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Storage losses in legumes

By P. DOBIE, *Tropical Products Institute, London Road, Slough, Berks SL3 7HL.*

Legume seeds are among the crops classified as 'durable'; it is possible to store them for extended periods of time after they have been dried. However, during storage they may be attacked by a number of biological agents which result in loss in the quality and physical losses in the quantity of the stored seeds. These agents include (1) micro-organisms, (2) rodents, and (3) insects.

Loss

The term 'loss' is used to describe several aspects of the deterioration of a product. Severe deterioration will result in a loss of weight of the stored food resulting in less food being available for sale or consumption. Less severe deterioration may result in a loss in quality of the product. Thus a consignment of produce containing a proportion of insect-damaged or mouldy grains will be given a lower quality grade than undamaged produce. This may reduce the commercial value of the crop depending upon the system of marketing standards in operation. Small traders and large marketing organizations are all aware of the danger of losing the goodwill of their customers if poor quality produce is sold. When storing seed for planting, the criteria of quality are very critical, as deterioration of the seed which would be acceptable or unnoticed in the case of food grain can cause severe loss in germination.

Micro-organisms. The most imporatant micro-organisms involved in the deterioration of legume seeds are fungi. Seeds which are stored with an excessively high moisture content will become heavily infected by moulds, and fungal infection can very rapidly result in complete destruction of the seed. To prevent the development of moulds it is necessary to dry the produce adequately. When legume seeds are exposed to the air, an equilibrium is eventually achieved between the relative humidity of the air and the moisture content of the produce. Produce which is exposed to a relative humidity of greater than 70% are likely to be infected by fungi. The moisture content of legume seeds in equilibrium with a relative humidity of 70% is about 14%; thus legume seeds must be dried to below 14% moisture content for protection against moulds. In addition, care must be taken to prevent the subsequent wetting of the produce and to prevent moisture movement within consignments of stored produce which could result in local pockets of high moisture content seed.

Several species of fungi which may infect legume seeds are capable of producing mycotoxins. These are extremely toxic compounds, the presence of which render legumes unsuitable for human or animal consumption.

Rodents. Rats and mice can cause appreciable losses during storage. In addition to the seeds eaten by the rodents, the produce may be contaminated by droppings, and considerable spillage may take place through holes chewed into bags.

Insects. In tropical and sub-tropical countries insects frequently account for the greatest weight loss of legumes after harvest. All of the important insect pests of stored legume seeds are beetles of the family Bruchidae. The Bruchidae are adapted to attack the mature seeds of legumes, and those which attack food legumes demonstrate a certain degree of specialization to different legume species.

The adults of the Bruchidae are typically small, convex beetles which are often distinctly marked. They are active and fly readily.

The larvae develop from eggs which (depending upon the species) are glued by the female parent to the surface of the mature seed, to the surface of the mature pod or are laid loosely inside the pod or loosely around the pods or seeds. After hatching, the larva immediately penetrates the seed and subsequent development takes place entirely within the seed cotyledons. The larva pupates within the seed, but before doing so prepares the point of its eventual escape from the seed by chewing away a circular escape tunnel through the cotyledon leaving intact only the testa at the outside. This area of undermined testa can be seen clearly as a grey 'window'. The larva pupates within the seed, and the adult which develops pushes its way through the 'window' (Fig. 1). Table 1 shows the host-specificity of the important economic genera of the Bruchidae.

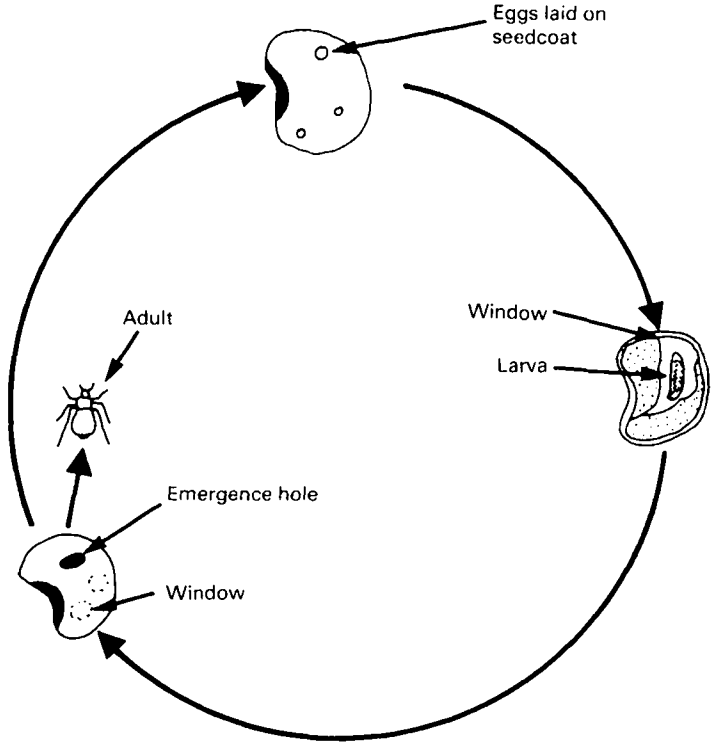

Fig. 1. Schematic representation of the life cycle of a typical Bruchidae.

