INSECT CONTROL BY AIRTIGHT STORAGE IN SMALL CONTAINERS

by

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Abstract

Gourds (the empty dry fruit-cases of *Lagenaria cineraria* and related Cucurbits) are often used in the tropics as domestic grain storage vessels. They have some potential for use as semi-airtight containers and tests have shown that surface treatment with linseed oil or varnish greatly reduces their oxygen permeability. Gourds of moderate or large size, so treated, were sufficiently airtight to give effective control of insect infestation if well-sealed at the neck. Complete disinfestation would be unlikely but insect damage would be minimised. Untreated gourds may give reasonably good results but they vary greatly in oxygen permeability and their performance is unpredictable.

The value of some other containers available for similar use is discussed.

Introduction

Commodities stored in airtight conditions are largely preserved from insect damage. This is quite well-known but commonly less well understood, although the underlying principles have been investigated and reviewed (Bailey, 1955, 1956 and 1957; Hyde, 1962; Oxley & Wickenden, 1963; Hall & Hyde, 1964).

Few containers are completely airtight and those which allow oxygen to re-enter fast enough to give concentration increases greater than about 0.5 per cent in 24 hours will not be completely effective for insect control (Hyde, 1962). The smaller the container, the greater the likelihood that slight leakage will exceed this critical rate of oxygen recovery. Moreover, even in containers which are sufficiently airtight for insect control, there may be some noticeable increase in insect damage, before all the insects are killed, unless the initial infestation is so heavy that oxygen depletion is extremely rapid. The critical oxygen level for insect mortality, which depends partly upon the concentration of carbon dioxide (Harein & Press, 1968), is, in practice, about 2 per cent oxygen by volume. Such a level may not be reached until eight or more weeks have elapsed. The amount of damage occurring in this period is generally negligible (probably less than 0.1 per cent; Bailey, 1955), provided that the container is sufficiently airtight, although it could be significant if the commodity concerned was one in which even very slight damage or insect spoilage would be unacceptable.

The Traditional Storage Gourd

Hollowed gourds (Fig 1), the dry fruits of *Lagenaria cineraria* (Cucurbitaceae) and allied plants, are traditionally used as domestic storage vessels for grain, pulses and other commodities in many parts of the tropics. In these areas, relatively high ultimate levels of insect damage to grain and pulses are traditionally tolerated and even partial insect control can constitute an improvement. Such vessels limit oxygen re-entry, to some extent, even when unsealed. It may be that they are favoured as grain storage vessels for that reason, since they may appear, in customary use, to reduce insect damage in comparison with bags and baskets used for storage. However, insect damage to grain and pulses stored in gourds can still be serious, especially where pre-harvest infestation occurs. Even in gourds which have been sealed by careful stoppering the damage is much greater than in sealed steel drums and varies greatly between different gourds (Fig 2). In common use, gourds are rarely provided with effective stoppers, so that even although the rate of insect multiplication inside the gourds may be somewhat suppressed the loaded gourds themselves constitute active sources of infestation. Such sources of infestation are particularly serious on peasant farms and contribute to the heavy pre-harvest infestation of grain and pulses, by storage pests, which is characteristic of such farms.

Fig 1. Hollowed gourds of the type used as storage vessels. (From left to right: Gourds D, B, E and C of Fig 3. Gourd B has a capacity of 8kg grain).

Improved Gourds

An inexpensive and simple method of rendering gourds more completely airtight could be useful to those who use them to store grain for seed or domestic use. Attempts to encourage the use of better closures for the mouth of the gourd are unlikely to meet with much success because, although an effective closure could prevent the escape of insects and reduce cross-infestation, this alone will not make the average gourd sufficiently airtight. Leakage of air through the gourd walls is considerable and, in many gourds, ample for insect survival. Consequent damage, in a well-plugged gourd, might sometimes be even greater than it would have been in a freely ventilated container or a gourd from which the insects could escape. (This may, perhaps, explain the apparently undesirable tendency to leave gourds unplugged).

