

Lecture-2

SEED PHYSIOLOGY

Much of the success on modern agriculture depends on the availability of high quality seeds with good genetic potential and proven performance in germination, emergence, and vigorous Vegetative growth.

Seed: Seed is a fertilized mature ovule containing an embryonic axis (embryo), stored food material(endosperm) and a protective covering (seed coat or testa).

2.1 Seed structures:

Living embryo, the most important part of seed, consists of two structures (i) embryonic axis and (ii) cotyledon(s). The embryonic axis is composed of three parts namely (i) radicle (embryonic root), the hypocotyls (point of attachment of cotyledons) and (iii) plumule (the shoot apex with the first true leaves). The three parts of embryonic axis are easy to identify in dicots, but in monocots (especially in the family Gramineae) their identification is difficult. In monocots, there is only one cotyledon, which is reduced and modified to form the **scutellum**. The basal sheath of cotyledon is elongated to take the shape of **coleoptile**, while in some cases (e.g., maize), the hypocotyls is modified to form mesocotyl. The base of hypocotyls sheathing the radicle is termed as **coleorhiza**.(Figure.1)

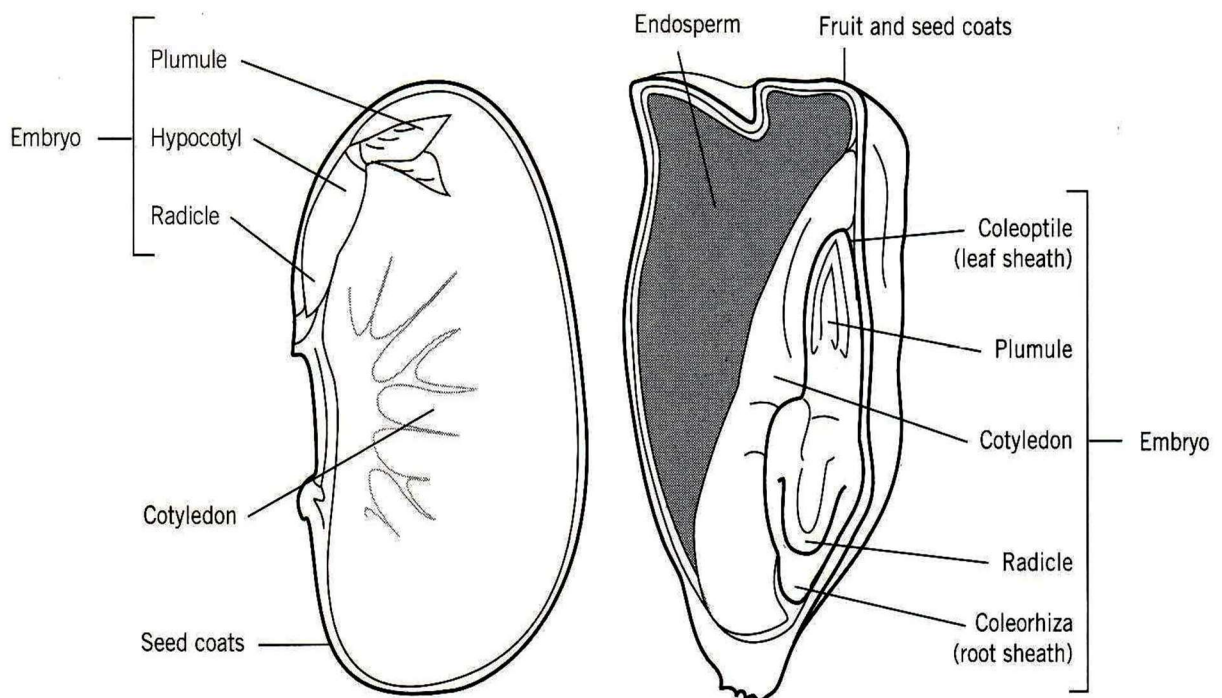


Figure.1 Seeds of common bean (*Phaseolus vulgaris*) (left), and Maize (*Zea mays*) (Right), a monocot, a dicot, showing the embryo.

*Figure.1 is from reference .5

2.2 Seed development: There are many variations in the pattern of seed development when the entire plant kingdom is considered. However, the general process of seed development is almost similar. This includes

- EMBRYO DEVELOPMENT
- ENDOSPERM DEVELOPMENT
- SEED COAT DEVELOPMENT

2.2.1 EMBRYO DEVELOPMENT:

Embryo is a connecting link between two generations of a plant and provides a continuity of genetic material. In most of the Angiosperms, the embryo and endosperm start their development as soon as double fertilization is over. Embryo is diploid in its genetic constitution and is developed from the zygote formed by fertilization between egg cell & one of the sperm nuclei. The embryo or embryonic axis represents the life of a plant in miniature.

The size and shape of embryo varies among the plant species. In Monocots (Ex.wheat) where the endosperm is well developed, the embryo occupies less space of the seed than in dicot species. Exceptionally, the cotyledons of Castor are thin and flattened (leaf like structure) since endosperm acts as a storage structure.

2.2.2 ENDOSPERM DEVELOPMENT:

Endosperm serves as the principal nutritive source (food material) for the embryo during seed development and germination. Endosperm development precedes embryo development. Endosperm is developed from primary endospermic nucleus which is a resultant of fusion between two polar nuclei and one of the sperm nuclei (which is formed from the division of generative nucleus). Thus, the endosperm of Angiosperms is Triploid ($3n$) and its development follows any one of the following three types.

