COST COMPARISONS OF DIFFERENT INSECT CONTROL MEASURES

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ABSTRACT

Since the early 1970's, bulk handling authorities have been attempting to reduce their dependence on chemical grain protectants by diversifying their pest control options. However, one factor slowing the adoption of alternative insect control methods has been their apparent high cost.

This paper reports some of the results of a major BAE study conducted between 1979 and 1981 on the economics of modifying existing grain storages for the use of alternative grain insect control measures. The costs of various fumigation/modified atmosphere control strategies such as the use of phosphine, carbon dioxide, exhaust gas and nitrogen are examined, together with costs of various other insect control strategies, including the use of chemical grain protectants.

It is shown that the costs of alternative insect control strategies vary markedly with the type of storage structure, and that these strategies as a group tend to appear expensive in relation to chemical protectants partly because a high proportion of their costs are in the form of capital costs.

It is concluded that the fumigation/modified atmosphere control strategies as a group represent the most economic approach to the elimination of dependence on grain protectants for insect control in Australia's central storage system.

INTRODUCTION

In a year of average grain production over three-quarters of Australia's wheat and one-third of its coarse grains are exported. The acceptability of Australia's grain to overseas buyers is of importance to government and to grain marketing authorities. For example, the Australian Government's Exports (Grain) Regulations require all wheat, barley, oats and sorghum exported from Australia to be inspected and shown to be free of insect infestation.

For about two decades, the bulk grain handling authorities (B.G.H.A.'s) have been able to rely almost exclusively on chemical grain protectants to ensure this requirement is met. However, grain insects have rapidly developed resistance to grain protectants. Since the early 1970's, bulk handling authorities have been attempting to reduce their dependence on chemical grain protectants by diversifying their pest control options.

Many alternative control methods have been investigated. However, one factor slowing the adoption of these methods, particularly those which would involve some modification of existing storages, has been their apparent high cost. For many of these methods, a high proportion of their costs appears in the form of capital costs. For this reason, they appear somewhat expensive in relation to a control strategy such as chemical grain protectants, for which the capital cost component is low. While costings of these different insect control measures have appeared from time to time, comparison of these costings have tended to be difficult due to the different accounting conventions and assumptions adopted.

Accordingly, and at the request of the Standing Committee on Agriculture, the Bureau of Agricultural Economics between 1979 and 1981, conducted a major study on the economics of modifying existing grain storages for the use of alternative grain insect control measures (Love *et al.*, 1983). This study formed the basis for a Working Party report presented to Standing Committee in 1981. Some results from the study were also presented at the First Australian Stored Grain Pest Control Conference in Melbourne (Love, 1981). However, limitations of space prevented a full presentation of results at that conference.

This paper presents more detailed results from the BAE study in relation to the costs of various fumigation/modified atmosphere control strategies. While the cost of these strategies will have risen somewhat in nominal terms since the study was conducted, it is considered that the relativity between these and other control strategies will not have changed greatly.

THE STATE BULK HANDLING SYSTEMS

In Australia, most grain is delivered into the central storage system at or soon after harvest. Its temperature at delivery is typically ideal for the rapid development of insect infestation. In addition, much of the grain may remain in storage for nine months or more before being outloaded. Thus, to supply grain for export in an insect-free condition requires each bulk handling authority to exercise stringent quality control measures at all stages of the grain storage, handling and transport process.

Construction of each of the State bulk handling and storage systems commenced at different times, and each system contains a different mix of vertical and horizontal storages. The size and quality of individual storages also differs. Vertical bins range in capacity from as little as 0.6 kt to as much as 10 kt, while the capacities of horizontal sheds range from around 3 kt to as much as 300 kt. As will be shown later in this paper, the costs of alternative control strategies depend to a large extent on storage type.

The capacities of individual State bulk handling systems by location and storage type, are given in Table 1. This table illustrates the preponderance of horizontal storage in New South Wales and Western Australia, and the high proportion of vertical storage in Victoria, Queensland and South Australia. From the point of view of assessing the costs of different insect control measures, however, the quality of storage is also important. Some idea of this can be gained from Table 2. The slight difference in total storage capacity between each table results from definitional differences as well as new storage added in 1980-81.

