Storage of Orthodox Seeds

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Seeds have an unique position in the world of plant propagation because they can be dried down and stored for long periods of time. This makes seeds ideally suitable for long-term storage (gene bank preservation) and the shipping of plant materials. The oldest recorded living seed is about 240 years old. This seed is from the species *Nelumbo nucifera,* however, there is doubt about the dating of this seed. In addition, we have other reports of germinable seeds about 100 to 150 years old. For tree seeds, companies are not interested in storing for more 10 to 20 years.

Seeds suitable for storage can be divided into two groups. One group, orthodox seeds, is desiccation tolerant and suitable for storage. The second group is desiccation sensitive and therefore very difficult or impossible to store. The desiccation sensitive seeds are called recalcitrant seeds.The largest group is the orthodox seeds and the following paper will only address these kinds of seeds.

Many different conditions influence the storage of seeds, but two issues are of great importance — seed moisture content (MC) and storage temperature.

MOISTURE CONTENT IN SEEDS

Seeds are hygroscopic, and as such there water content will be a balance between there MC and the relative humidity (RH) in the air. Interactions between seed MC and RH in the air are normally presented as graphs called sorption isotherms. Investigations of MC at different RH have shown that all water in seeds is not bound with the same strength. The water in seeds can normally be divided into three types.

1) Bound water (about 3% to 8% MC in seeds)
2) Less tightly bound water (about 8% to 14% MC in seeds)
3) Mobile or free water (about 14% to 40% MC in seeds)

In order to remove bound water it is necessary to have a RH close to 0% and still it will be difficult and occur very slowly or not at all. The less tightly bound water can exist over a broad range of RH (about 20% to 60%) and it is in this MC that seeds have to be dried down for long-term storage. The mobile/free water is much more loosely bound and little change in RH can result in important changes in the seed MC.

DIFFERENT RELATIONS FOR WATER IN SEEDS

- MC in seeds is always measured on a fresh-weight basis
- MC in matured seeds is in the range of 10% to 30%
- MC in fully imbibed seeds is between 35% and 45%
- Orthodox seeds can be dried down to a very low MC (2% to 6%) without loosing germinability
- At a MC lower than 8% to 9% their will normally be no insect activity
- At MC lower than 10% to 12% their will normally be no fungal activity
- At MC lower than 8% to 10% the respiration will be very low
- At MC of about 14% to 16% heating can occur

From the U.S.A. we have the following "rule of thumb". For each 1% decrease in MC in seeds between 5% to 14% MC, the life of the seed is doubled. The optimal moisture content for seeds in airtight full containers for long-term storage is about 4% to 8%.

THE TEMPERATURE AT STORAGE OF SEEDS

Temperature is another important factor in the storage of seeds. There is a relationship between MC of seeds and temperature in the long-term storage of seeds. Seeds with a high MC are much more sensitive to high and low temperatures