Surface coatings, of oil, varnish or paint, can greatly reduce the oxygen permeability of gourds (Fig 3). Oil or varnish treatments seem unlikely to reduce the oxygen recovery rate below 1 per cent per 24 hours so that complete elimination of insects cannot be relied upon. However, improved infestation control, and considerable reduction of damage, can be expected in treated gourds of moderate or large size (B, C and D in Fig 3; see also Fig 1). Very small gourds are likely to be of little use, even if treated with special low-permeability coatings such as polyurethane film (E in Fig 3; and Fig 1).

Variation Between Gourds

Untreated gourds appear to be very variable in performance (Figs 2 and 3). It seems likely that gourds with relatively thick walls may be somewhat less permeable than others and large gourds will generally be better than small ones because of their lower surface/volume ratio. The actual soundness of the gourd will be another factor: small pits and abrasions occur in the surface of most gourds. It may be that fairly satisfactory untreated gourds can be selected by trial and error. However, any gourd would be considerably improved by the application of one or two coats of linseed oil. Castor oil would probably be as good. Such vegetable oils can often be obtained locally. The use of varnish, or paint, would depend upon local cost and availability, but these coatings are not markedly better than linseed oil. Polyurethane coatings (Fig 3, B*) could provide a more ideal sealing treatment but are less likely to be readily available.

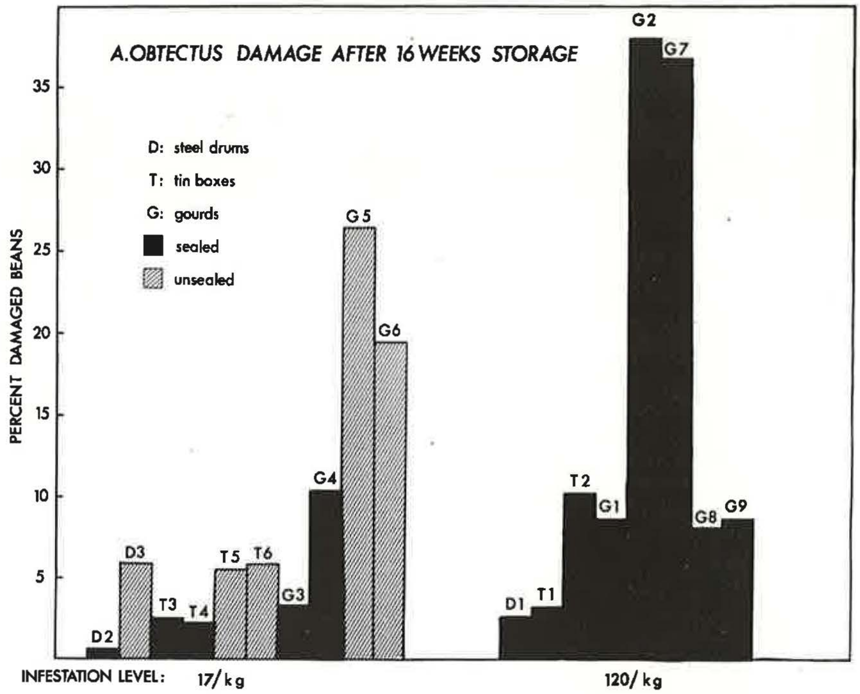

Fig 2. Damage levels in replicate lots of dry beans stored at 26°C in small containers.