A) Nuclear endosperm: In the nuclear type of endosperm development, the primary endosperm nucleus divides by repeated mitotic free nuclear divisions without the formation of walls. Ex. Wheat.

B) Cellular endosperm: In the cellular type of endosperm development, the first nuclear division of the primary endosperm nucleus is followed by the formation of either a longitudinal or transverse cell wall in the central cell. Subsequent nuclear divisions and wall formations result in the formation of a cellular type of endosperm, e.g., *Petunia*, *Datura*, *Balsam*, etc.

C) Helobial endosperm: It is an intermediate form of nuclear & cellular endosperm development. Helobial type of endosperm development is prevalent in monocotyledons.

In monocots development of endosperm reaches to its maximum by the time of maturity. However, in dicots endosperm development is not so conspicuous because of its continuous utilization by the embryo or it may remain as a small part of the seed (e.g. Groundnut and Soyabean).

Seeds with well developed endosperm are called endospermic or **albuminous** while those with small amounts of endosperm are non- endospermic or **exalbuminous**.

2.2.2.1 EXAMPLES OF ENDOSPERMIC SEEDS:

Monocots: Rice, Wheat

Dicots: Castor, opium

Legumes: Fenugreek

NON ENDOSPERMIC SEEDS

Monocots: Orchids, Water plantain

Dicots : Grams, Peas, Beans

2.2.2.2 ALEURONE LAYER:

In cereals and endospermic legumes the majority of cells in endosperm are non-living. However, the living cells are present in the outermost layer of endosperm and this layer is known as aleurone layer. During the development of endosperm, cells in aleurone layer are filled with protein granules and most of them are enzymatic in nature. Consequently this layer functions both as a storage tissue and also secretes enzymes of hydrolytic nature (like α -amylase) necessary for germination.

2.2.2.3 PERISPERM : In some of the plant species like coffee and Pig weed, endosperm is absent and the perisperm acts as a storage tissue. Perisperm ($2n$) is developed from maternal nucellus.

2.3 SEED COAT DEVELOPMENT:

During seed maturation the outer structure of ovules namely integuments undergo marked recognition to form the seed coat (testa). The seed coat acts as a protective barrier between the embryo and the external environment. The color and the texture of the seed coats vary from species to species and with in the species.

Almost all seeds bear a scar like point called **hilum**. This is the point at which a seed remains joined with the funicles. The **micropyle**, which is a small hole at one end of hilum, is present in seed coats of many species. Sometimes hairs or wings are also present in testa; these structures help in seed dispersal, e.g., in willow, lily etc. Seed coat may also bear outgrowths of the hilum region, viz, **strophiole** which

controls movement of water into and out of seed, and the **aril**, which contain chemicals. For example, the aril of nutmeg is used as a source of spice mace. In castor bean, the aril, which is associated with micropyle, is called **caruncle**.

2.3 MORPHOLOGICAL AND PHYSIOLOGICAL CHANGES DURING SEED DEVELOPMENT:

1. Soon after fertilization the embryo starts developing as soon as endosperm completes its development. This phase of development is characterized by **cell division** and **differentiation**.
2. Several **sub-cellular organelles** viz., Plastids, Mitochondria, Ribosomes, Golgi complex and Endoplasmic reticulum become recognizable immediately after cell formation.
3. The sub-cellular organelles undergo changes in their arrangement and activities. They also participate in the processes leading to the formation of embryo.
4. The embryo shows variation in shape depending upon its location (Folded cotyledons in Cotton, Bent in Fabaceae, Spatulate in Lamiaceae and peripheral in Caryophyllaceae)
5. Variation in the ratio of embryo and endosperm
 - In dicots the developing embryo utilizes endosperm completely. Therefore the ratio of embryo to endosperm is more.
 - In monocots the ratio of embryo to endosperm is less.

2.4 BIOCHEMICAL CHANGES DURING SEED DEVELOPMENT:

1. The seed increases in its weight due to synthesis and deposition of seed reserves like starch, fat, protein, nucleic acid and phytine.
2. Starch is the major **carbohydrate** that increases rapidly in the endosperm.
3. As development proceeds, the proteins (nitrogen) accumulate in the cotyledons of the embryo.
4. The synthesis of proteins in the embryonic axis will be accompanied by increase in RNA & DNA (nucleic acids) due to formation of new cells.
5. There will be simultaneous accumulation of storage **lipids** (lipid bodies) in the cell membranes between phospholipid layers.
6. **PHYTIN**- a rich source of Phosphorus is deposited as **myo-inositol hexa phosphoric acid**. This is found in the endosperm and aleurone cells of many seeds. (During germination phytin is hydrolyzed by the enzyme phytase to give inositol, which participates in numerous biosynthetic pathways essential to the developing embryonic axis)
7. Seeds also synthesize minor constituents like alkaloids (caffeine-in Coffee), Glycosides (Synigrin in Musturd), vitamins (Thiamin, Biotin and

ascorbic acid),inhibitors(Coumarin,ferulic acid and ABA)and hormones (Auxins,gibberellins etc.,)

8. There will be a change in the pigmentation of seed coat of peas which become colorless due to loss in the chlorophyll in chloroplasts.
9. Moisture content drops to 10-15% as a consequence of increase in depletion of seed reserves.
10. Thus, the above biochemical changes of seed indicate the complexity of development and maturity.
