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Dormancy in Seeds and Buds[1]

by
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What is Dormancy: Many of the living organisms, both plants and animals, pass over during their life-cycle into a state of 'rest' or 'quiescencce' under certain conditions, generally adverse, and regain their normal activity when restored to their original conditions. This state of rest is normally characterised by low physiological activity and the biochemical processes are reversibly arrested for different periods of time. It is referred to as viable lifelessness, suspended animation or the widely used term, '*anabiosis*', which has been reviewed recently by Keilin (1959). Dormancy, which is classified under '*hypobiosis*' (low activity), includes 'hibernation', 'aestivation', 'diapause' and 'quiescence' of animal organisms, as also the 'rest' period in seeds, buds and spores of plant life.

Dormancy in seeds and buds of higher plants has been under review from time to time in view of its theoretical and practical importance; the more recent reviews are included in Encyclopedia of Plant Physiology, Vol. 15 (1965), in Annual Review of Plant Physiology (Vegis, 1964), and in the monograph on 'The germination of seeds' by A. M. Mayer and A. P. Mayber (1963).

There has been some confusion in the usage of the term 'dormancy' for seeds and buds. It is generally considered to be a state, arising usually as a result of adverse environmental conditions, when there is cessation of growth and developmental processes, associated with low metabolic activity. Barton (1961) states that 'primary dormancy', present in the seed at maturity, presumably has its origin during the development of the embryo and its surrounding structures while still in the mother plant. It should be distinguished from cases of 'secondary dormancy' which is induced in seeds exposed to conditions, usually favourable to growth *i. e.*, a moist medium and a warm temperature. Secondary dormancy can also arise as a result of unfavourable conditions to which the sprouting seeds are exposed. The term, 'after-ripening', broadly relates to the preparation of the seed for resumption of growth.

Dormancy, according to Pollock and Toole (1961), indicates two inactive conditions, one due to an unfavourable environment and the other to internally imposed blocks; seeds of silver maple (*Acer saccharum*)

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germinate in early summer when they fall from the parent tree on to moist ground; they are 'inactive dormant' at the time of maturity. However seeds of apple tree (*Pyrus malus*) can germinate only after 'rest' period; after-ripening removes germination blocks; the seeds are 'blocked-dormant' at maturity. They however caution that the terms 'dormancy' or 'rest' should be used carefully with respect to each case after defining the conditions. In seeds of *Paeonia suffruticosa*, the root grows under normal (warm) germinating conditions; shoot-growth requires pre-chilling but it is not effective until after the root has grown. It is quite in step with the changes in the environment of the natural habitat of these trees. Seeds of the *peony* tree ripen in late summer and winter temperature is too low for germination; so, the seed germinates in spring with the root alone growing; the chilling required for shoot-growth is experienced during next winter and the shoot grows in the following spring: an admirable adaptation to the surrounding environment, apparently controlled by internal 'blocks

Vegis (1964), however considers dormancy of plant organs including seeds to be composed of three stages or periods; (i) 'pre-dormancy' or 'early rest', (ii) 'true dormancy' or 'main rest' or 'middle rest' and (iii) 'post dormancy' 'after rest' (for buds) or 'after-ripening' for seeds. During the 'true' or 'deep' dormancy period, growth cannot occur under any external conditions, while it is not so for the pre and post-dormancy periods, although under these conditions, the range of external factors (light, temperature, *etc.*) can be wide or narrow for resumption of growth. The duration of the three periods varies with the species and their natural habitats and any of these three states may even be altogether absent. The range of external conditions under which growth can be resumed during the pre-dormancy period gradually narrows down, while the reverse occurs with the progress of the post-dormancy period. The three states of dormancy are apparently more pronounced in buds of aerial shoots and of tubers and turions than in seeds. Several examples are quoted in support of the above view (Vegis, 1964).

Van Overbeek (1966) states "dormancy is a phase of development, a phase of differentiation". Growth in size may be minimised although cell-division and even increase in dry-weight may occur in some cases. It is, however, surprising to note that he cites in support, the chilling experienced by winter cereals during periods of low winter temperatures for initiating flower formation. Further, in tulip and hyacinth bulbs, physiological preparations for flowering in spring take place in a series of distinct stages even when they are stored in the shelves of a warehouse. Thus the term 'rest period' or 'dormancy' has a wider significance than the usual cessation of growth activity.

It is apparant from the above that Barton and Vegis were interested in explaining dormancy as observed in various species of plants in their natural habitats, the interactions between the different environmental factors (temperature, light, humidity, *etc.*) in inducing or terminating dormancy, while Pollock and Van Overbeek are eager to understand the 'blocks' in the metabolism. However, in seeds at least, one should define 'germination too, its beginning and completion. Does it start with the breaking of the seed-coat and the appearnce of the radicle or main root, and end with the' appearance of the plumule. Under field conditions, germination is noted with the emergence of the seedlings above the soil-surface which will naturally involve shorter or longer duration depending upon the species and the environmental conditions. Studies in laboratory cultures apparently have recognised these aspects, as is evidenced by the observation on epicotyl dormancy in some species of *Lilium*, *Paeonia*, *etc*, (Barton, 1961).

