DEPT OF BIOLOGICAL SCIENCES

BOT 424

Plant Growth and development

GERMINATION

Germination is the resumption of metabolic activities by the seed tissues and it involves

(a) Dehydration
(b) Utilization of stored food
(c) Gradual development of synthetic systems which enable the young plant to be autotrophic ,

Life of a flowering plant starts after fertilization which is double in the embryonic sac . The egg nucleus fuses with one male nucleus

→ (2n) → embryo

Two plants nuclei fuse with second male
Nucleus → endosperm (3n)

After this fertilization → embryo undergoes some growth →

Growth stops → water content of seed falls → metabolism slows down

Plant may die if herbaceous or annual but do not if shrubs or perennial ← seeds are dispersed

When seed are shed the degree of development of embryo varies in different plant s.

In orchids (orhidaceae) ____________ embryo consist of undifferentiated cells.

In grasses (Graminneae) _______ embryo well developed and already differentiated into leaves, nodes and roots.

In dicotyledons __________ partial development of embryo with plumule developing to shoot and radicle to roots .

The mature seed when released from the parent plants contains the embryo in a metabolically inactive dormant state.

Stored food of seeds

Seeds contains stored (reserved) food and this makes up to 85-90% dry weight of seed . In dicots the food is stored in rhe cotyledons while in monocots it is stored in endosperm s

In small lettuice seeds (Lactuca sativa), stored food support s the growth for several days when seed is grown in dark .

In fairly big peas and beans, stored food lasts for several (2) weeks. In coconut, (cocus nucifera) , halve of the stored food is utilized in 15 months of the dark growth. Stored food of seed contains lipids. Proteins , carbohydrate s , nucleic acids , amino acids ,vitamins ,coenzymes and minerals

Chlorophyll is absent in seeds. The stored food is present as insoluble compounds. Like starch stored as starch grains (Amyloplasts) ,Hemicelluloses present in all cell wall (date nut) lipids deposited as droplets of various sizes . Protein s deposited as protein bodies (aleurone grains).

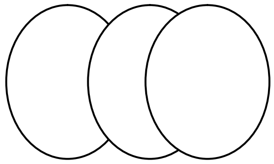
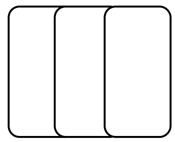
Some seeds do contain unusual amino acids which are not constituent of proteins . eg pyrazol-1-yl-alanine – found in seed of some members of the cucurbitaceae and give s 26% protein content eg canavanine found in the legume seed of canavalia ensiformis .

These amino acid s are called non- protein amino acids or free amino acid are toxic to animal and seeds containing them are avoided by insects and other seed – eating animals .

Metabolic rate

Extremely low metabolic rate found in un geminated seeds and this is due to low water content of 5-10% fresh water basis while plant tissue having high metabolic rate have 70-90% water content.

Moreover, the water in seed is bound water firmly bounded to colloids , inaccessible to hydrolytic reaction , unfreezable and under high vacuum.Because of this cells in dry seed are not round but shrunken and angular

Round Angular

PHASES OF GERMINATION

(a) Hydration phase.
(b) Active phase of metabolism

Hydration of germination

The first process that occurs in germination is water uptake by imbibition and osmosis imbibition is dominant in the initial phase of water uptake. As the water content rises , imbibition force decreases and osmotic forces become more important and determine the final water content through the micropylar pore (Hilium) and the testa .

With the entrance of water, seed increases in size and testa gets ruptured.

Water intake is faster in the embryo tissue than in the storage tissue .

The dehydration continues until 50-60% water content (fresh water basis) is achieved by the size and shape they had before the drying out which occurred during ripening of the seed.

As the seed becomes hydrated , metabolic activities are started with the help of enzymes , co-enzymes and substrate present in the seed .For example in wheat (Triticunvulgare) proteinases ,transaminases and glutamic decarboxylase are activated at 15% water content while respiratory dehydrogenases start functioning at 25% water content

Active phase of metabolism

It occurs when water content is above 25%

Development follows a differentiation course in two functional region of the seed.

