FREE NOTES · NCERT + NEET LEVEL

Plant Growth & Development

Growth and its measurement, phases and rates (arithmetic and geometric), differentiation, plasticity, plant growth regulators (auxin, gibberellin, cytokinin, ethylene, ABA) and their uses.

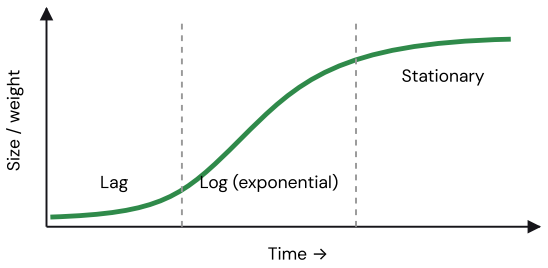
01 Growth and its measurement
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01 Growth and its measurement

- Growth = irreversible permanent increase in size; in plants it is **open** (indeterminate) because meristems keep adding cells.
- Primary growth: apical meristems (length). Secondary growth: lateral meristems (girth).
- Measured as increase in fresh/dry weight, length, area, volume, cell number. A maize root apical meristem makes >17,500 cells per hour; watermelon cells grow up to 350,000 times in size.
- Phases: meristematic (dividing, rich protoplasm, large nuclei), elongation (vacuolation, new wall), maturation (attain max size).

02 Growth rates

- **Arithmetic**: one daughter divides, other differentiates; $L_t = L_0 + rt$; linear graph (root elongating at constant rate).
- **Geometric**: both daughters divide; $W_1 = W_0e^{rt}$ (r = relative growth rate, efficiency index); **sigmoid** curve in nutrients-limited conditions.
- Absolute growth rate: total growth per unit time. Relative growth rate: growth per unit time per unit initial size.
- Conditions for growth: water (turgidity), O_2, nutrients, optimum temperature, light, gravity.

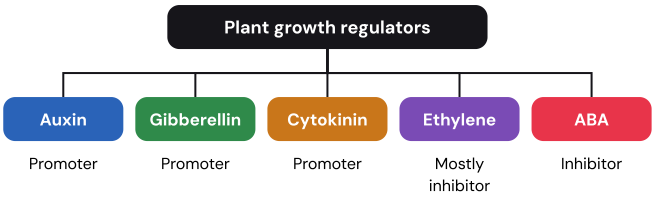


Sigmoid growth curve

03 Differentiation and plasticity

- **Differentiation**: cells mature to perform specific functions (tracheary elements lose protoplasm, develop lignified walls).
- **Dedifferentiation**: differentiated cells regain division ability (interfascicular cambium, cork cambium). **Redifferentiation**: their products mature again.
- Development = growth + differentiation; controlled by intrinsic (genes, PGRs) and extrinsic (light, temperature, water, O_2, nutrition) factors.
- **Plasticity**: different structures in response to environment or life phase: **heterophylly** in cotton, coriander, larkspur (juvenile vs mature leaves) and buttercup (in air vs water).

04 PGRs: discovery



Five major groups of PGRs

PGR	Discovery
Auxin	Charles & Francis Darwin (phototropism of canary grass coleoptile); F.W. Went isolated from oat coleoptile tips
Gibberellin	E. Kurosawa: "bakanae" (foolish seedling) disease of rice by fungus *Gibberella fujikuroi*
Cytokinin	F. Skoog: kinetin from autoclaved herring sperm DNA; zeatin from maize kernels and coconut milk
ABA	Inhibitor-B, abscission II, dormin were found to be the same
Ethylene	Cousins: volatile from ripe oranges hastened ripening of bananas

