SEED STORAGE

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The Seed. Seed is an important item in commerce, agriculture and the regeneration of natural processes and may be defined as a mature ovule, as distinguished from a fruit which is a mature ovary. The seed consists of an embryo with reserve food, as endosperm and nucellar tissue surrounded by one or two integuments (seed coats). However, either or both the endosperm and nucellar tissue may be lacking, in which case the reserve food is contained in the cotyledons of the embryo. Generally, a seed is accepted as a unit for sowing, irrespective of its development on the parent plant.

The Resting Seed. The resting seed of most of the economic plants contain a well-developed embryo and reserve foods stored in the endosperm or in the cotyledons of the embryo, all of which are enclosed in a seed coat. Respiration is very low in many dry resting seeds which contain such chemical substances as suberin and cutin. These substances slow down the absorption of moisture by the seed and the exchange of gasses through the seed coat. In the resting condition seeds are reasonably resistant to outside environmental conditions. As long as they remain dry, so long as harvesting has been done when seeds are ripe, and favourable storage conditions are maintained, then viability for planting is ensured from one to several years after harvesting.

Process of Germination. Dry seed in the resting condition requires considerable moisture before germination will take place. Under suitable moisture, temperature, and oxygen supply, the seed coat becomes softened and more permeable to water and gases such as oxygen and carbon dioxide. As water enters the embryo and endosperm, the process of digestion, respiration and growth begins.

Digestion. The food in the resting seed is in a suitable condition for storage but must be broken down through digestion before germination can commence. Digestion is the process of chemically breaking down a complex food into a simpler one. It is usually a process of hydrolysis by enzymes wherein water is chemically added to the compound (food storage) and then broken down into a simpler form, necessary for commencement of germination.

Respiration. The rate of respiration in air-dry seeds is low and the energy produced during respiration is dissipated into the air in the form of heat. Where seeds have been dry processed and stored under controlled temperatures in equilibrium to seed moisture or at very low temperatures, respiration is extremely low, thus *the seed is held in "suspended animation"* (increasing the storage life).

Storage of Seeds. When assessing a seed lot for storage, one must consider its viability at time of storing, it's value in relation to storage space, etc. Assuming seeds are undamaged, showing high germination, and free from admixtures, the function of storage is to provide an environment in which changes in the seeds will be held to an acceptable level. Since seeds are living things, some change will occur under any circumstances. The viability potential cannot increase during storage but decrease in viability potential will depend largely on temperature and moisture content. The purpose of temperature and moisture control is not to stop deterioration but to slow it down to an acceptable rate. Methods of measuring the potential for continued storage are not available, except that seeds may be tested at any or regular periods by germinating samples to assess the point beyond which they will not grow, or will grow only with reduced seedling vigour.

Since temperature and moisture content tend to control the rate of respiration and of deterioration, many studies have been made of the relationship between seed moisture and storage temperature to ascertain the useful storage life of seeds. Germination data collected over many years in relation to storage moisture and temperature show that lower moisture contents and lower temperatures extend the length of life of seeds of many species by more or less systematic multiples. For example, if reduction of the moisture content from 13% to 12% doubles the potential storage period, then a further reduction to 11% may be expected to result in a storage life twice as long as 12%. The storage life responds in a similar way to changes in temperature and does not extend to extremes of temperature and moisture content.

Seeds are hygroscopic. That is, they tend to either gain or lose moisture, depending on how much moisture they contain and on the humidity of the air in which they are stored. At a given temperature, for each level of seed moisture content, there is a corresponding specific level of atmospheric humidity at which there will be no net exchange of moisture between seed and air. If air humidity is reduced in the storage area, moisture content of the seed will fall to bring both into equilibrium.

Not all seed can be what is termed "dry-conditioned"; that is, stored in a controlled atmosphere of say 25% relative humidity and storage temperature of 23.9°C (75 deg. F). In certain species seed dormancy does exist and we have found that with such flower kinds in the Leguminosae family as sweet pea and pearl lupine seeds develop dormancy due to deterioration of the outer cell layer of the seed coat, making seeds impervious to water. Seeds of these lines we hold in open storage.

STORAGE OF VEGETABLE AND ANNUAL FLOWER SEED

We in the vegetable and flower seed industry acknowledge the work carried out some 20 years ago by Dr. J. F. Harrington of the University of California, Davis, California, in the practical methods of storage of vegetable seeds; as a guide to implementation of controlled storage he recommended the following:

1. For each one percent reduction in moisture content the storage life of the seed is doubled.
2. For each 5° C. lowering of storage temperature the storage life of the seed is doubled.

At normal storage temperatures, if the seed moisture content is above 18 to 20 percent, frequently micro-organisms multiply and there is a sudden rise in temperature causing heating, damaging the viability of the seed and possibly causing fire. At this same high moisture level several species of fungi will flourish. They attack the seed and, in time, destroy its viability. Growth of micro-organisms will cease when seed moisture is at or below 12 percent.

