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Process of Seed Germination: 5 Steps (With Diagram)

Article Shared by Srinibas Kumar

The process of seed germination includes the following five changes or steps.

Such five changes or steps occurring during seed germination are: (1) Imbibition (2) Respiration (3) Effect of Light on Seed Germination(4) Mobilization of Reserves during Seed Germination and Role of Growth Regulators and (5) Development of Embryo Axis into Seedling.

(i) Imbibition:

The first step in the seed germination is imbibition i.e. absorption of water by the dry seed. Imbibition results in swelling of the seed as the cellular constituents get rehydrated. The swelling takes place with a great force. It ruptures the seed coats and enables the radicle to come out in the form of primary root.

Imbibition is accomplished due to the rehydration of structural and storage macromolecules, chiefly the cell wall and storage polysaccharides and proteins. Many seeds contain additional polysaccharides, not commonly found in vegetative tissues. Seeds packed dry in a bottle can crack it as they imbibe water and become swollen.

(ii) Respiration:

Imbibition of water causes the resumption of metabolic activity in the rehydrated seed. Initially their respiration may be anaerobic (due to the energy provided by glycolysis) but it soon becomes aerobic as oxygen begins entering the seed. The seeds of water plants, as also rice, can germinate under water by utilizing dissolved oxygen.

The seeds of plants adapted to life on land cannot germinate under water as they require more oxygen. Such seeds obtain the oxygen from the air contained in the soil. It is for this reason that most seeds are sown in the loose soil near the surface. Ploughing and hoeing aerate the soil and facilitate seed germination. Thus the seeds planted deeper in the soil in water-logged soils often fail to germinate due to insufficient oxygen.

(iii) Effect of Light on Seed Germination:

Plants vary greatly in response to light with respect to seed germination. The seeds which respond to light for their germination are named as photoblastic. Three categories of photoblastic seeds are recognized: Positive photoblastic, negative photoblastic and non-

photoblastic. Positive photoblastic seeds (lettuce, tobacco, mistletoe, etc.) do not germinate in darkness but require exposure to sunlight (may be for a brief period) for germination. Negative photoblastic seeds (onion, lily, Amaranthus, Nigella, etc.) do not germinate if exposed to sunlight. Non-photoblastic seeds germinate irrespective of the presence (exposure) or absence (non-exposure) of light.

In these light sensitive seeds, the red region of the visible spectrum is most effective for germination. The far-red region (the region immediately after the visible red region) reverses the effect of red light and makes the seed dormant. The red and far-red sensitivity of the seeds is due to the presence of a blue-coloured photoreceptor pigment, the phytochrome. It is a phycobiloprotein and is widely distributed in plants.

Phytochrome is a regulatory pigment which controls many light-dependent development processes in plants besides germination in light- sensitive seeds. These include photo-morphogenesis (light-regulated developmental process) and flowering in a variety of plants.

Phytochrome and Reversible Red-Far-red Control of Germination:

The pigment phytochrome that absorbs light occurs in two inter-convertible forms Pr and Pfr. Pr is metabolically inactive. It absorbs red light (660 nm.) and gets transformed into metabolically active Pfr (Fig. 4.10). The latter promotes germination and other phytochrome-controlled processes in plants. Pfr reverts back to Pr after absorbing far-red (730 nm.).

In darkness too, Pfr slowly changes to Pr. Owing to this oscillation of phytochrome between Pr and Pfr status, the system has been named as “reversible red—far-red pigment system” or in brief phytochrome system. Treatment with Red light (R) stimulates seed germination, whereas far-red light (FR) treatment, on the contrary, has an inhibitory effect.

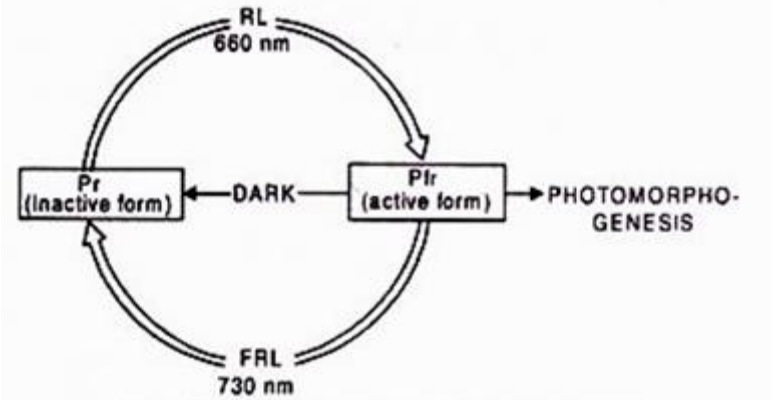

Fig. 4.10. Functioning of phytochrome system.

