THE STORAGE OF PASTURE SEEDS

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Efficient seed storage is an essential part of a good farming economy. In grassland farming it is obviously desirable that the seeds relied on for the establishment of new pastures should not deteriorate in the time between harvesting and sowing. Though a high standard of *care* is generally exercised in the main seed stores, serious deterioration sometimes occurs, especially with seeds received in bad condition from the grower. More frequent instances of rapid deterioration are found in retailers' stores and during shipment. These losses are undoubtedly avoidable.

CAUSES OF DETERIORATION

The deterioration of seeds during storage *is* brought about by three main agencies.

(a) Insects.

(b) Moulds.

(c) Spontaneous chemical changes within the seed.

The last of these *is* the most general and most important.

INSECTS

Fortunately, insect infestation is rarely serious in this country. When it does occur it can be combated by fumigation or the use of modern insecticidal dusts. A cool, dry store provides conditions which are the least favourable to insects and at the same time the most favourable for the preservation of the vitality of seeds.

MOULDS

All seeds carry on their surface the spores of common moulds such as *Aspergillus, Altenaria,* and *Penicillium.* These spores remain dormant if the atmossphere about the seed has a relative humidity below 75 per cent. If the relative humidity is above that level, the spores germinate and the moulds. grow and feed on the substance of the seed. The respiration of the moulds increases the humidity and' raises the temperature so that in extreme -cases there is a pronounced heating or sweating of the seed. Whenever moulds are active the seed loses vitality rapidly. The only practicable way to prevent the complete spoiling of the seed is immediate drying at a moderate temperature.

SPONTANEOUS CHEMICAL 'CHANGE

This is the most general cause of deterioration. In stored seeds the normal processes of living are arrested by desiccation and can be resumed only when sufficient water has been reimbibed. But though normal vital activity is at a standstill, some chemical changes can occur. Some of these are beneficial and promote prompt and vigorous germination.. These we speak of as' after-harvest ripening. Other changes are harmful and result ultimately in the inactivation of essential enzymes and, the loss of viability. It is these degenerative changes that concern us in the study of the deterioration of seeds during storage. Their effects can be illustrated by the results of some recent experiments with ryegrass seed.

Freshly harvested Italian ryegrass seed with a moisture content of 15.4 per cent. was stored at 100 degrees F. and samples were taken periodically and tested in three ways (1) in the germinator, (2) by staining with tetrazolium, (3) by measuring the rate of growth of plants raised from the seed. The germination tests showed that some seeds lost their viability within the first week, and after 3.2 weeks practically none remained viable. The life span of the seed was distributed normally with a mean of 37 weeks and a standard deviation of 17 weeks.

Staining seeds with tetrazolium shows not only which seeds are viable, but also what. parts of the' embryo of each seed retain their vitality and what parts have died. At the commencement of the experiment the embryo of each seed stained completely, showing that all parts of all embryos were alive. After fifteen weeks all the embryos failed to stain in any part, showing that they were entirely dead.

At intermediate stages during the course of the experiment some embryos were partially stained,, showing that portion of the embryo was dead, but the remainder was still alive. The distribution of seeds according to staining pattern at. progressive stages in the storage experiment are shown in Table 1.

Table 1: The Distribution of seeds according to embryo staining pattern at successive stages during deterioration undek adverse storage conditions

'Length of storage period in weeks	Percentage of seeds in each staining class					
	1	2	3	4	5	6
0	100	0	0	0	0	0
3	83	2	2	5	3	5
- 6	36	7	4	12	8	33
9 9	6	4	3	7	10	70
12	0	1	0	2	4	93
15	0	0	0	0	0	100

From these data it is concluded that each embryo during storage tends to lose vitality, part at a time, in a regular way. The root dies first, then the shoot, and finally the scutellum. This explains the occurrence among plants raised from the deteriorating seeds of a small proportion of abnormal seedlings having shoots but no seedling roots.

It is important to know what loss of vitality takes place before any part of the embryo actually dies. To determine this, seeds still surviving after two-thirds of the sample had died or been disabled- by loss of roots were compared with seeds of the same line stored under favourable conditions where no perceptible deterioration 'had occurred. The median -time required for germination was approximately 2 'days'longer with the seeds surviving adverse storage. Though there was a difference in the speed of germination the subsequent rates of growth were identical. For six weeks after germination growth continued in plants from both lots of seed at a uniform exponential rate equivalent to 18 per cent. per day.

In- brief, the degenerative changes occurring in stored seeds are continuous and cumulative. They ultimately result in the death of the embryo, part at a time, from root tip upward. Before causing death they produce an inhibition of growth which is only temporary and is not perceptible after germination.

The disadvantages of old or badly stored seeds can be summarised as follows:

1. Reduced germinating capacity.
2. Delayed germination.
3. Disabling of a proportion of the seedlings' by loss of roots.

The effect of delayed germination may be serious under field conditions where there -is early competition between. the sown species or from weeds. Seedlings tend to grow rapidly and at an exponential rate. For example, in the experiment just described the ryegrass seedlings doubled in weight every 4 days. Even where there is no competition for light, water, and nutrients, such a seedling emerging 4 days later than its neighbours would continue for some weeks to be only half their size. Where there is competition between plants the late starters tend to be quickly suppressed..