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Table 1. *Host specificity of Bruchidae*

	Vigna unguiculata	*Phaseolus radiatus*	*Phaseolus vulgaris*	*Phaseolus lunatus*	*Phaseolus angularis*	*Cajanus cajan*	*Cicer arietinum*	*Lablab niger*	*Dolichos biflorus*	*Lens esculenta*	*Pisum sativum*	*Voandzeia subterranea*	*Glycine max*	*Arachis hypogea*	*Vicia faba*
Callosobruchus maculatus	•	•				•	•	•		•		•	•		
Callosobruchus chinensis	•	•			•		•	•	•	•	•				
Callosobruchus analis	•	•													
Callosobruchus rhodesianus	•														
Callosobruchus phaseoli	•						•	•							
Callosobruchus subinnotatus												•			
Acanthoscelides obtectus			•									•			
Zabrotes subfasciatus	•		•	•	•							•			
Caryedon serratus														•	

The amount of loss caused by insects

Insect infestation causes considerable loss due to the tunnelling activity of the larvae in the seed. It has been estimated that the loss in weight of a seed of cowpea due to a single larva of *Callosobruchus maculatus* (a common pest of cowpeas) can be between 3·39 and 5·46% (Brooker, 1967). Unfortunately there have been few good studies of the over-all losses caused by Bruchidae in stored pulses. In Nigeria Caswell (1973) concluded after surveys carried out in local markets that about 5500 tons/year of a 1 million ton harvest of cowpeas (5·5%) were consumed by bruchids. Giles (1977) reported losses of 12·4%/year in beans in Nicaragua, amounting to about 5240 tons.

Comprehensive and reliable information concerning the quantity of losses caused by insects can only be obtained from well-designed surveys involving the measurement of losses using proven methods of loss assessment (e.g. Harris & Lindblad, 1978). Although such investigations have been carried out on stored cereals, stored legumes have not yet been studied in depth. Results are also lacking concerning the nutritional losses associated with insect infestation.

Reducing losses during storage

As mentioned previously, losses due to spoilage by micro-organisms can be eliminated by the careful and adequate drying of produce. Rodent damage can be reduced by designing stores which eliminate rodents or by intensive programmes of trapping or poisoning.

The reduction of losses due to insects can be difficult in tropical and sub-tropical regions where the rate of insect multiplication is great. Legumes stored on farms by small-scale producers are often stored in their pods: the pods form a significant barrier to infesting insects and reduce infestation level. Various insecticides are

supplied in the form of dilute dusts which are applied by thoroughly mixing with the crop to be protected. Recently, very good results have been obtained against Bruchidae at the Tropical Products Institute using pirimiphos-methyl applied at a rate of 5 parts per million. Traditionally, very fine sand, mineral dusts, wood ash and rice husks have been used to protect legumes against Bruchidae. The dusts may damage the insect cuticle by abrasion or absorption or they may create a barrier which prevents the insects gaining access to the seeds. None of these techniques has been rigorously tested. It has been found that various edible oils mixed with pulses at the rate of 5–10 ml/kg are highly effective in preventing the development of bruchid eggs, and in some cases are toxic to adult beetles (Singh *et al.* 1978).

Large quantities of legumes can be disinfested by fumigating the produce with gas under impermeable sheets or in gas-tight silos. The most commonly used fumigants are phosphine, produced by the breakdown of pellets containing aluminum phosphide and methyl bromide which is supplied under pressure in cylinders.

Recently attempts have been made to identify varieties of legumes whose seeds are resistant to insect attack. Seeds of *Psophocarpus tetragonolobus* (Winged Beans) have been shown to be completely resistant to the most important economic species of Bruchidae (Dobie *et al.* 1979). A variety of *Vigna unguiculata* (cowpeas) has been found which is highly resistant to attack by *Callosobruchus maculatus*. The cause of this resistance is a protease inhibitor which is present at a high level (Gatehouse *et al.* 1979).

'Hard shell'

'Hard shell' is a term used to describe the condition whereby legume seeds fail to take up water during cooking and therefore do not cook properly. A high incidence of 'hard shell' will reduce the value of legumes. The incidence of 'hard shell' has been attributed to the conditions under which legumes are stored. The relationship between physical storage conditions and 'hard shell' has not been quantified, although it has often been suggested that excessive drying induces the condition (Crean & Haisman, 1963). Giles (1977) showed that in Nicaragua the incidence of 'hard shell' in beans (*Phaseolus vulgaris*) in various storage sites was inversely proportional to the moisture content of the beans and the relative humidity of the air. Studies have been made of the physico-chemical properties of legumes which cause 'hard shell'. This extensive body of research will not be reviewed here. The challenge for storage technologists is to identify the storage conditions which will minimize the incidence of 'hard shell' and thus permit longer storage of susceptible varieties.

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