STORAGE PEST MANAGEMENT IN THE AUSTRALIAN SEEDS INDUSTRY

NEIL W. HEATHER

Entomology Branch, Department of Primary Industries
Meiers Road
INDOOROOPILLY Qld 4068 AUSTRALIA

Abstract

The diversity of seeds which are traded by Australian seed merchants greatly complicates insect pest control practices. Many seeds are too small for internal feeding species. For these, the major pests are the beetle species in which all developmental stages are external, to which may be added moths in warmer climates. Larger seeds are additionally subject to infestation by internally feeding beetle species.

Residual protectants play a major role but in practice, with one exception, are restricted to chemicals which have been developed and approved for use on cereal grain. This is partly because the limited market for protectants does not warrant separate development of long term, (potentially more toxic) seed protectants as opposed to grain protectants. Also, such seed could not then be sold for other purposes in times of over-supply or following loss of viability through ageing. Fumigants, must not affect seed viability adversely, leading to an almost exclusive usage of phosphine in this role.

Insect sanitation procedures and physical control measures assume an even higher profile than elsewhere in the grains industry, because of product diversity and longer storage times. Other management practices, often undertaken for unrelated reasons contribute to pest control. These include cleaning during grading operations, drying, cool storage by aeration or refrigeration, and impermeable hermetically sealed packaging. These have the combined advantages of reducing the rate of loss of seed viability with residue free pest control.

The integration of each of these pest control procedures into programmes appropriate for the seeds handling industry is discussed.

Introduction

Seeds are a high value commodity and insect pest management is a very important factor in their storage and marketing. In the Australian seeds industry there is a great diversity of seed species stored and traded often within the same storage complex. There is a range from small grass seeds to large legumes and as a result storage insect pest species, and their relative importance, vary.

Insect damage to seeds in storage results from any one or combination of ways: loss of the germ and or endosperm leading to germination failure and loss of viability; damage to the seed coat increasing the risk of fungal attack before germination; heating and moisture migration effects within bulks; and insects as contaminants of the sample leading to quality or quarantine problems.

Long term protection of seeds against insects relies heavily on the conbined effects of: initial freedom from infestation; disinfestation by mechanical cleaning, fumigation or insecticide application; storage under optimal conditions of temperature and humidity for the prevention of insect attack; insect sanitation within storages; and packaging or storage in insect resistant packages or receptacles.

The grain trade, because of its size, has initiated most insect control research on stored products. Although grain and seed can be the same commodity and although the same insect species are involved it is not always appropriate to transpose grain pest control directly to seed. However given the dearth of specific research on this important aspect of seed merchandising it is frequently necessary to adapt those controls on an *ad hoc* basis. On the other hand the pest species are almost exclusively cosmopolitan so research in other countries has relevance.

The management strategies discussed in this paper to some extent reflect the legislative constraints on usage of agricultural chemicals in Australia and, more specifically, in Queensland.

Insect pest species

A number of pests are common to all seed species. These include Tropical warehouse moth; *Ephestia cautella* (Walker), Rust-Red flour beetle *Tribolium castaneum* (Herbst), Sawtoothed grain beetle *Oryzaephilus surinamensis* (Linnaeus), Flat grain beetles *Cryptolestes* spp, Lesser grain borer, *Rhyzopertha dominica* (Fabricius), Weevils, *Sitophilus* spp, and Bruchids. Their order of importance differs according to the seed species, but the last three are restricted to seeds of sufficient individual size to support the larval stage throughout its development.

Initial freedom from infestation

Any assurance that a product is free of infestation by insects at inspection is directly dependant on the sampling system used. A survey by White (1981) showed that wheat accepted by central storages in 1975 had a mean infestation of 21.9 stored products insect pests per tonne following a nil tolerance at a sampling rate of 0.5 kg per tonne. These infestations resulted from infested harvesting machinery (full loads) cross infestation by infestation from farm storages (most loads) and multiplication following cross infestation (late loads). A similar pattern is to be expected for seeds.

High density sampling soon becomes logistically impracticable and it is a tenet of good pest management in stored seeds that all seed will be infested at intake. Infestation levels could, however, be kept at low initial levels by the implementation of quality assurance systems under which seed is produced on farms where a pest management programme is in place to minimise sources of infestation.