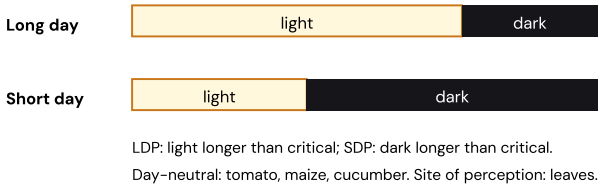
05 PGRs: effects and uses

PGR	Main effects / uses
Auxin (IAA, IBA; NAA, 2,4-D synthetic)	Rooting of stem cuttings; prevent fruit and leaf drop; **apical dominance**; parthenocarpy (tomato); 2,4-D weedicide (kills dicot weeds); xylem differentiation
Gibberellin (GA_3, 100+ types)	Stem elongation (grapes stalk, apple shape); delay senescence; sugarcane yield up to 20 tonnes/acre more; malting in brewing; bolting in beet, cabbage
Cytokinin	Cell division; new leaves, chloroplasts, lateral shoots; overcome apical dominance; delay leaf senescence (nutrient mobilisation)
Ethylene (gas)	Fruit ripening (increases respiration: respiratory climacteric), senescence, abscission; horizontal growth of seedlings, apical hook; flowering in pineapple, mango; ethephon most used source; promotes female flowers in cucumber
ABA (stress hormone)	Stomatal closure, seed and bud dormancy, inhibits growth, helps seed withstand desiccation; antagonist of GA

06 Interactions and summary

- PGRs rarely act alone: e.g. apical dominance by auxin is countered by cytokinin; GA and ABA have opposite effects on dormancy.
- Many extrinsic factors (temperature, light) act through PGRs; e.g. vernalisation and photoperiodism (not in current syllabus detail) involve hormones.
- Practical: removal of shoot tip (decapitation) in tea plantations and hedge making increases lateral branching.

07 Extra: photoperiodism, vernalisation, seed dormancy



Photoperiodism

- **Photoperiodism** (Garner and Allard): flowering response to day length. Long-day plants: wheat, radish, sugar beet. Short-day plants: soybean, tobacco, rice, chrysanthemum. Day-neutral: tomato, maize, cucumber.
- **Vernalisation**: promotion of flowering by a period of low temperature; prevents precocious reproductive growth late in season. Biennials (carrot, cabbage, sugar beet) and winter varieties of wheat, barley, rye.
- **Seed dormancy**: viable seed fails to germinate under favourable conditions; causes: hard seed coat, ABA, phenolics, immature embryo. Broken by scarification, gibberellins, chilling, light.
- **Richmond–Lang effect**: cytokinin delays leaf senescence. **Ethephon** = ethylene source; **malting** uses GA (brewing).
- Seed germination: imbibition → enzyme activation (GA → α-amylase in aleurone) → radicle emerges first.

08 Important Q&A

Q1. What is apical dominance? How is it used in tea plantations?

Growing apical bud inhibits lateral buds (auxin). Removing shoot tips in tea gardens lets lateral buds grow into bushy plants with more leaves.

Q2. Why is ABA called stress hormone?

Its level rises in stress (drought); it closes stomata and increases tolerance.

Q3. Which PGR causes bolting and how is it used in sugarcane?

Gibberellin; spraying elongates internodes, increasing yield by up to 20 tonnes/acre.

09 Common mistakes

- Calling 2,4-D a natural auxin (synthetic).
- Saying ethylene is only an inhibitor (also promotes ripening, female flowers).
- Mixing heterophylly examples.
- Confusing absolute and relative growth rate.

10 Practice (NEET style)

1. Bakanae disease led to discovery of?
2. Hormone for fruit ripening?
3. PGR that delays leaf senescence?
4. Growth equation with e^{rt} is?
5. Weedicide that kills dicots?

ANSWERS

1) Gibberellin · 2) Ethylene · 3) Cytokinin · 4) Geometric growth · 5) 2,4-D

11 Quick revision: 5 minutes before the exam

GROWTH

- Open growth
- Lag-log-stationary (sigmoid)
- Arithmetic L_o+rt

PROMOTERS

- Auxin: rooting, apical dominance
- GA: bolting, sugarcane
- CK: cell division

INHIBITORS

- Ethylene: ripening
- ABA: stomata close, dormancy

DISCOVERIES

- Went: oat
- Kurosawa: rice
- Skoog: kinetin

Have a doubt? Ask the AI Doubt Solver at padhaiadda.netlify.app, or take the mock test on this chapter.