THE INSECT CONTROL SYSTEMS

The BAE study examined a number of insect control methods: chemical protectants, refrigerated and ambient aeration, and a group of fumigation/modified atmosphere strategies which used either phosphine, carbon dioxide, exhaust gas or nitrogen gas. The objective of the study was to identify which of the various alternative insect control techniques would provide the most cost effective means of reducing or, more preferably, eliminating Australia's reliance on grain protectants in the existing grain storage system.

Control measures designed to completely eliminate the use of grain protectants include refrigerated aeration and fumigation/modified atmosphere.

With refrigerated aeration, grain is cooled by the forcing through it of large quantities of artifically chilled air. The objective is to reduce grain temperatures in all parts of the grain bulk below those at which insects can breed (about 15°C). During the storage period any populations of insects present at the commencement of storage hopefully will die out. Maintaining the grain at these low temperatures should also discourage reinfestation.

With fumigation/modified atmosphere control methods, the storage is sealed to an appropriate level of gas-tightness, and an atmosphere lethal to grain insects is introduced. The objective is to kill, over a period of days or weeks, any insects present. Over the fumigation period, the induced atmosphere may degrade to a sub-lethal level. This level may, however, be sufficient to discourge reinfestation. Reinfestation is also discouraged by the physical barrier provided by the sealed fabric of the storage. If the grain is to be stored for a long period (over six months), a retreatment may have to be considered.

COST CALCULATIONS

To enable valid comparison between the various control methods, all capital costs were discounted over the lifetime of the storage modifications. The annual equivalent of the capital costs were then added to annual operating costs to arrive at a total annual cost. These total annual costs were expressed on a dollar per tonne of grain treated basis, assuming a 90 per cent fill at the beginning of the storage period and that only one parcel of grain was treated each year.

Whatever the fumigant or modified atmosphere used, a storage must first be sealed to the required level of gas-tightness. Virtually all new grain storages in Australia are now built so as to be able to be sealed or readily sealable. For older structures, however, the cost of sealing can represent a significant capital cost.

When converting one of these older storages for fumigation/modified atmosphere, the cost of sealing per se accounts for about 70 per cent of initial capital cost. The remainder consists of the cost of engineering modifications and the installation of the necessary gas introduction plumbing.

Welded steel silos are readily sealable, since their walls are usually gas-tight. The walls of many concrete bins particularly older bins, however, are often porous and cracked. These have to be coated with a sealant to be made gas-tight. Bolted steel structure have to be sealed around bolt heads and joints. All structures require sealing around doors, hatches and vents. Uncapped silos such as many of those found in South Australia present special problems. These cells must be capped before they can be sealed.

Necessary engineering modifications can include the installation of relief valves to allow for diurnal pressure variations, the fitting of infill sheeting between the walls and roof, the blanking of eaves, and the sealing of hatches and external ducting, and recirculation fans. In the cost analysis, it was assumed that the storage fabric would need to be resealed every eight years. It was also assumed that the pressure valves and gas-introduction plumbing would need to be replaced after twenty years. An allowance was made for annual repairs and maintenance. Both nitrogen and carbon dioxide were assumed to be delivered in liquid form by road tanker. The cost of carbon dioxide treatment was calculated for bins and for sheds. The cost of nitrogen treatment was calculated for bins only.*

The cost of exhaust gas (produced by the burning of LPG) was calculated on the basis of one burner per block of six 2.2 kt bins. It was

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* To be effective in excluding oxygen, nitrogen has to be maintained at an atmospheric concentration of greater than 98 per cent. This can be achieved in bins but would be difficult to achieve in a large shed. With carbon dioxide, the maintenance of such high concentrations of this gas is less critical. Hence carbon dioxide can be used in sheds. In a large shed, carbon dioxide levels are kept even horizontally because of gas density effects and are maintained so vertically by recirculation.

assumed that one burner would be able to purge one bin at a time while also maintaining an insecticidal atmosphere in those bins already purged. It was also assumed that, for horizontal sheds, one burner would be needed for each 10 kt, or part thereof, of nominal capacity. However, it was noted that if modified atmosphere storage using exhaust gas were to be introduced to a particular region, a system of rotating LPG burners would probably be possible. This could reduce the cost of this type of modified atmosphere storage.

