Dormancy of Seeds and Seed Germination

19.1. INTRODUCTION

Most of the viable seeds germinate immediately if placed under suitable conditions necessary for germination (moisture, air, suitable temperature and proper sequence of light and dark) but the seeds of certain plants fail to germinate even if placed under all favourable conditions. The germination of such seeds may be delayed for days, weeks, months or even years. Such seeds are said to be in the state of dormancy. The dormancy may be defined as the condition of seed when it fails to germinate even though the favourable environmental conditions are present.

Dormancy in seeds may be either due to lack of some necessary external environmental factor or as a result of internal causes. *Wareing* (1969) defined dormancy as any phase in the life-cycle of a plant in which active growth is temporarily suspended. According to him the dormancy due to unfavourable environmental conditions is called *imposed dormancy* or *quiescence*, while the dormancy due to conditions within the dormant plant or organ is called *innate dormancy* or *rest*.

Innate dormancy is a condition in which germination or growth fails to occur even though the external environmental conditions are favourable. The fully dormant condition of a seed is a gradual process and is not attained suddenly. During the entire process, there may be following three phases of dormancy.

(*i*) *Predormancy* or *early rest* : During this phase, the dormant organ has capacity to resume growth by various treatments i.e., capacity of germination or growth is not completely lost. It is called *predormancy*.

(*ii*) *Full dormancy* or *mid rest* : When a seed or organ becomes completely dormant and germination or growth cannot be induced immediately by changes in environmental conditions, it is called *full dormancy* or *mid-rest*.

(*iii*) *Post dormancy* or *after rest* : When a dormant seed or organ gradually emerges from full dormancy and in it the germination or growth can be induced by changing environmental conditions, it is called *post-dormancy* or *after-rest*.

The dormancy may be true, relative or secondary.

(*i*) *True dormancy* : When in a seed or organ, the germination or growth cannot be induced under any set of environmental conditions, it is called *true dormancy*.

(*ii*) *Relative dormancy* : When in a seed, the germination can be induced under specific conditions even at the time of its deepest dormancy, it is called *relative dormancy*.

(*iii*) *Secondary dormancy* : When a seed has not fully emerged from dormancy and is again thrown back into full dormancy by certain environmental conditions, *e.g.*, temperature etc., it is called *secondary dormancy*.

19.2. SEED DORMANCY

Crocker (1916) divided seed-dormancy into seed-coat induced and embryo-induced.

1. *Seed-coat induced dormancy*: The dormancy of seeds due to extreme hardness of seed-coat is called *seed-coat induced dormancy*. The hard seed coat checks the entry of water, exchange of gases and expansion of embryo.

(2) *Embryo induced dormancy* : The dormancy of seeds due to rudimentary or complete dormant embryo is called *embryo induced dormancy.* In this case the rudimentary embryo is incompletely developed and requires a rest period for complete development while complete dormant embryo shows dormancy due to physiological conditions.

Other types of dormancy may be:

(3) *Secondary dormancy* : When the seeds become dormant again after breaking the dormancy, it is called *secondary dormancy.* It may be due to combination of different kinds of dormancy in a single seed, *e.g., Xanthium pennsylvanicum.*

(4) *Special type of dormancy* : The failure of seedling development is not always traceable due to dormancy of seed itself. In many of the spring wild plants the germination of seed takes place but the growth is restricted due to establishment of young roots. Sometimes the system of epicotyl fails to germinate. In some cases, the epicotyl may be pushed through the seed-coat but remains dormant. This dormancy is often broken by exposure to low temperature.

19.3. CAUSES OF THE SEED DORMANCY

The dormancy of seeds may be either due to single or a combination of many different factors. As stated earlier, it may be seed coat-induced dormancy or embryo induced dormancy.

Seed-Coat Induced Dormancy

The seed coat of most of the seeds is formed by the integumentary layers of ovules. Chemically it is composed of a complex mixture of polysaccharides, hemicelluloses, fats, wax and proteins. During seed ripening, the chemical components of the seed coat become dehydrated and form a hard and tough protective covering around the embryo. The seed-coat induced dormancy may be due to following causes.

(1) *Water impermeability*: The seed coats of many plant species are completely impermeable to water. This condition is very common in the seeds belonging to families Leguminosae, Malvaceae, Chenopodiaceae, Convolvulaceae, Solanaceae and Nymphaeaceae etc. Here the germination fail to occur until water penetrates through the seed-coat. In many such seeds permeability of coat to water increases slowly in dry stage. The action of micro-organisms like bacteria and fungi also increases the permeability of seed-coats to water and shortens the dormant period of seeds. In many plants the seeds have waxy coating.

