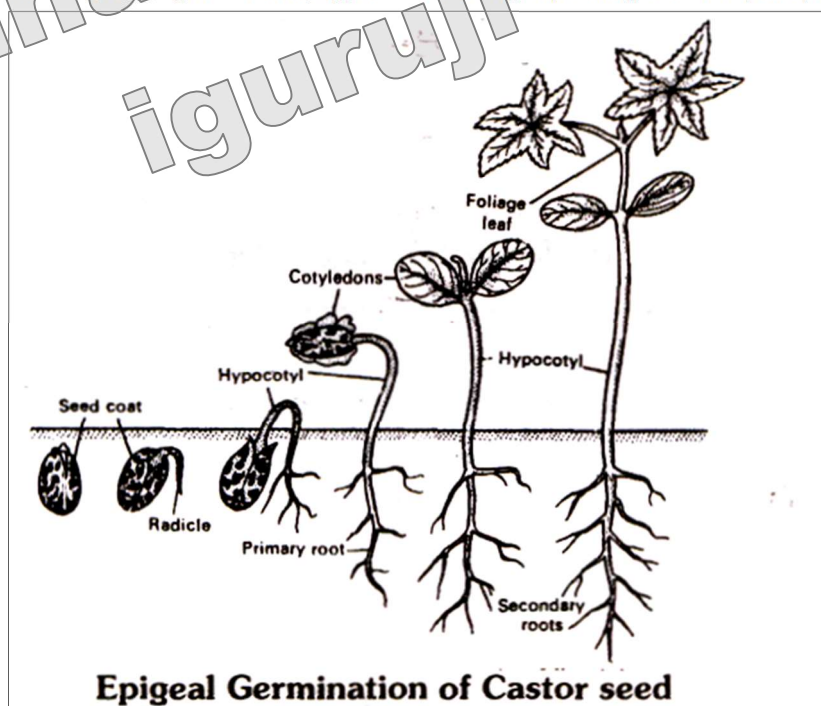


Seed Dormancy And Germination, Hormonal Regulation Of Growth And development. Physiological Effects And Mechanism Of Action Of Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic Acid And Jasmonic Acid, Plant rhythms And Biological Clock, Secondary Metabolites, Plant Responses To biotic And Abiotic Stresses. Physiology Of Flowering- Photoperiodism And vernalization.

Germination of seed

- The embryo of seed grows in to a sporophyte plant. The radicle produces primary root. The plumule develops short and latter on cotyledons degenerates.
- In some of the plants cotyledon comes above the surface of the soil during the germination of seed. Such type of germination is called epigeal germination, e.g. Capsella. This is due to higher growth take place in hypocotyle region of embryo in seed, so that cotyledon pushed above the soil surface [capsella, castor, French bean etc.]
- In some of plants the epicotyle region grow faster during the germination results cotyledon remains under the soil. It is known as hypogeal germination, e.g. In most of angiosperms [pea. Gram, Rice, Maize etc]



Factors Affecting Seed germination

The process by which the dormant embryo wakes up [becomes active] and begins to grow is known as germination of seed. The seed germination take place in the presence of favorable condition such such as temperature, moisture, and air. This is a very delicate stage in the life of the plant. Any minute change in the environment has harmful effect on growing embryo. So that favorable environment should be essential for germination. The following factors are essential for germination of seed.

1. **Moisture:** The moisture or water is the most important factor for germination of seed. Generally, the cells of embryo contain about 10-15% water in the dormancy period. The vital activities like growth and development is unable to continue in this less amount of water. For active life processes, water must be present about 75-90%. The seed absorbs water and swell up to increase in size before the germination. Water absorb through seed coat and micropyle.

The following effects have been observed in seed due to absorption of water:

- a. The seed coat becomes soft and absorbed water reaches to the cells of embryo. When the ratio of water increases in the cells, the protoplasmic contents becomes more active.