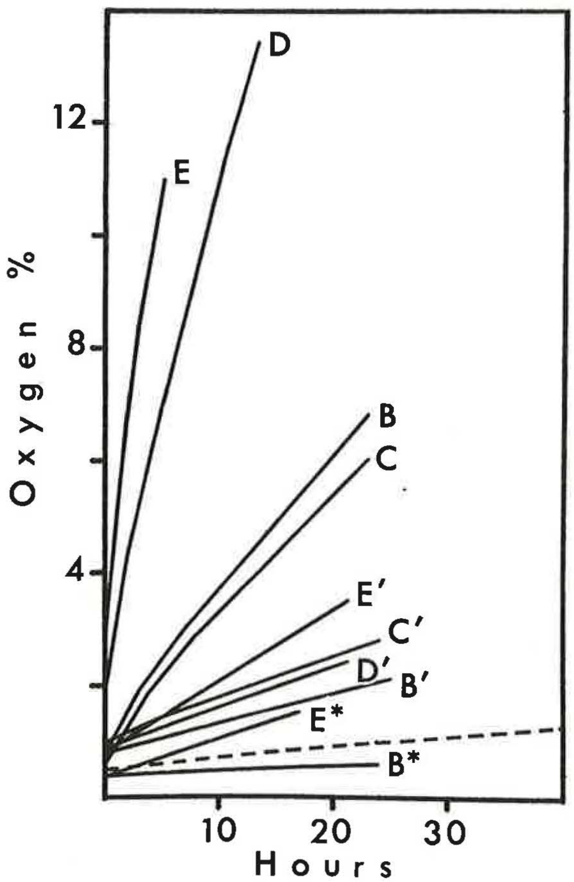

Fig 3. Oxygen recovery in nitrogen-filled gourds without surface treatment and after treatment with linseed oil (C^1, D^1 and E^1), varnish (B^1) or a polyurethane coating (B* and E*). (The broken line shows the critical oxygen recovery rate of 0.5 per cent per 24 hours. Oxygen concentration measurements were made with a Beckman oxygen analyser).

The progress of oxygen depletion, before and after treatment, in two gourds of the same capacity half-filled with 4 kg of wheat including, in each instance, replicate lots of infested grain is shown in Fig 4. Gourd A was treated with linseed oil (A^1) and Gourd B with varnish (B^1). The important point illustrated is that in the treated gourds the oxygen concentration fell quite rapidly to a minimum of about 3 per cent whereas in both untreated gourds the depletion rate was slower overall and the minimum concentration reached was about 5 per cent. Complete disinfestation was not achieved in these tests but the infestation was more nearly eliminated in the treated gourds where the relatively rapid oxygen recoveries after 25-30 days probably represent the intrinsic oxygen re-entry rates, little affected by further insect activity. The recovery rate for gourd B, in which the oxygen level came closest to the critical level of 2 per cent, is approximately 1 per cent per 24 hours from day 30 to day 35. This is the same rate as that shown in Fig 3 for the same treated gourd (B^1) when empty. The subsequent decline in these re-entry rates conforms with the slight resurgence of insect activity manifest when the gourds were opened at day 43, when some live adults were found. Gourds A and B yielded, respectively, 35 live plus 1,125 dead adults and 12 live plus 1,300 dead adults. These figures may be compared with 1,296 and 1,359 live adults in two control cultures. It is likely that the results would have been better still had the gourds been completely filled with grain, but half-filled gourds were used so that these tests would be fairly stringent and more in line with what might be expected in practice.