(2) *Gas impermeability* : The seed coats of certain seeds are impermeable to gases such as oxygen and carbon-di-oxide. Since oxygen is required for early respiratory activity in germinating seeds, the seeds fail to prolong germination.

In *Xanthium*, two types of seeds are found in a fruit which are not equally dormant under natural conditions. The lower seeds generally germinate in the spring following maturity while upper seeds remain dormant. The dormancy of upper seeds has been demonstrated due to impermeability of seed-coat to oxygen. If oxygen pressure is increased, the seed germination occurs. The oxygen requirement in upper seeds is greater than the lower seeds. Such dormancy of seeds is reduced by storing them for a longer time. This type of dormancy has also been reported in many grasses and some members of Compositae.

(3) *Mechanical resistance of seed-coat to the growth of embryo* : The seeds of some common weeds such as *Alisma, Amaranthus* and *Capsella* etc. have such hard and tough seed-coat that it prevents any appreciable expansion of embryo. Thus, they remain dormant. In the seeds of *Amaranthus*, the water and oxygen penetrate through the seeds readily but enlargement of embryo is limited by mechanical strength of seed coat. As long as the seed coats are saturated with water, the dormancy in *Amaranthus* may persist for about 30 years. However, if the seed-coats become dry and then again become saturated with water, they are no longer able to resist the expansion of embryo. The seed-coats rupture and germination takes place. At above 40°C some germination of seeds also takes place because the seed-coats become less resistant to pressure developed by imbibitional forces in the embryo.

Embryo-induced Dormancy

Embryo-induced dormancy may be of two kinds.

(1) *Rudimentary and poorly developed embryo* : In many plant species like *Anemone nemorosa, Fraxinus excelsior, Ginkgo biloba,* members of Orchidaceae, *Orobancheae* etc., the seed dormancy may be due to immature and rudimentary embryo. In such seeds the embryo does not develop as rapidly as surrounding tissues. Thus, when the seeds are shed, they are still imperfectly developed due to incomplete embryo. The germination of such seeds takes place only after a period of rest (dormancy) during which the further development of embryo is completed.

(2) *Embryo fully developed but unable to resume growth* : In many species, *e.g.*, seeds of apple, peach, Iris, Hemlock, peas, cherry, etc., although the embryos are completely developed in ripe seeds but the seeds fail to germinate even when the environmental conditions for germination are favourable. Dormancy of such seeds is due to physiological conditions of embryo. The embryo of such seeds does not germinate even if the seed-coats are removed. The germination in such seeds can be induced if they are stored in moist, well aerated and low temperature conditions. This process is called *stratification* or *after-ripening.* The ripening involves principally a series of physiological changes in the dormant embryo which gradually convert a dormant embryo into one that resumes growth.

Dormancy due to Specific Light Requirement

The seeds of certain plant species such as *Lactuca sativa, Lythrum salicaria, Nicotiana tabacum* etc. have a specific light requirement for germination. In imbibed *Lactuca sativa* seeds the germination is stimulated by red light of 660 nm wavelength, while it is inhibited by far-red light of 730 nm wavelength. This indicates the involvement of photoreversible pigment, phytochrome, in germination. Light not only affects qualitatively but also quantitatively. The reciprocal increase in germination with increase in intensity and exposures of light duration has been reported in *Rumex* seeds. The germination of certain seeds requires a specific photoperiod, *e.g. Bignonia* requires a photoperiod of 12 or more hours for seed germination. The light sensitive seeds are called *photoblastic.*

Dormancy due to Germination Inhibitors

In many seeds the dormancy occurs due to presence of germination inhibitors in seed-coats, endosperm, embryos or structures surrounding them such as the juice or the pulp of fruits *e.g.* in tomatoes, and in glumes, *e.g.* in Oats. A number of chemical substances such as organic acids, phenolics, tannins, alkaloids, unsaturated lactones, mustard oil, ammonia releasing substances, cyanide releasing substances, indoles and gibberellins etc. have been isolated from the seeds which act as germination inhibitors. Besides, the other natural inhibitors are coumarin, parascorbic acid, ammonia, phthalides, ferulic acids, and abscisin II etc. If these inhibitors are leached out, the germination of seeds takes place.

19.4 METHODS OF BREAKING SEED DORMANCY

The dormancy of seeds can be broken and the dormant seeds can be induced to germinate by one or combination of more than one methods described below.