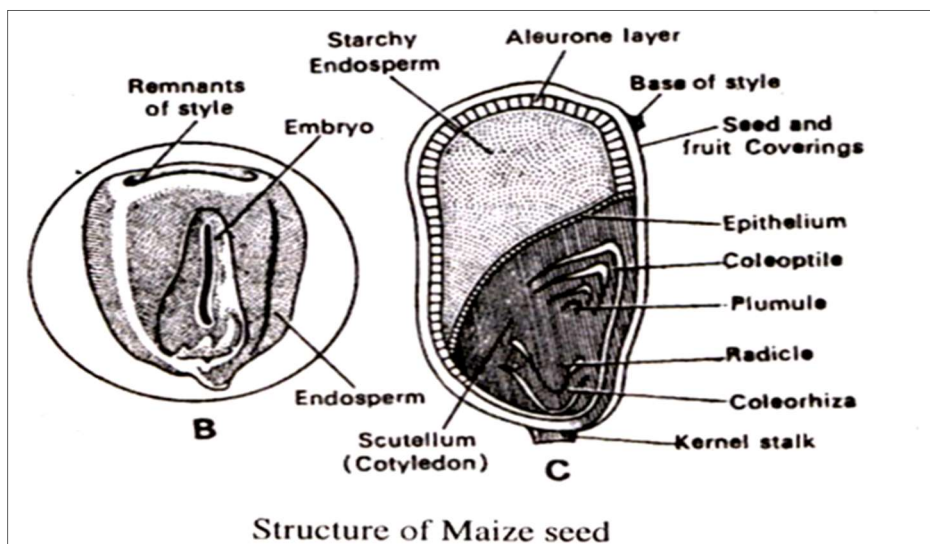
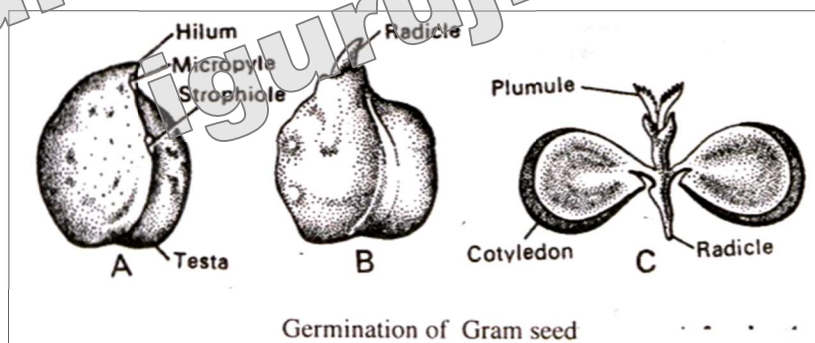
- b. The size of embryo increased due water absorption results, seed coat breaks up and radicle and plumule easily comes out. Seed coat absorbs water, it becomes soft and increase its permeability. Resulting it increases rate of exchange of oxygen and CO₂. The rate of respiration increases in active cells of embryo. Thus it require more oxygen.
- c. The enzymes are present in the cells or endosperm or cotyledons, which are only active in the presence of water. The stored food changed in to dissolved form by the activity of enzymes and it is reaches to the active embryo.