(a) In the embryo – cells begin to elongate and divide growth is visible in the radicle before the plumule (emergence of radicle is normally taken as sign for germination.

Germination could be

Epigeal- if cotyledons are taken above the ground.

Hypogeal – if cotyledon are left below the ground

(b) In the storage tissue, there is hydrolysis of the stored food and the resulting soluble products are translocated to the growing embryo. Thus no cell division in the storage tissue.

Mobilization of food reserves

Hydrolysis of stored food is carried out by hydrolytic enzymes (Table below)

Stored food	Enzymes	Product of hydrolysis
Starch	α and B	maltose, glucose
	Amylase	glucose
	Maltose	
	Phosphorylase	glucose-i-phosphate
Hemicellulose	cytases	hexoses, pentoses
Lipid	lipases	fatty acids α glycerol
Protein	proteinases	amino acids, peptides
	proteases	amino acids
	Peptidases	
Ribonucleic acid	Ribonucleases	Ribonucleotides
Cellulose	cellulase	cellobiose

Cellobiase glucose

All the enzymes are non – specific except proteinases eg. Proteinase preparation from cabbage (Brassia) seed is in active towards the ptoeins from the seed of beans.

Enzymes activity in a seed come about either by release of an enzymes present in an in active form or by enzymes synthesis

$$\text{Insoluble food reserves hydrolytic soluble substances} \xrightarrow[\text{Enzymes}]{}$$

In maize soluble substances rise from 2% to 25% of dry weight, after five days of germination. As their reserves are exhausted, storage cells collapse.

Utilization of food reserves for seedling growth

Soluble products from hydrolysis are utilized by the growing plant. Most of the lipids are converted to glucose (the useful form for the developed plant), by glyoxylate cycle. Eg

Days germinated	Lipid	Weight per 100 Carbohydrate	seedlings(g) total dry weight
0	26.2	1.51	37.64
4	25.0	5.10	45.1
6	10.8	18.2	45.1
8	5.4	23.3	43.9
11	1.78	17.7	38.4

There is also interconversion of amino acid e.g in barley, glutamic acid and proline are converted into aspartic acid, alanine and glycocine (by transaminations).

As endosperm proteins fall, embryo proteins rise. As soon as growth begins in the embryonic regions, synthesis of RNA and DNA commences there from non – nucleic material.

The growing regions of the seedling exert a control over the activity of the storage tissues. Using pea seedlings, increases in enzymes activity in the cotyledons fails to take place if the embryo is excised.

Growing plumule contains a regulator gibberillin which promotes synthesis if enzymes in the cotyledons.

In the cotyledon of cucuirta maxima, synthesis of proteolytics enzymes is promoted by cytokinous.

Respiration during germination

They intense metabolism of the germinating seed is accompanied by high rates of respiration in both the embryonic and storage tissues in active respiratory enzymes are activated once a critical water content is passed (15%). After the initial hydration is completed (Ca 50% H_20 content), the respiration rate remains fairly constant.

Physiology of dormancy

Defined as a state in which viable seeds, or buds fail to germinate under optimum conditions of moisture, temperature and oxygen. Dormancy is accompanied by low metabolism, low water content and zero growth during which the seed is very hardy and can withstand cold and drought. Ceasation if growth that occurs in response to unfavourable external conditions such as low temp lack of water is called quiescence or enforced dormancy.

Advantages of Dormancy

(a) Enables some seeds and buds to remain viable for some time under harsh environmental conditions like some seeds being able to withstand the dry and cold seasons.

(b) Prevents wastage of seeds as in the cereals by preventing germination immediately after the harvest of the seeds. The seeds can germinate after been stored in a dry place for months.

Types of dormancy

(a) Seed coat dormancy - obtains when seed coat is hard and

(i) Impermeable to water e.g. in leguminous like flamboyant, parkia.

(ii) Impermeable to gases e.g. xanthium

(iii) Physically prevents embryo expansion e.g. Amaranthus.

(b) After – ripening dormancy - Occurs when plants produce seeds which do not germinate immediately under favourable optimum conditions butt do so after a period of dry storage. Examples are cereals like wheat, maize, rice, sorghum millet, barley, oat.