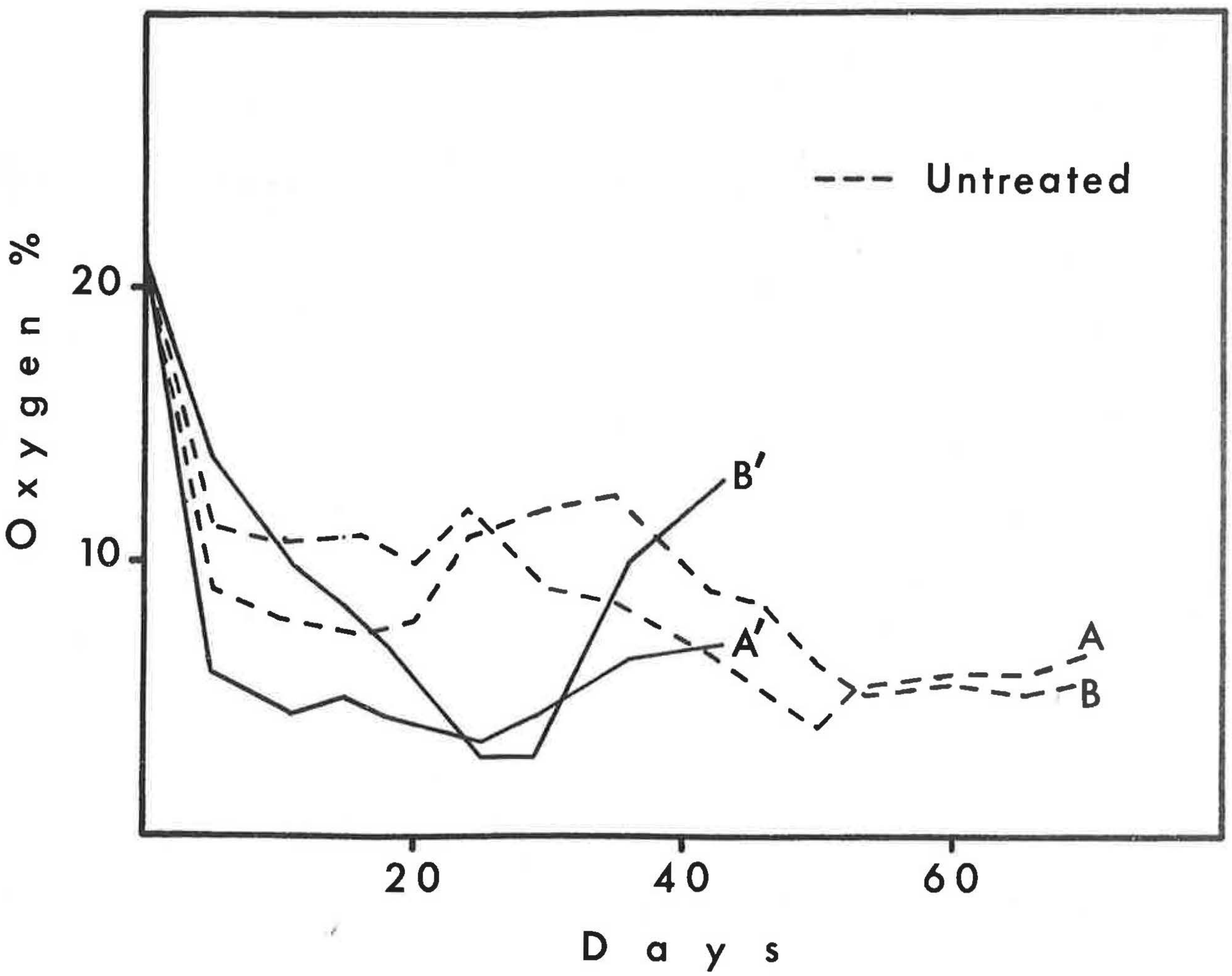

Fig 4. Oxygen depletion in treated and untreated gourds containing infested wheat. (Oxygen readings by Beckman analyser).

Other Containers

Steel drums, designed for the transport of liquids, and therefore effectively airtight, give excellent results (Fig 2) and the use of such containers is obviously preferable where it is possible. Cost is a considerable factor, but relatively inexpensive drums of this type are already available in parts of East Africa, in a range of capacities from 5 gallons to 48 gallons (around 15-150 kg grain), and the use of these could be encouraged. However, confusion between this type of specially constructed drum and less expensive metal boxes, with unwelded seams, must be avoided. Such boxes are commonly available in many parts of the tropics. The comparative tests made in Kenya, using typical examples, showed that these were generally better than untreated gourds but were also unpredictable in performance (Fig 2). Supplementary sealing at the joints and around the lid appeared to be necessary.

Bags made of film-plastic, such as polyethylene film, are sometimes advocated for storage of produce. Such bags, if made from fairly heavyweight film (not less than 400 gauge, or 100 microns, in thickness) would be moderately airtight and might be expected, on grounds of oxygen permeability, to give a degree of control similar to that obtained in coated gourds. However, most plastic films can be punctured by many species of stored products insects, especially in conditions such as would exist in a sealed bag of infested grain. They are therefore unlikely to have much value in practice for the storage of infested produce unless this puncturing is prevented. O'Dowd and Caswell in Nigeria have found, for example, that an inner liner of fine-weave cloth - such as a flour bag - is necessary to prevent the penetration of polythene by Bruchid beetles from infested cowpeas. This simple modification gives very good results.

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