Disinfestation

Mechanical procedures: Depending on whether or not seed is cleaned and graded at intake, mechanical cleaning and grading can effect major disinfestation. It will not, however, remove juveniles of pest species which develop within seeds although the process is likely to produce significant impact mortality. The insect removal efficiency of machines of this type has not been well documented but White (1983) found that samples of 20 adult insects within a bulk of 25 kg of wheat were all removed by an inclined sieve after 3-7 passes depending on the insect species.

It is reasonable to expect that cleaning and grading machines based on flat perforated tables or inclined perforated cylinders could be at least as effective.

Fumigation: Disinfestation by fumigation is well documented and its efficacy will not be reviewed here. For seeds, the choice of fumigant is very important. Phosphine (PH_3) in the most practicable fumigant for seed because of the absence of phytotoxic effects at the dosages required. Methyl bromide may be required by quarantine authorities and will always cause some loss in germination although this can be minimised where seed has a low moisture content. Modified atmospheres of carbon dioxide (CO_2) (Jay 1971) or nitrogen (N_2) (Banks and Annis 1977) may have value in this role. In some parts of Australia a carbon disulphide/carbon dioxide mixture is sometimes used for seeds.

Insecticide disinfestants and protectants: The most widely used disinfestant in the seed industry in Australia is dichlorvos but it has little residual effect. It is most economically applied as a spray at 1 litre per tonne. A number of other insecticides are approved for use as grain disinfestants and protectants on cereal grains. These include fenitrothion (highly effective against moths), chlorpyrifos methyl, pirimiphos methyl, bioresmethrin, phenothrin, and carbaryl. The latter three are usually mixed singly with one of the first three for greater effect across the pest spectrum (White 1988). Only four insecticides are currently approved as seed protectants: amorphous silica, cypermethrin, maldison, and lindane. Of these cypermethrin is perhaps most versatile. Short to medium term protection of cereal seeds can be achieved with the grain protectants listed. The seed dressing insecticide chlorpyrifos ethyl, widely used for protection of seed against soil insects, would appear to justify consideration for development as a seed protectant because of its general efficacy as an insecticide and long half life, conferring potential for long term protection.

Storage conditions

The best storage environment for seed is primarily governed by the physiological requirements for maintenance of germination. Temperature and relative humidity decrease storage life; their effects are independent but additive and increase with time. Harrington (1973) set out practical rules as a guide to storage life predicting a halving of storage life for every 1% increase in moisture content or 5°C increase in storage temperature. Delouche *et al* (1973) devised indices calculated from the sum of storage temperature (°C) and percent relative humidity for the same purpose.

It is fortuitous that the conditions which are physiologically optional for stored seeds are also optimal for deterring insect infestation and development. Desmarchelier (1988) showed that the intrinsic rate of increase $\underline{r}$ of eight species of stored product pest Coleoptera was linearily related to wet bulb temperature and it can be expected that the moth pest species would be similar. Evans (1977) had earlier defined cold mortality for the rice weevil *S.oryzae* and, again, other species could be expected to behave similarly. These data enable selection of cooling strategies appropriate to the seed species, its pest risk potential, and the intended term of storage. Strategies available for seed are wider than for most grains because of the higher economic value of the commodity and include ambient aeration, refrigerated aeration, "air conditioning" and above or sub-freezing refrigerated storage. The lowest temperature options will disinfest as well as protect seed against insect attack. High temperature disinfestation (Evans and Thorpe 1981) is not seen as appropriate for seeds but could have value in special circumstances.

A further environmental factor which can be manipulated is the atmosphere. Carbon dioxide and nitrogen atmospheres have been referred to in the context of insect fumigants. Hermetic sealing and oxygen depleted atmospheres (Navarro *et al* 1977) are further options. The method is probably less flexible than temperature and humidity modification, an important disadvantage with seed merchandising.

Insect sanitation

Taken in its widest sense insect sanitation or hygiene is a management strategy to minimise insect activity. It incorporates a range of procedures.

Storage management: A seed store sanitation programme should employ the following procedures:

1. Ensure that incoming stock is free of infestation, if necessary with precautionary disinfestation treatments or cleaning.