(c) Immature embryo dormancy - Obtains when the embryo of the seed is partially mature when fruits are shed. Fully mature embryo has to be attained before germination could be obtained. E.g. Ricinus.

(d) Inhibitors presence dormancy - If inhibitors are present in seeds at 5 – 10ppm, dormancy result e.g. in Milicia excelsia, Francinus Excelsus, Absicisic acid, ammonia, parasorbic acid, dehydracetic acid.

(e) Promoters absence dormancy - If promoters are lacking in seeds, dormancy results. Examples of promoters are Gibberilins, cytokinins, auxins and ethylene. No example yet.

(f) External factor requirement dormancy

(i) Light requirement - some seeds need exposure to red light or white light before they will germinate e.g. letuce seed (Lactuca sativa) pepper grass seed (Lepidium virginicum) Xanthium pennsylvancium, Rumex cripsus L. Rumex obtusifolius

(ii) Cold requirement - some seeds need a period of pre – chilling (0 – 15^{0}C) with adequate aeration for weeks before germination is obtained. e.g. Brassica juncea; Poa pratensis; lettuce seed where low temp (15^{0}C) can substitute for red light promotion of germination.

Methods of Breaking Seeds Dormancy

The method depends on the dormancy type in question.

(a) Scarification method - Refers to any treatment that renders the seed coat permeable to water and/or oxygen or weakens the seed coat so that embryo expansion is possible. Divisible into

(i) Mechanical scarification - Treatments which crack or scratch or weakens seed coat like shaking the seeds with sand; filling the seeds with sand – paper; cutting the seed – coat with a knife; breaking the seed – coat with a pressure of 500 – 2000 Atmospheres; heating the seeds in boiling water or in the oven and applying radiations like infra – red, X – ray, on the seeds.

(ii) Chemical scarification - Treatments which dissolve or weaken the seed coat. Achieved by dipping seeds into strong acids e.g. H_2s04; organic solvents e.g. acetones alcohol; using enzymes like hemicellulase and pectinase, soaking in water, salt and hormones solutions.

(b) Drying of seed - Employs for seeds having after – ripening dormancy. The seed are either stored in a dry place or are placed in heaters to reduce the seed water content.

(c) Allowing embryo to mature - Seeds with immature embryos are left in an environment favourable to germination until when the embryo is fully mature.

(d) Light treatment - This is by exposing wet seeds to red light (climax 660nm) for 10hours at 25^0C.

(e) Cold treatment - this is by exposing seeds to low temperatures (0 – 15^0C) for weeks under an aerated condition (pre – chilling treatment).

(f) Solvent treatment - this is by leaching out growth inhibitors from dormant seeds that contained them using solvents most especially water. E.g H_20 leaching of dormant seeds of chlorophora excelsia which contains ABA cause dormancy breakage.

(g) Application of growth promotions - 1 – 5ppm of cytokinin + gibberellin; auxin + gibberellin; ethylene + gibberellin will induce germination in dormant seeds for example letuce seeds.

Khan (1971) indicated how the presence of growth inhibitors (ABA, coumarih) and growth promoters (gibberellin, cytokinins) could cause a seed to germinate or be dormant.

Situation	Gibberellins	Cytokinin	Inhibitor	Result
1	+	+	+	Germination
2	+	+	-	Germination
3	+	-	-	Germination
4	+	-	+	Dormancy

5	-	-	-	Dormancy
6	-	-	+	Dormancy
7	-	+	+	Dormancy
8	-	+	-	Dormancy

+ = physiologically effective level - = physiology ineffective level.

THE PHYSIOLOGY OF SENESCENCE AND ABSCISSION

Senescence

Senescence is the process of decomposing changes which are natural causes of death. Similar to the ageing process and measured as a loss of chlorophyll or protein.

Ageing is gradual accumulation of physiological changes with time; which increases susceptibility to death but are not lethal in themselves.

Aging–gradual changes in time, some of which may be decomposing changes and increases susceptibility to death.

Senescence – decomposing changes that cause death.