At seed moisture content below 9 percent no species of seed-storage insects can reproduce, thus eliminating damage to seed and assisting seedsmen in hygiene of their seed storage rooms. Some seeds at around 6 percent moisture can be stored even at warm temperatures — up to 30° C for three or more years without loss of germination. At this low moisture level aging becomes a very slow process and is even slower at still lower moisture contents. Seeds of some species can be dried to 0 percent moisture without apparent harm, but may develop severe dormancy at moisture contents below 3 percent; examples would be lettuce and cucumber seed.

There are a few arid areas in the world where seeds are produced and stored where the relative humidity is so low that seeds reach an equilibrium with air moisture as low as 6 percent when dried in the field at harvest time. Due to high relative humidities in Australia, especially in the northern regions, it is necessary for seedsmen to pack seeds in moisture-proof containers, such as cans and foil pouches, allowing resellers a long shelf life of seeds for sowing without loss of viability.

Vegetable and flower seed can also be stored at cold temperatures, even below freezing, if the seed is at least air-dried. Unfortunately, most cold temperature storage in warm climates have high relative humidities, so seeds acquire dangerously high moisture levels during storage. Seeds of high moisture content may be stored successfully as long as they remain cold but will deteriorate rapidly when moved to high temperatures if held for several days before planting, or shipped to customers through normal delivery methods. The dry-conditioned method for storage of vegetables and flower seeds is the key to success in the garden seed business.

STORAGE OF SEED OF TROPICAL SPECIES

Extensive studies are being carried out in Africa, India and South America on storage methods of seeds of tropical and sub-tropical species. Some of our so-called indoor plants fall into this group. Seeds of some species of philodendron are now successfully being dry-conditioned. Others are still being sold packed to germinate in transit to customer.

A high percentage of seeds of tropical species lose their germinative capacity, completely or partially, in a short time. The range of species to be studied is varied and whilst some seeds can be dry-stored, many others can only be stored successfully in sealed or open containers at 4° to 6° C. Such work on tropical and sub-tropical species is continuing.

STORAGE OF DECIDUOUS TREE AND SHRUB SEEDS

Deciduous tree and shrub seeds are extremely variable in their structure, both externally and internally. Because of the nature and variability of this large group of seeds, a great deal is yet to be learned concerning optimum storage methods and the length of time which these seeds will retain their viability and vitality.

At this stage there is no hard and fast rule on the storage of tree and shrub seed. C. E. Heit, New York Agricultural Experiment Station, Geneva, N.Y., (who has worked for over 20 years as a seed technologist) reports seeds of legume and other hard-seed-coat genera, such as *Acacia, Cassia* and *Rhus*, can be suitably stored in a dry, well-ventilated room at normal temperatures.

Seeds from fleshy fruits have been successfully stored at low temperatures with a moisture content ranging from 4 to 7 percent, provided all dried flesh was removed from seed before storage. Mr. Heit found that fruit acids in any remaining dried pulp had a tendency to induce dormancy during germination and was not related to storage conditions.

STORAGE METHODS FOR CONIFER SEEDS

Mr. Heit has found that conifer seed taken from only fully developed cones were best for successful long term storage; he found that almost all species of conifer seed with a moisture content between 4 and 8 percent stored successfully at a range of 0-4.4° C. (32° to 40° F.). He has successfully stored and tested viability of conifer seed lots which retained their original strong germination for 5, 15, 25 and 30 years.

CONCLUSIONS

Seed technologists around the world have studied methods of successfully storing seeds, as in vacuum, addition of carbon dioxide, removal of oxygen from the stored area, addition of nitrogen, deep freezing and the use of dessicants in the stored area. A problem encountered in successfully storing seeds of aquatic plants was the temperature of the water in which the seeds were held. Drying temperature appears to be an influencing factor with certain citrus seed species. A build-up of carbon dioxide in sealed storage is another difficult question. These and many more problems are not yet solved by man. Since the advent of dry-conditioning in Australia some 15 years ago, many thousands of dollars have been saved by all users of seed. My own experience with gerbera seed indicates we can now store it for periods in excess of 3 years where once one or two months was its life.

SOME SALT-TOLERANT NATIVE AUSTRALIAN PLANTS

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When discussing salt tolerance in native plants, it is necessary to understand that without a careful analysis of the nature of salinity in any given area it is seldom possible to predict, without the use of field trials, the success rate of any given species in new situations. However, despite this proviso, it is true that certain species have a considerable tolerance to wide ranges of salinity.

Again, it is necessary to arrange salt tolerant plants in two categories:

(1) Plants to be grown in soils with high salinity — for example, reclamation work around salt lakes and on farms.

(2) Plants to be grown in soils of rather lower salinity where sensible soil husbandry may produce a more favourable pH reading by admixtures of peat, compost, etc., but situations in which the plants are subject to wind-blown salt, and hence saline windburn. Category 2 refers, therefore, to plants to be grown on our sea coast in Belt 1 (after Menninger). These notes concentrate on plants which might be grouped in category 2, though some listed could be used for both purposes.

Before any generalizations are made regarding suitable species for use in either of these situations, it should be emphasized that