Significance of dormancy: Dormancy in plants is an adaptation to adverse environmental conditions. It has a survival value. It involves both space and time. It may even enable chance crossing between plants of different varieties of species. Mutations are known to occur in dormant seeds. Thus it not only maintains continuity of the species but also is perhaps a source of variations and consequently of evolution, which has not apparently attracted much attention.

Factors influencing dormancy: Dormancy is often considered to be a genetically controlled factor. But it is now known that the type of response to the individual and combined external factors alone is transmitted hereditarily (Vegis, 1964). The external factors which induce dormancy vary with the species because some experience in their natural habitat hot and dry summer, cold winter or both. Again diurnal or seasonal variations in light and temperature can also induce dormancy. However cultivated varieties exhibit less pronounced to environmental factors than the wild species.

Temperature and light (quality and duration) are important factors which influence dormancy. Plants growing in temperate regions usually mature their seeds in late summer or autum. Even though the soil is moist, the mature seeds do not germinate in the soil and grow during the cold winter. They however remain imbibed with water and sprout in the spring. 'Stratification' *i. e.*, keeping imbibed seeds at a low temperature (0–10° C) for 4 to 8 weeks, is adopted for breaking dormancy in winter cereals. Similarly pre-chilling for the required duration can break dormancy in buds.

Light is a potent factor in controlling dormancy in seeds of certain plants. Work on light sensitive lettuce seeds (Borthwick *et al*, 1952) has shown that exposure to red light (6700 A°) breaks dormancy while it is reversed by far-red light (7300 A°). The favourable red light effect can be replaced by exogenous application of *gibberellin*. In many of the dormant buds, exposure to long-day conditions could restore growth and the reverse is associated with short-day exposure. Thus, not only continuous light but also the quality of light as well as the photoperiod are found to control dormancy in seeds and buds of different species. Further, an interaction of light and temperature is generally observed in the above effects.

An after-ripening of seeds of some plants under dry storage is necessary to complete their dormancy. Seeds of many of the cultivated plants in warm regions, which do not germinate immediately after harvesting, do so after dry storage for a few weeks.

Besides the above environmental factors, certain characters of the seeds or buds are closely associated with dormancy. Hard testa as in seeds of *leguminosae*, strophiolar plug in certain *papilionaceous* seeds, waxy or hairy covering on seed-coats or bud scales, immature embryos, *etc.* are known since long to cause dormancy in these seeds or buds. The hard testa or waxy covering forms an impervious layer to water and gases and prevents germination or growth. During after-ripening of the seeds in soil or the rest period of the buds, chemical changes occur in the coverings resulting in improved permeability to water and gases.

During the last two decades, germination or growth inhibiting chemical substances in the seeds or buds are recognised to cause dormancy. The level of endogenous inhibitors is gradually lowered during the rest period. It has also been found that the inhibitor disappears in dormant buds after treatment with a dormancy-breaking agent (Vegis, 1964). Evenari (1949) enumerates a long list of possible inhibiting chemicals in seeds. Wareing and his co-workers (1963) isolated a growth-inhibiting substance from the leaves of *Acer psendoplatanus* which can induce dormancy in buds. It was later termed Dormin and is apparently identical with Abscissin II. The significance of dormin will be discussed later under 'dormancy mechanisms'.

Breaking of dormancy: Methods to break dormancy in seeds with impervious testa of waxy and hairy covering are known since long. Mechanical abrasion of the hard testa or treatment with concentrated sulphuric acid or alcohol are successfully adopted in several cases to break dormancy in seeds.

Exposure of imbibed seeds to suitable low temperature for the required period (stratification) is commonly practised for winter cereals to break dormancy. Similarly, light-sensitive seeds can complete the rest period under illumination. Great care, however, is needed to decide the type of illumination, its duration and the temperature maintained during and after illumination in each case for success.

Germination inhibitors in seeds can be successfully eliminated by washing the seeds in running water.

Potassium nitrate, thiourea and *ethylene chlorhydrin,* are known to break dormancy in seeds and buds. Among growth-regulators, *gibberellin* (GA_3) alone is found to promote germination of dormant seeds or growth of resting buds. It can replace the light factor in light-sensitive seeds. Endogenous *gibberellins* or similar substances apparently increase in quantity in the dormant organs during after-ripening or post-dormancy (Vegis, 1964). However, *gibberellins* may not be involved in all cases of dormancy.

Thus, dormoncy in seeds or buds is a complicated phenomenon, controlled both by internal and external factors. In view of its practical importance to growers of economic plants, much information is already available on the various aspects of the topic. However, the mechanisms of dormancy is little understood. Only in recent years the theoretical aspect of dormancy is receiving attention to explain the causes of dormancy in terms of physiological blocks due to altered balance in growth promoting and growth inhibiting endogenous substances.