2. Eliminate spillages before insects can use them to multiply and hence provide a source of infestation of clean stock.

3. Move stocks strictly in rotation so that possible infestations do not have time to develop.

4. Segregate stocks with differing infestation potentials to minimise cross-infestation.

5. Construct or modify design of storage facilities to facilitate implementation of sanitation procedures i.e. ease of cleaning up spills, be self shedding for dust residues, and permit

effective fumigation when it is necessary.

6. Use insecticides to disinfest produce and storages, provide protection against reinfestation and control residual populations.

Chemical measures: Fumigants and insecticides as grain disinfestants or protectants have been discussed in an earlier section. Fumigants can be used to disinfest the whole storage facility if it is already sealed; methyl bromide may have some usage in this role. Residual insecticide applications are most important in any sanitation programme. The choice of chemicals for this purpose in Queensland (White 1988) is wider than for grain protection although the grain protectant chemicals also have value used in this way at higher concentrations than for grain. Azamethiphos, carbaryl, fenitrothion, chlorpyrifos methyl, pirimiphos methyl, permethrin, and deltamethrin are all potentially useful in this role. Usually they are applied to walls of storages, outsides of bag stacks and the inside of storage bins before refilling.

Space treatments: These treatments make use of aerosols to knock down and kill flying insects and they are most appropriate for the control of moths. Bengston (1976) made use of the findings of Steele (1970) on the rhythmic behaviour of *E. cautella* to develop a timed release system of dichlorvos as an aerosol. By releasing a pulse of this highly volatile insecticide at dusk each day, control was dramatically improved over the previous methods, which was slow release "pest strips" or manual misting on a less frequent schedule. A commercial adaption of this system using carbon dioxide as a propellant is now available.

Because of the importance of moths as seed storage pests this strategy can be an important component of any seed storage pest management program especially in tropical areas.

Packaging

The use of seed packaging materials which will exclude insects is a highly effective method of pest control (Wohlgemuth 1979) provided that adequate disinfestation is first undertaken. Subsequently it also controls moisture uptake. These materials are typically laminates of paper, plastic films and aluminium foil. They are most widely employed for small seeds but also have some usage for larger quantities e.g. 25 kg packs. An innovative development of this method of packaging is the use by Jay (pers. com.) of purging with carbon dioxide before sealing. This disinfests and then shrinks the pack as it is subsequently taken up by the seeds, enhancing the utility of the technique.

Discussion

It will be apparent that the components of an effective storage pest control programme for seeds require careful integration if the outcome is to be successful and economically feasible. Throughout the grains industry there is a general move away from chemical protection of grains because of decreasing public acceptance and the problems of pest resistance. For the seed merchandising industry this will mean that fewer new suitable chemicals will become available. Conversely it could decrease selection for resistance on those that remain, extending their service life. However because of the long term storage life for most seeds, protectants carry a heavier resistance selection load than do grain protectants. Management strategies have been proposed to minimise this problem (Heather 1981). Although the seeds merchandising industry in Australia is becoming aware of the benefits of an integrated approach to pest control there is considerable scope for development and acceptance of this approach.

References

Banks, H.J. and Annis, P.C. (1977). Suggested procedures for controlled atmosphere storage of dry grain. Division of Entomology Technical Paper No 13. CSIRO.

Bengston, M. (1976). Timed daily emission of dichlorvos for control of *Ephestia cautella* (Walker) infesting stored wheat. *J. Stored Prod. Res.* **12**: 157-164.

Delouche, J.C. Mathes, R.K., Dougherty, G.M. and Boyd, A.H. (1973). Storage of seed in sub-tropical and tropical regions. *Seed Sci. and Technol.* **1**: 671-700.

Desmarchelier, J.M. (1988). The relationship between wet bulb temperature and the intrinsic rate of increase of eight species of stored-product Coleoptera. *J. Stored Prod. Res.* **24**: 107-113.

Evans, D.E. (1977). The capacity for increase at low temperatures of several Australian populations of *sitophilus oryzae* (L). *Australian Jour. of Ecol.* **2**, 55-67.