FACTORS DETERMINING RATE OF DETERIORATION

The. life span of seed. is to some degree an inherent characteristic of each species. Thus seeds of browntop or-ryegrass survive for about twice as long as, seeds of chewings fescue or crested dogstail under the same conditions.. But the deterioration of each kind of seed, whether due to insects, moulds, or spontaneous. chemical change, proceeds. at a rate which is largely determined by the conditions of storage. The principal factors are the temperature and the moisture status of the seed.

Temperature

The rate at which seeds lose their vitality in--&eases with rising temperature. The temperature coefficient for this rate has been determined for several kinds of seed and in each case the result was approximately, 10. In other words the life span of these seeds increased tenfold with each fall of 10 degrees C. It is not normally practicable to increase the storage life of seeds in bulk by reducing the temperature.
A reduction in temperature raises the relative humidity of air, with the result that the seeds absorb water unless they are in a sealed container. The increase in water content then offsets the advantage of the reduced temperature. In a similar way the ill effects of high temperatures in a well-ventilated seed store may be offset by the reduction of the relative humidity and the consequent drying. of the seed.

Moisture Status of tlie Seed

The moisture status of seed is a most important factor in determining the rate of deterioration. When extremely dry, seeds are very resistant to unfavourable conditions. They are uninjured by any degree of freezing even to the temperature of liquid air; they may remain viable after being heated to 100 degrees C. for 24 hours ; and they are immune to the attacks of insects or moulds. As the moisture content increases the rate of deterioration rises. When the moisture content reaches the level where the seed is in hygroscopic equilibrium with air at a relative humidity of 75 per cent. the rate of deterioration becomes greatly accelerated because moulds become active.

The important factor is not so much the amount of water in the seeds, but rather the water potential ; that is, the force with which the water is bound to the seed material. When there is little water present it is strongly bound, whereas additional amounts of water are held with less powerful forces. One effect of this force is to reduce the vapour pressure of the seed below that of free water. So we can speak of the relative vapour pressure of seed, which is the vapour pressure of the seed as a percentage of that of water at the same temperature.

I venture to predict that the time will come when this property of seed will be widely used as the index to moisture status and the gauge of "condition." As an index of moisture status the relative vapour pressure has two advantages over the percentage water content.

1. Our present knowledge indicates that the relative vapour pressure has the same significance with regard to keeping qualities for agricultural seed of all kinds and conditions. On the other hand, the significance of the percentage water content varies according to the composition of the seed, especially the oil content, and it is complicated by hysteresis, that is, the difference in the reaction of seed when giving up water and taking up water;

2. Seeds are hygroscopic and consequently water is exchanged between seed and the surrounding air until a state of equilibrium is established. At this stage the relative vapour pressure of the seed and the relative humidity of the air are identical. By determining these values for the seed and the store atmosphere respectively it is immediately apparent whether the

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seed will gain or lose water. This knowledge could be a useful guide in the preconditioning of seed and in controlling ventilation.

There are several ways of measuring the relative vapour pressure. At present we use an electric hygrometer, which determines the resistance of a hygroscopic plastic film. At the same time we are interested in applying more direct methods based on dew point and wet and dry bulb thermometers.

The relationship between water content and relative vapour pressure has been determined for different kinds of seed. A knowledge of these relationships makes it possible to predict the amount of water to be removed in conditioning seed to a given relative vapour pressure or the change in weight to be expected from' a modification of storage conditions.

PRACTICAL MEASURES FOR IMPROVING STORAGE

The most immediate need in many stores is for drier storage conditions. The aim should be to keep the humidity down to 60 per cent. or less. Where this aim is kept m view the following precautions would be taken :-

1. Lines of seed containing excessive moisture would be preconditioned by artificial drying preparatory to storage.

2. The exhaust air from the drying machine would not be liberated in the store.

3. Produce such as potatoes, onions, or living plants, all of which raise the relative humidity, would not be kept in the same store with seeds.

4. In some circumstances consideration might be given to the practicability of controlled ventilation or air conditioning for maintaining dry conditions.

Though the 'principles of seed storage are fairly well understood, we still lack some information essential for their effective application to the storage of pasture seeds. We have insufficient knowledge of the specific reactions of different pasture seeds to known storage conditions, and we have inadequate records to characterise the environment within our seed stores.

The first of these gaps in our knowledge is being repaired by work at the Grasslands Division on the reaction of different seeds to controlled storage conditions. It would be a great help if at the same time continuous records of temperature and relative humidity over 12 months could be made available from a large number of' different seed stores.

DISCUSSION

Q. (Inch): Is there any benefit from drying seed soon after harvest

A. Drying would be worth while, particularly where the crop is in good condition and has to be harvested in unsettled weather. Also if drying facilities were available it would be advantageous to cut and thresh earlier than is normal and so have a lower seed loss from shattering.

Q. (H. Kimpton): Is there a quick and reliable method of measuring vapour pressure of seeds that could be used in commerce

A. The electric hygrometer is satisfactory but expensive. Experiments are now being carried out with more direct methods such as the wet and dry bulb method and the dew point method which I think could be developed for commercial use.