The cost of fumigation using phosphine was calculated on the use of one 'blanket' (1,100 g phosphine equivalent) per 1.35 kt of grain.

The annual capital and operating costs for the various fumigation/modified atmosphere treatments, as calculated in the Bureau study, are presented in Table 3. These costs are summed to arrive at a total annual cost, and compared with the total annual costs of other insect control options, in Table 4.

IMPLICATIONS OF THESE COSTS

Two things are apparent from Table 4. Firstly, the costs of fumigation/modified atmosphere using phosphine, carbon dioxide or exhaust gas appear to be generally lower than the costs of refrigerated aeration or modified atmosphere storage using nitrogen. Secondly, the table illustrates clearly how the overall cost of fumigation/modified atmosphere strategies varies with the type of storage structure required to be modified. There are two reasons for this. The major one is that the cost of sealing presently-unsealed storage structures varies, being cheapest for welded steel bins and most expensive for older concrete bins (especially those which have to be capped prior to sealing).

The cost of sealing horizontal sheds appears intermediate between the two. There also appear to be economies of size in the sealing of larger horizontal sheds, as a result of their lower surface area per unit volume of usable storage capacity.*

A secondary reason (important in the case of carbon dioxide and exhaust gas) is that horizontal sheds, even fully filled, have a large amount of

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* However, it should be noted that because larger sheds are usually used for segregating several grades of grain, the degree of fill may sometimes be less than if only one grade had been stored. Therefore, on a per tonne of grain treated basis, the cost advantage of sealing larger sheds may be reduced or, in some situations, reversed.

headspace relative to fully filled bins. Consequently, more gas may be needed per tonne of grain treated.

CONCLUSIONS

From the cost data in Table 4, which relate to the modification of existing grain storages for the use of alternative grain insect control measures, the following conclusions can be drawn:

- For those control methods examined, the lowest-cost insect control strategy which has the potential to completely eliminate the need to use chemical grain protectants appears to be phosphine fumigation in welded steel bins.

- The cost of sealing existing horizontal sheds and fumigating with phosphine appears comparable, in broad terms, with the cost of those chemical grain protectants used in the eastern States of Australia.

- If a shed were to be sealed, and fumigated with carbon dioxide or exhaust gas instead of phosphine, the total cost of treatment could rise to, in some cases, about twice the cost of those chemical grain protectants used in the eastern States of Australia.

Overall, the Bureau study concluded that, on a national basis, the fumigation/modified atmosphere control strategies as a group represented the most economic approach to the elimination of dependence on grain protectants for insect control in Australia's central storage system. The cost of sealing welded steel bins and horizontal sheds, plus the cost of fumigation (assuming phosphine would be used as the principal fumigant) appeared on par with the cost of grain protectants in the eastern States. The study also concluded that in view of the high cost of sealing older-type capped and uncapped bins, for these storages, the best option appeared to be to attempt to reduce the amount of grain protectant needed by timely grain movement and/or grain cooling.

REFERENCES

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Pest control alternatives for the central storage system. Proceedings of the First Australian Stored Grain Pest Control Conference, Melbourne, Victoria, May 1981, Sect 1, 9-13.