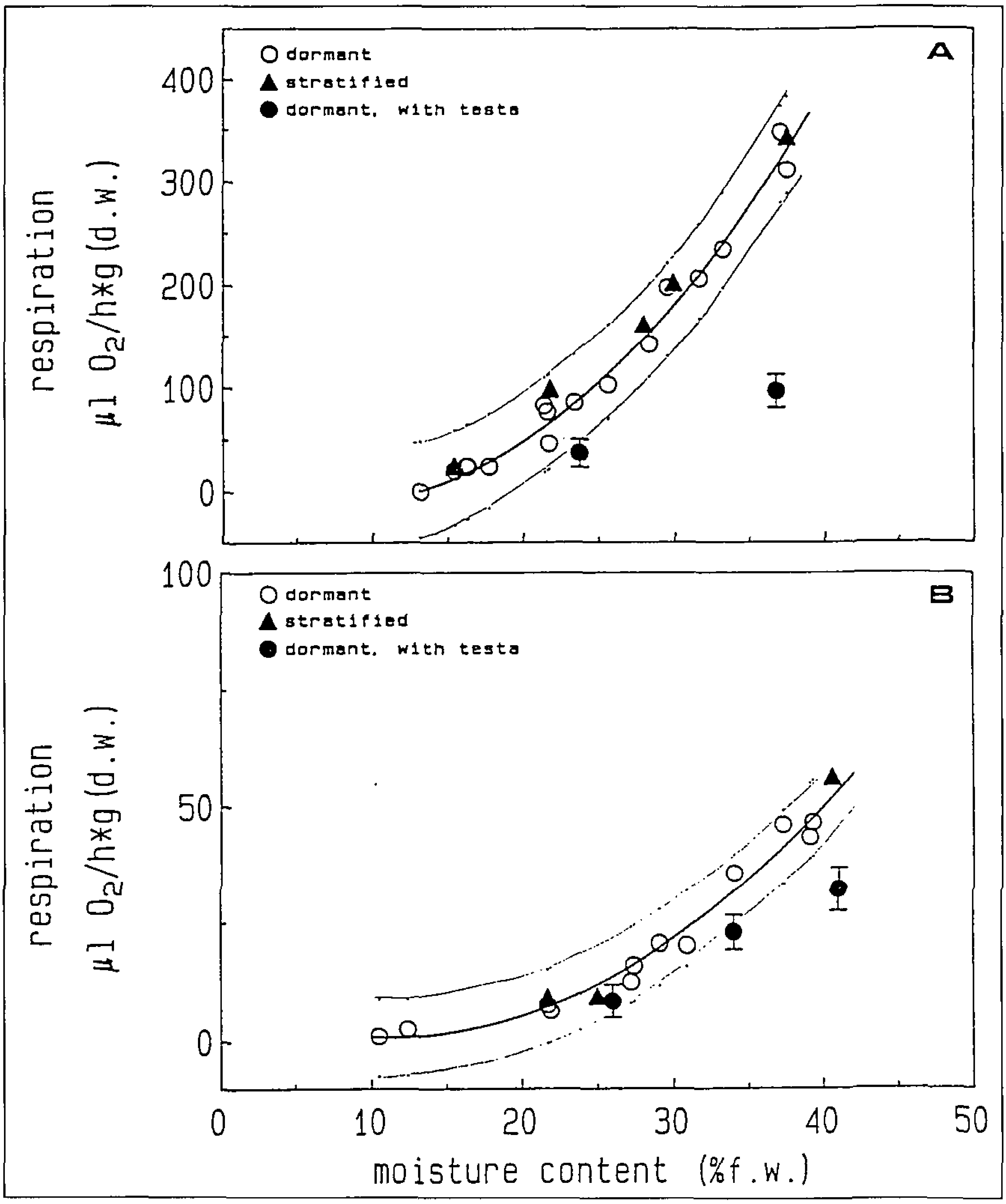

Figure 1. Relation between respiration and mosture content of embryos or seeds from beech nuts. Curves delimited by 95% confidence limits for prediction. Bars represent 95% confidence limits. Respiration at 25C and 4C in A and B respectively. (Poulsen, 1992)