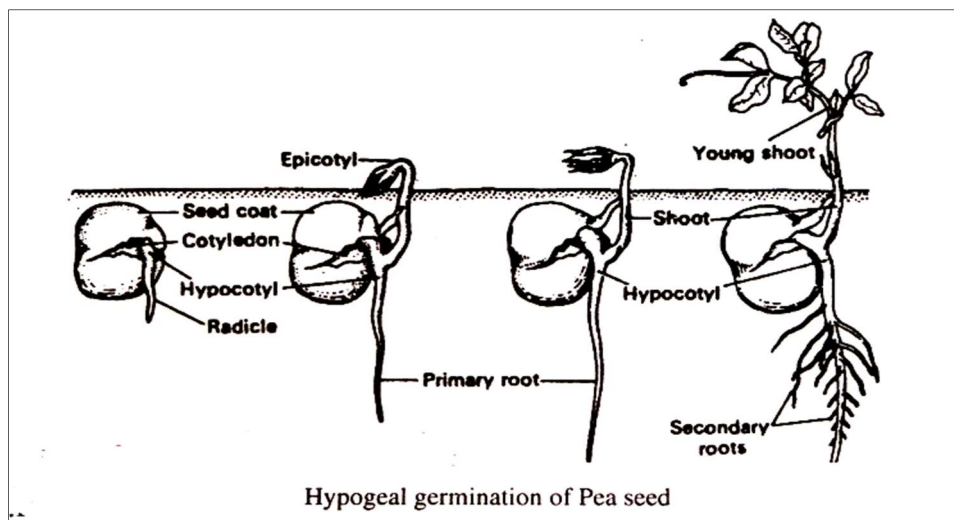
2. Oxygen [O₂]: The process like cell division, cell elongation etc. of the embryo require energy. This energy release by the oxidation of carbonic substances. Oxygen is essential for oxidation process. The upper surface of soil contains sufficient amount of O₂. The healthy germination does not take place in the absence or scarcity of oxygen in deep soil. So that crop seed sown in the in soil by the farmers in the field is only up to 5-7 c.m. deep.

3. Temperature: The suitable temperature is essential for germination of seed. The protoplasm of the cell remains active at certain range of temperature. Most of seed do not germinate in between the range of 0°C to 5°C and above the 45°C, The favourable range of temperature is 20-25°C for germination of seed in the majority of seeds.

4. Food or Nutrition: The growing embryo requires [needs] nutrition during germination. The embryo depends upon stored food materials in cotyledons or endosperm in the germination period up to the formation of primal} root from the radicle and first leaf from the plumule.

5. Light: Light produces different effect in different variety of seeds. The most of the plants do not require light up to the formation of first leaf. Adversely, the rate of germination very fast in the absence of light But for some plants light is very essential for germination.





They will not germinate in the dark. For example seed of epiphytes, orchids, tobacco, mistletoe etc. After the development of newly leaves on shoot then light is very essential factor. The chlorophyll is not formed in the absence of light and this newly formed plant [juvenile] will die in the absence of photosynthesis and deficiency of food.

SPECIAL POINTS

- (1) Highest amount of **fat** is found in endosperm of **Coconut**.
- (2) Kinetin hormone is present in **endosperm**.
- (3) The immediate effect of pollen grains on endosperm is called **xenia**.
- (4) Embryonic development of capsella is **endosporic** because it is developed from chalazal region of embryo.
- (5) Single celled suspensor is found in **Triticum** [wheat] and **Caryophyllum**. Their seeds are **caryopsis** fruit.
- (6) Suspensor is absent in **Sunflower** and **Marigold**.
- (7) 125 meiotic divisions are essential for development of 100 grains of wheat.
- (8) Two generation and three genotypic cells are present in Angiospermic seed.
- (9) Heaviest 6 k.g. weight of seeds found in **Lodoshia** & 1 meter in length and wt. of fruit is 18 kg.
- (10) Edible part of Betalnut is endosperm.
- (11) Abscissic acid is the natural germination inhibitor of seed.
- (12) The germination of seed take place inside the fruit while it is attached with plant is called **vivipary**.
- (13) Light inducess germination in Lettuce/**Lactuca sativa**
- (14) Anatomical transition from root to stem occurs in hypocotyle region,
- (15) Seed of the **Ruella** dispersed by jaculator technique.
- (16) Smallest or minute seeds are found in **Orchids** which are lightest in plant kingdom and are called "**Dust seeds**" [wt. 20.33 μ g].
- (17) Longest leaf in Angiosperm is **Raphia vinifera** [10-15 m] and broadest in diameter in **Victoria regia-1-1.5 m**.