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Table 1 Storage capacity of the mainland state bulk handling authorities: 1980-81

State	Storage capacity	Location		Type		
		Country	Seaboard	Vertical	Horizontal	Other (a)
	kt	%	%	%	%	%
New South Wales	5 963	95	5	25	71	4
Victoria	3 940	73	27	53	46	1
Queensland	1 479	92	8	79	31	-
South Australia	4 080	57	43	80	13	7
Western Australia	7 909	76	24	13	59	28
Mainland States	23 371	78	22	39	50	11

(a) Includes horizontal-type emergency storages such as steel-frame sites (Western Australia), 'A' frame sites and timber framed bulkheads (New South Wales), and various types of bulkheads and sheds without fixed machinery.

Sources: AWB, Annual Report 1980-81; BGHA's (personal communications).

Table 2 Storage capacity of the Mainland State Bulk Handling Authorities: by storage type: 1979-80

Type	Capacity	Percentage of total capcity
	kt	%
Welded steel/sealed concrete silos	1 801	8.2
Horizontal sheds	8 525	38.6
Capped concrete/bolted steel silos	739	3.4
Uncapped concrete silos	2 858	12.9
Large sub-terminals (a)	1 311	5.9
Provisional/Temporary (b)	1 657	7.5
Seaboard terminals	5 197	23.5
Total	22 088	100.0

(a) Large horizontal sub-terminals (New South Wales) and transfer depots (Western Australia). Victorian and South Australian sub-terminals included in country storages.

(b) Includes timber bulkheads and some horizontal storages without machinery, but not 'A' frame sites, bunker storages or bagged grain sheds.

Source: Love (1981).

Table 3 Capital and operating costs(a) of various fumigation/modified atmosphere insect control strategies: for various types of storage

	Type of storage				
	Vertical silo			Horizontal silo	
	Welded steel	Capped concrete	Uncapped concrete	15 kt	30 kt
	$/t	$/t	$/t	$/t	$/t
Annual cost equivalent of capital costs (sealing and modification) (b)	0.13	1.42	1.98	0.79	0.52
Operating cost (c)					
- phosphine	0.04	0.04	0.04	0.04	0.04
- carbon dioxide	0.36	0.36	0.36	0.50	0.50
- exhaust gas	0.33	0.33	0.33	0.55	0.35
- nitrogen	0.67	0.67	0.67	-	-

(a) Cost of grain treated, assuming 90 per cent fill at time of treatment and that only one parcel of grain is treated each year.

(b) Includes cost of contract for maintenance of the seal to a specified standard.

(c) For one gas treatment.

Note: A real rate of interest of 5 per cent has been assumed. This rate is defined as the nominal or market rate of interest less the annual rate of inflation.

Table 4 Total annual cost(a) for selected grain insect control strategies

Storage type and Storage period	Control strategy					
	Chemical protectant(b)	Refrigerated aeration	Fumigation/modified atmosphere(c)			
			Phosphine	Carbon dioxide	Exhaust gas (d)	Nitrogen
Six months						
- welded steel bin	0.55	-	0.17	0.49	0.46	0.80
- 15 kt horizontal shed	0.55	2.39	0.83	1.29	1.34	-
- 30 kt horizontal shed	0.55	1.94	0.56	1.02	0.99	-
- Capped concrete bin	0.55	2.38	1.46	1.78	1.75	2.09
- Uncapped concrete bin	0.55	2.38	2.02	2.34	2.31	2.65
Ten months (e)						
- Welded steel bin	0.82	-	0.21	0.85	0.79	1.47
- 15 kt horizontal shed	0.82	2.60	0.87	1.79	1.89	-
- 30 kt horizontal shed	0.82	2.16	0.60	1.52	1.22	-
- Capped concrete bin	0.82	2.59	2.14	2.08	2.08	2.76
- Uncapped concrete bin	0.82	2.59	2.06	2.70	2.64	3.32

(a) Cost of grain treated, assuming 90 per cent fill at time of treatment and that only one parcel of grain is treated each year.

(b) Cost in New South Wales, Victoria and Queensland.

(c) In sealed storage.

(d) Low oxygen atmosphere produced by burning propane in air.

(e) For fumigation/modified atmosphere, one retreatment after six months' storage is assumed. For chemical protectants, a retreatment at half rate is assumed.