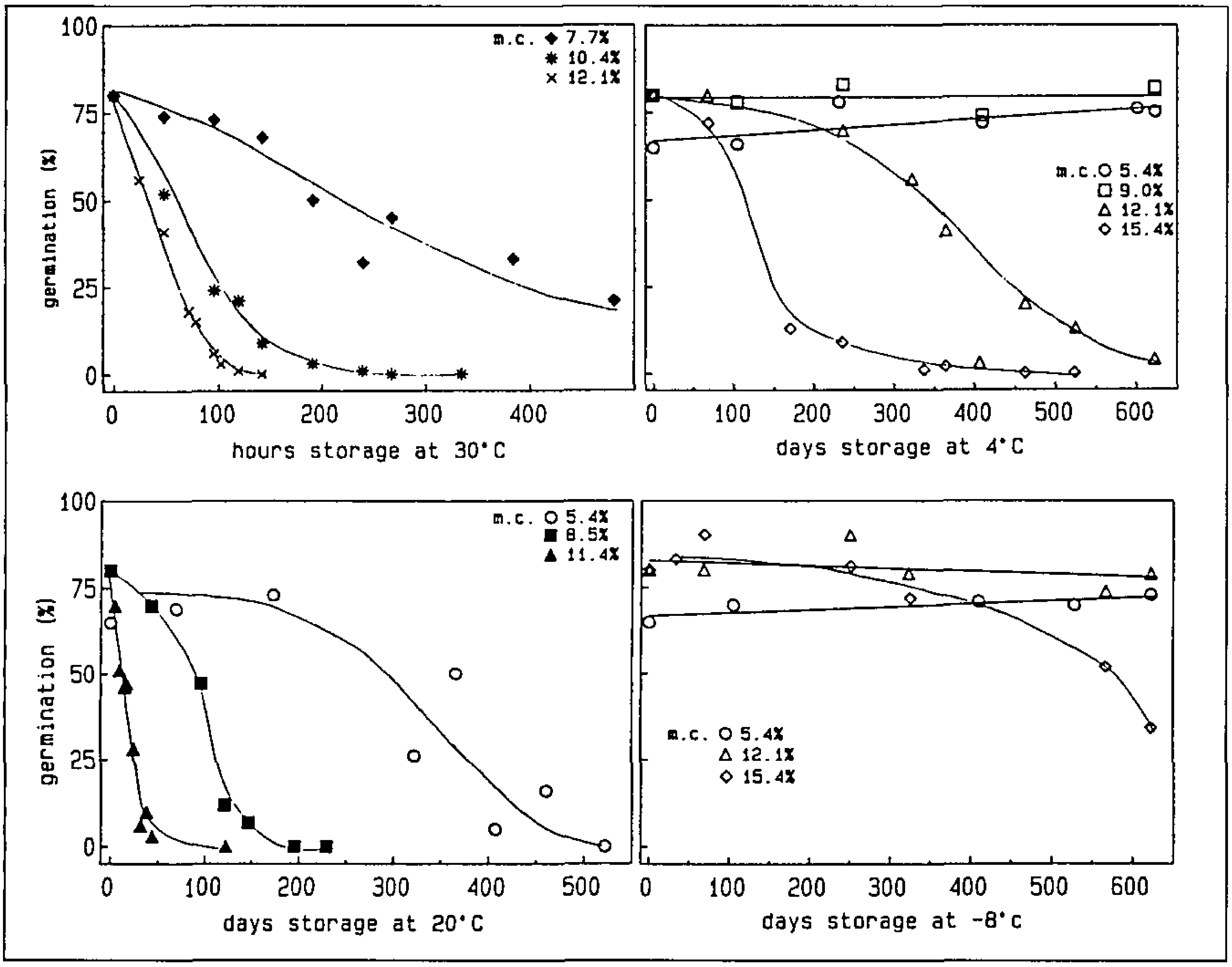

Figure 2. Survival curves for beech nuts (limited amount of the total data set shown). Seeds dried to 5.4% suffered a 'drying shock,' the initial germination percentage was reduced, consequently the survival increases. Lines fitted by linear regression, curves fitted by eye. (Poulsen, 1993)

than seeds with low MC. For example, seeds stored for a few days with a MC of about 30% will be damaged at temperatures above 25C during the drying process and at temperatures below -4C there will occur freezing damage. On the other hand, for seeds with a low MC, such as 10%, the same temperatures will not be injurious to the seeds.

Respiration in seeds is very sensitive to both high temperature and high MC. For seeds of *Fagus sylvatica* with a MC of 35% the respiration about doubles for about every 10C increase for temperatures between 4 to 25C (Fig. 1). Figure 2 shows a good example of how fast seeds can be destroyed when stored at high MC and at high temperature. Note that seeds stored at 30C only survive for hours.The danger of fungi attack also increases at higher temperatures and higher MC in the seeds. The optimal storage temperature for orthodox seeds is 0±2C in a container at low RH.

OTHER CONDITIONS INFLUENCING STORAGE OF SEEDS

Seed Quality and Viability. A seed sample with a low germinability and low vigour is not suitable for long-term storage, as dead seeds and low vigour seeds are much more sensitive to attack by fungi than high vigour seeds. Similarly seeds harvested at an immature stage or seeds damaged during grading and cleaning are also poor candidates for storage.

Genetic Conditions. Most orthodox seeds of tree species are suitable for long-term storage — normally for 5 to 10 years or more. Seeds with hard seed coats are particularly well suited for long term storage. These seeds are also called impermeable seeds and they are mainly seeds from plants belonging to the Fabaceae, i.e., *Acacia, Caragana, Cytisus,* and *Robinia.*

Another group, even though they are not recalcitrant seeds, are by nature not suitable for long-term storage. This group is characterized as having small seeds, which matured early in the growing season and the seeds are able to germinate immediately or only have a short dormancy. Examples of seeds in this group are *Betula, Populus, Salix,* and *Ulmus.*

Atmospheric Conditions. Long-term storage of seeds can not take place in the open, but must always be in closed containers. The use of inactive gasses to improve the seed longevity has been examined. The idea behind this treatment is to reduce respiration and thereby delay the breakdown of the seeds. The inactive gasses carbon dioxide (CO_2) nitrogen (N), Helium (He), Argon (Ar) plus vacuum have been tried.

In seeds with a low MC and storage at low temperature it is possible to obtain a minor promotive effect by using inactive gasses. If low MC and low temperature conditions are not used the inactive gasses can have a negative effect because they can induce anaerobic respiration in the seeds. Normally it will not be necessary to use inactive gasses for long-term storage of seeds.

Seed Size. Variation in seed size within a seed sample can influence long-term storage. Their is a clear interaction between seed density and suitability for storage. Seed with high density, e.g. well-filled seed, survives longer than light seeds. If storage is only for a few years there will hardly be any difference between small and large seeds. If the storage period is to the limit of survival, the small seeds often will die first.

Seed Chemical Composition. Food reserves in seeds are mainly starches, lipids, and proteins and the content can vary from a low percentage up to 40% to 60%. Tests with a large number of species did not show a correlation between long storage and high protein content. For starch it seems clear that increasing starch content prolongs the storage period. For lipids the correlation is not very clear, but there seems to be a tendency to decreasing storability. These correlations are based on a large number of species and it will be easy to find taxa which do not fit this pattern.

USED LITERATURE FOR PREPARING THE SUBJECT

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