeneration during development.

   Specific cells can be induced to dedifferentiate and develop the capacity to regenerate.

Epigenetic factors in development

3. Control of developmental cycles

- Seasonal - (Phenology) plants respond to seasonal changed in the environment
  - temperature
  - moisture (wet and dry seasons)
- Aging (Ontogeny) – plants respond to changes due to aging, length of life phenomenon.

Life Cycles of Seedling Cultivars

Seedling = An individual plant that develops from a seed regardless if it is an annual, biennial, herbaceous perennial, or woody perennial.

Annual

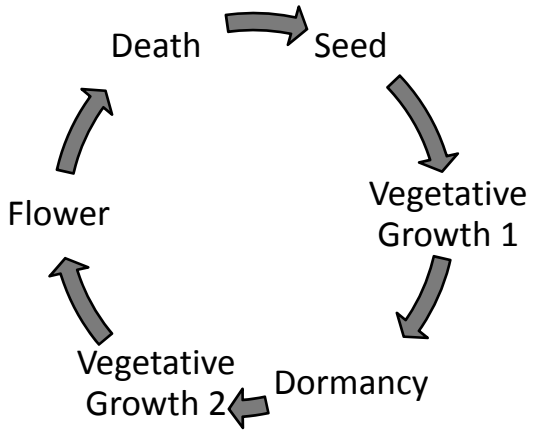
Annual - plants that complete the entire sequence from germination to seed dissemination and death in one growing season.

Biennial

Biennial - plants that require two growing seasons to complete the sequence.

- The plants are vegetative and grow as low clumps or rosettes the first season.
- The second season, the plants are reproductive, produce flowers and seeds, and then die.

Biennial Life Cycle

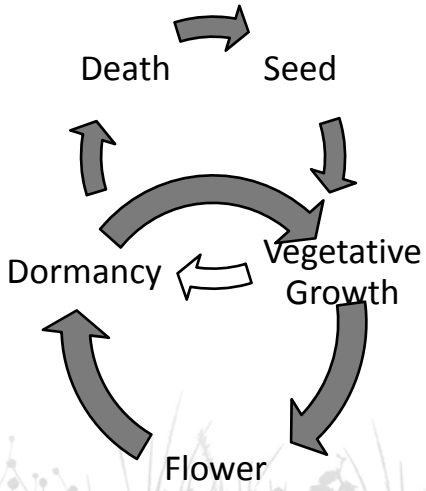


Herbaceous perennial

Herbaceous perennials - produce shoots that grow during one season and die back during the winter.

- Plants survive during adverse conditions as specialized underground structures with roots and crowns that remain perennial (bulbs, corm, rhizomes, tubers).

Perennial Life Cycle



Woody perennials

Woody perennials - develop permanent woody stems that continue to increase annually from apical and lateral buds with characteristic growth and dormancy periods.

Life Cycles of Seedling Cultivars

The life cycle of a seedling may be separated into four broad growth and development stages.

Phase 1 Embryonic
Phase 2 Juvenile
Phase 3 Transitional
Phase 4 Adult (mature)

Phase 1. Embryonic

- Begins with the formation of a zygote and involves the growth of the cell into an embryo.

Phase 2.
Juvenile

- Begins with seed germination.
- New roots, nodes, leaves, and axillary growing points are produced.
- Lateral growing points produce only shoots.

Phase 3.
Transitional

- The vegetative period at the end of the juvenile phase and prior to the reproductive stage.

Phase 4.
Adult or Mature

- Shoot meristems have the potential to develop flower buds and the plant produces flowers, fruits, and seeds.

Characteristics of plant development associated with phase change:

- Time of flowering
- Morphological expression of leaves and other structures
- Potential for regeneration

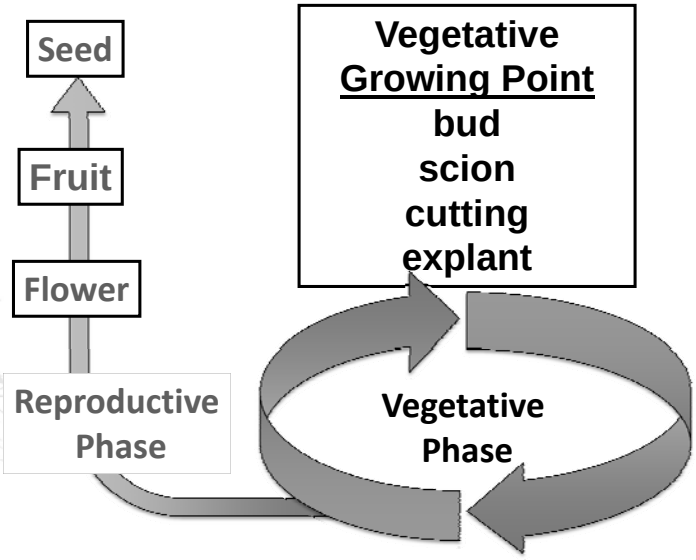
Phase Change
English Ivy

Juvenile Intermediate Adult

Life Cycles of Clonal Cultivars

Clonal life cycle = growth and development of a plant when propagated vegetatively from a particular propagule of an individual plant.

Clonal Life Cycle



Life Cycles of Apomictic Cultivars

Apomixis - a natural reproductive process in which the embryo develops directly from specific vegetative cells of some part of the reproductive structure that has not undergone meiosis.

7. Legal Protection of Cultivars

- Townsend-Purnell Act 1930
- Plant Variety Protection Act, 1970, revised in 1994.
- International Convention for the Protection of New Varieties of Plants (1961, 1972, 1978, and 1991)

Plant Patent –

- A grant from the U.S. Patent Office, which extends patent protection to plants.
- Exclusive rights are given to the inventor of a 'distinct and new' kind of plant (cultivar) for a 20-year period.

Plant variety protection

- The U.S., Plant Variety Protection Act (PVPA) extends plant patent protection to seed-propagated cultivars that can be maintained as ‘lines’, including F1 hybrids.

Trademarks

- A registered trademark offers protection for a name that indicates the specific origin of a plant or product.
- The trademark is distinct from the cultivar name and both identities should be provided.

Utility Patents

- Utility patents are used by commercial biotechnology and engineering firms to control the use of specific genes and technologies.

Contracts

Contracts can be used to control the propagation of specific plants as well as selling of their fruit or other products. Enforcement comes under contract law and not Patent law.

Copyrights

Copyrights have the purpose of preventing unauthorized reproduction or copies of printed materials. Usually used to control reproduction of pictures or printed material about the plant that is used in brochures.