Molecular Biology Of Seed Development

- All mature seeds contain an embryo and a protective covering called a seed coat (testa). In early development all angiosperm seeds also contain an endosperm, but in many seeds the endosperm is completely absorbed by the developing embryo. The embryo and endosperm are products of fertilization while the seed coat develops from the integuments of the ovule.
- The seed coat contains a variety of adaptations related to protection and dispersal mechanisms. The seed coat usually forms a dry tissue. It may contain waxes for water impermeability, mucilage to make seeds sticky, compounds resistant to digestion by animals, etc. In pomegranate, the seed coat forms the fleshy tissue that is consumed by humans. The seed coat often contains multiple layers with different characteristics.
- Maternal tissues appear to have an important influence on seed development. An arabidopsis mutant called **aberrant testa shape (ats)** that lacks one of the 2 integuments also lacks several cell layers in the testa

(3 layers vs. 5 normally). The seed are abnormally shaped in this mutant and seed shape shows maternal effect (ie. the genotype of the maternal parent determines the shape of the seed). Therefore, the seed coat and not the embryo determines the shape of the seed, and the embryo just grows to fill in the shape determined by the testa.

- Another maternal gene called *FBP7* is specifically expressed in the ovule and seed coat and is required for normal ovule development. Downregulation of this gene in transgenic plants resulted in degeneration of the endosperm that was dependent on maternal genotype. This demonstrates the interaction between maternal tissues and those produced by fertilization.

The importance of global gene regulation

- Several genes have been identified that negatively regulate seed development until fertilization has occurred. A mutant screen on a sterile line identified 3 genes that regulate seed development. Seeds develop on these mutants in the absence of fertilization. They are called *fis* for *fertilization independent seeds*. The genes appear important for control of seed development by fertilization. Several similar genes have been identified and cloned. They include:
 - *FIE* = *fertilization independent endosperm*, encodes a WD type POLYCOMB protein
 - *MEDEA* encodes a SET domain type POLYCOMB protein
 - *FIS2* = *fertilization independent seed2*, encodes a zinc finger protein
- **POLYCOMB** proteins are involved in chromatin structure and regulate (repress) the expression of genes in big portions of the genome. Therefore, the repression of large groups of genes is necessary to inhibit seed development until fertilization has occurred.
- All three genes show parent-of-origin effects (imprinting). The maternally inherited gene is expressed and required but the paternally inherited gene is not expressed or required for seed development. (I.e. heterozygous mutants show 50% seed abortion, even when fertilized by wild type pollen .
- **MEDEA and FIE proteins have been shown to interact by yeast 2-hybrid**

Preparation for developmental arrest (seed/embryo maturation).

- Most cell division is complete by the beginning of the maturation phase of embryo development, but the embryo can increase in size up to 100 fold. This is by cell expansion and accompanies a massive accumulation of storage compounds. The major storage compounds are proteins, starch and lipids. These storage compounds are what give nutritional value to important crops such as cereals and beans. They are also valuable for other uses such as production of vegetable oil and starch which are used in a wide variety of ways ranging from cooking to industrial lubricants and plastics. Therefore there is a huge economic interest in seed storage compounds.

Accumulation of storage products

- Storage proteins represent an important source of amino acids, nitrogen and carbon for the germinating seedling. Storage protein mRNAs represent up to 20% of the total mRNA found in a maturation phase embryo. They are synthesized on the RER and accumulate in the vacuole or as membrane bound vesicles called protein bodies. The storage proteins are encoded by several multigene families with up to 55 different genes coding for a given storage protein. Synthesis is controlled at the transcriptional level, with a few regulatory genes each controlling particular classes of storage proteins. An example is the *opaque2* gene of maize which codes for a transcription factor.
- The regulation of starch and lipid accumulation, although no less important, is less well understood. These compounds are produced by complex enzymatic pathways. Each class of compound is a mixture of molecules with different chain lengths, chain branching characteristics, levels of saturation and other chemical modifications. Thus the synthesis of these compounds is much less straight forward than storage proteins.

Acquisition of desiccation tolerance

- At the end of embryonic development, most seeds dehydrate to about 5% moisture content. Such severe dehydration is lethal to most plant tissues and embryos express a developmental program that allows them to survive. Acquisition of desiccation tolerance is part of the seed maturation program. Two problems faced by desiccated cells are high ionic concentrations and membrane stresses. At such low moisture levels, solutes would