Evans D.E. and Thorpe, G. (1981). High temperature disinfestation of grain: progress and prospects. Proc. First Aust Stored Grain Pest Control Conference. CSIRO Melbourne. Ch **4**: 1-4.

Harrington, J.F. (1973). Predicting the storage life of seeds. *Seed Sci. and Technol.* **1**: 701-709.

Heather, N.W. (1981). Measures to delay resistance to protectants. Proc. First Aust. Stored Grain Pest Control Conference. CSIRO Melbourne. Ch 8: 1-8.

Jay, E.G. (1971). Suggested conditions for using carbon dioxide to control insects in grain storage facilities. USDA-ARS Bull.

Longstaff, B.C. and Evans, D.E. (1983). The demography of the rice weevil *Sitophilus oryzae* (L), submodels of age-specific survivorships and fecundity. *Bull. of Entom. Res.* **73**: 333-344.

Navarro, S., Gonen, M., Kashanchi, Y. and Frandji, H. (1977). Use of a controlled atmosphere for the control of stored product insects. 1. Experiments in a flat metal bin. Progress Report for 1975/76 of Stored Products Division, Agricultural Research Organisation Bet Dagen, Israel.

Steele, R.W. (1970). Copulation and oviposition behavior of *Ephestia cautella* (Walker). *J. Stored Prod. Res.* **6**, 229-245.

White, G.G. (1981). Undetected infestation in wheat deliveries from farms. Proceedings, First Aust. Stored Grain Pest Control Conference Melbourne. CSIRO Melbourne. Ch **1**: 13-16.

White, G.G. (1983). A modified inclined sieve for separation of insects from wheat. *J. Stored Prod. Res.* **19**: 89-91.

White, G. (1988). Grain storage insect control recommendations. Queensland Department of Primary Industries Farmnote F157.4pp

Wohlgemuth, R. (1979). Protection of stored foodstuffs against insect infestation by packaging. *Chem Ind* May 1979 pp 330-334.

GESTION DES RAVAGEURS DES STOCKS DANS L'INDUSTRIE DES SEMENCES AUSTRALIENNE

N.W. HEATHER

Entomology Branch, Department of Primary Industries
Meiers Road, Indooroopily, Queensland 4068, Australia

Résumé

La diversité des semences entrant dans la composition du marché australien complique grandement les pratiques de lutte contre les insectes ravageurs. Plusieurs sont trop petites pour les espèces se nourrissant à l'intérieur du grain. Pour elles, les principaux déprédateurs sont les coléoptères dont tous les stades de croissance sont externes ainsi que les mites dans les zones à climat chaud. Les semences plus volumineuses subissent, en outre, une infestation par des coléoptères se nourrissant à l'intérieur du grain.

Les insecticides résiduels jouent un rôle majeur mais, en pratique et à part une exception, ils se limitent aux produits chimiques conçus pour le seul traitement du grain. La cause est, en partie, leur marché limité qui ne peut garantir la fabrication de protecteurs de semence de longue durée (et potentiellement plus toxiques) contrairement aux substances de protection des céréales en grain. De plus, de telles semences ne pourraient alors se vendre à d'autres fins, en période de sur-production ou, après avoir perdu de leur valeur lorsqu'elles sont trop anciennes. Les fumigants ne devant pas nuire à la valeur germinative des semences voient leur utilisation limitée au seul emploi de la phosphine.

Les procédures d'assainissement des dégâts dus aux insectes et les mesures de lutte physique sont plus appréciés dans l'industrie céréalière en raison de la diversité des produits et des durées de stockage plus longues. D'autres pratiques de gestion entreprises souvent sans raison apparente contribuent à la lutte contre les ravageurs. Elles comprennent le nettoyage au cours des opérations de triage, séchage, stockage en atmosphère réfrigérée par aération ou réfrigération et de conditionnement en emballages hermétiquement clos. Ces pratiques de gestion sanitaire présentent l'avantage de réduire le taux de perte de valeur germinative des semences à l'aide de moyens de lutte contre les ravageurs dépourvus de résidus pesticides.

L'intégration de chacun de ces procédés de lutte contre les ravageurs à des programmes appropriés à la manipulation industrielle des semences est discutée.