Let US examine seed germination in positive photoblastic seeds e.g. lettuce (Lactuca sativa). When brief exposure of red (R, 660 nm.) and far-red (FR, 730, nm.) wave lengths of light are given to soaked seeds in close succession, the nature of the light provided in the last exposure determines the response of seeds. Exposure to red light (R) stimulates seed germination. If exposure to Red light (R) is followed by exposure to far-red light (FR), the stimulatory effect of Red light (R) is annulled.

This trick can be repeated a number of times. What is crucial for seed germination is the quality of light to which the seeds are exposed last. This also indicates that responses induced by red light (R) are reversed by far-red light (FR).

Whole of this can be shown as given ahead:

R..	Germination
R + FR	No germination
R + FR + R	Germination
R + FR + R + FR	No germination
R + FR + R + FR + R.....	Germination

Light requirement for seed germination may be replaced by hormones such as gibberellins or cytokinins. Several development processes of plants controlled by phytochrome may be mimicked by appropriate hormones given singly or in combination with other hormones at the correct time.

(iv) Mobilization of Reserves during Seed Germination and Role of Growth Regulators:

During germination the cells of the embryo resume metabolic activity and undergo division and expansion. Stored starch, protein or fats need to be digested. These cellular conversions take place by making use of energy provided by aerobic respiration.

Depending upon the nature of the seed, the food reserves may be stored chiefly in the endosperm (many monocotyledons, cereal grains and castor) or in the cotyledons (many dicotyledons such as peas and beans). Thorough investigations in the mobilisation of reserves from the endosperm to the embryo via a shield-like cotyledon (scutellum) has been done in several cereal grains (Fig. 4.11).

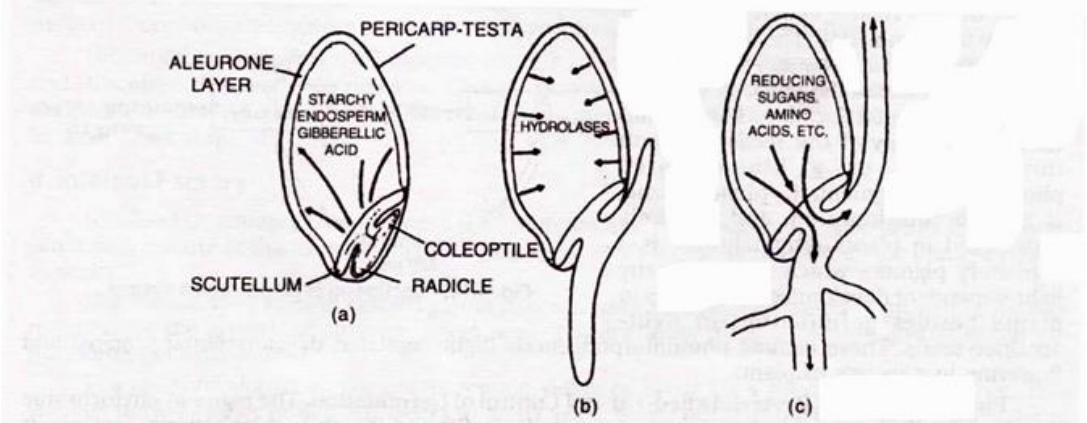

Fig. 4.11. Diagram showing relationship between GA production and hydrolytic enzyme synthesis and release in germinating barley grain. GA produced by the coleoptile and scutellum (*a*) migrates into the aleurone layer (*b*) where hydrolytic enzyme production is stimulated. These enzymes are released into the starchy endosperm (*c*) where they serve to hydrolyze endosperm reserves producing solutes that can inhibit further enzyme production and function to nourish the growing embryo.

The outer layer of special cells (aleurone layer) of endosperm produces and secretes hydrolyzing enzymes (such as amylases, proteases). These enzymes cause digestion i.e. breakdown of the stored food such as starch and proteins in the inner endosperm cells.

The insoluble food is rendered soluble and complex food is made simple. These simpler food solutions, comprising of sugars and amino acids thus formed, are diluted by water and passed towards the growing epicotyl, hypocotyl, radicle and plumule through the cotyledon.

Gibberellic acid plays an important role in initiating the synthesis of hydrolyzing enzymes. Gibberellin, therefore, promotes seed germination and early seedling growth. Assimilation of this food by the growing organ induces growth and the seedling soon assumes its ultimate shape.

It is very significant to note that the dormancy inducing hormone, abscisic acid (ABA), prevents the germination. The concentration of ABA has been shown to increase during the onset of dormancy of the embryo during seed development in several kinds of seeds.

When young embryos of cotton are removed and grown in culture, they continue to grow without the development of any dormancy. Dormancy in such cases can be induced by the addition of ABA at a crucial stage of growth.

(v) Development of Embryo Axis into Seedling:

After the translocation of food and its subsequent assimilation, the cells of the embryo in the growing regions become metabolically very active. The cells grow in size and begin divisions to form the seedling.

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