Scarification

This method is used for breaking dormancy of seeds caused by hard seed coats which become impermeable to water and gases etc. In this method the seed-coat is rendered permeable to water and gases either by mechanical method or chemical treatments. The seed coat becomes soft and weak by this treatment. The method employed in softening or weakening the seed-coat is called *scarification.* When mechanical breaking of seed coat is done at one or more places, it is called *mechanical scarification.* The treatment of seed coat with strong mineral acids or other chemicals is called *chemical scarification*. Mechanical scarification is done by shaking the seeds with sand or by scratching or nicking the seed-coat with knife. Chemical scarification is usually done by dipping the seeds into strong acids like H_2SO_4 or into organic solvents like acetone or alcohol. It can also be done by boiling the seeds in water. Under natural conditions in the soil, certain micro-organisms like bacteria and fungi act upon the seed coat to decompose it but this process requires a lot of time.

Stratification

This method is used to break the dormancy of seeds caused due to condition of embryo. In this process the seeds are exposed to well aerated, moist conditions under low temperature (0° to 10°C) for weeks to months. This treatment is called *stratification* or *after-ripening*. During stratification some chemical changes occur in the immature embryo of seeds which are necessary for seed germinaion. These changes are as follows—

(*i*) The concentrations of nitrogen and phosphorous are shifted to the various parts of the seeds.

(*ii*) Various constituent amino acids, organic acids and enzymes are also shifted.

(*iii*) Cyanogenic glycosides are decomposed.

(*iv*) The concentration of various growth regulators is changed.

Alternating Temperature

In some seeds, *e.g. Poa pratensis*, the seed dormancy is broken by the treatment of an alternating low and high temperatures. The difference between the alternating temperatures should not be more than 10-20°C. This method is beneficial in those seeds in which the dormancy is due to immature embryos. Alternating temperature of 15°C and 25°C is useful in breaking the dormancy of photoblastic seeds like *Rumex crispus*.

Light

The light sensitive seeds are called *photoblastic* which may be of following three types :

(*i*) *Positive photoblastic seeds* : The seeds requiring single exposure of light for germination are called *positive photoblastic seed, e.g., Lactuca sativa*.

(*ii*) *Negative photoblastic seeds* : The seeds requiring complete darkness for germination are called *negative photoblastic seeds*.

(*iii*) *Non-photoblastic seeds* : The seeds requiring either light or darkness for germination are called *non-photoblastic seeds*.

The dormancy of positive photoblastic seeds can be broken by exposing them to red light (660 nm). Far-red light inhibits the seed germination indicating the involvement of photoreversible pigment phytochrome in the process of seed germination. This pigment occurs in two forms, one red absorbing and other far-red absorbing. Both these forms are photochemically interconvertible. The red absorbing form (P_R) is converted into far-red form (P_{FR}) after absorbing the red light. The far-red form absorbs the far-red light and is converted back into red absorbing form of the pigment.

$$P_R \underset{735 \text{ nm}}{\overset{660 \text{ nm}}{\rightleftharpoons}} P_{FR}$$

It is supposed that in positive photoblastic seeds, the far-red absorbing form of the pigment is stimulatory to seed germination while red-absorbing form is inhibitory to seed germination.

Pressure

The seed germination in certain plants like sweet clover (*Melilotus alba*) and alfalfa (*Medicago sativa*) can be greatly improved after being subjected to hydraulic pressure of about 2000 atm. at 18°C for about 5-20 minutes. This pressure changes the permeability of seed coat to water resulting into seed germination.

Growth Regulators

Growth regulators are most widely used to hasten the development of roots or cuttings and to increase the number of roots. Kinetins and gibberellins have been used to induce germination in positively photoblastic seeds like lettuce and tobacco etc. Besides, a number of chemicals such as KNO_3, thiourea and ethylene etc. have also the capacity to induce seed germination.

19.5. ADVANTAGES OF SEED DORMANCY

(*i*) The dormancy of seeds help the plants of temperate zones to tide over the severe colds.

(*ii*) The dormancy of seeds due to impermeable seed coats ensures good chances of survival to the plants of tropical regions.

(*iii*) The dormancy of seeds in cereals is most important to mankind. If these seeds germinate immediately after harvest, they will be quite useless for mankind.

(*iv*) Dormant seeds and organs in perennial plants resist unfavourable conditions for their development.

(*v*) The seeds form a measure of the quantity and duration of rainfall, both of which determine the amount of soil-moisture available for plant growth.