# Western Australian Fumigation Practice Survey (1992)

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*Abstract*

Sealed storage for grains has been in use on farms in Western Australia for ten years and represented 44% of on-farm silo capacity in 1987. Phosphine is a commonly used stored-grain fumigant and phosphine resistance has been recorded in grain insects in the past decade. Phosphine fumigation procedures in unsealed structures created a selection pressure on the target organisms.

Earlier surveys showed that grain storages purchased as sealed units were not being maintained. Up to 56% of silos failed the standard test for gastightness.

A study of randomly selected farms from 43 shires of the Western Australian wheat belt was conducted to investigate the relationship between poorly maintained sealed grain storage and the incidence of phosphine resistance on those properties.

The survey found that sealed silo maintenance had deteriorated, with a 75% failure of silos tested. The results of the survey revealed no relationship between phosphine resistance and poor fumigation technique.

## Introduction

In conjunction with a phosphine resistance survey conducted by the Department of Agriculture (Emery, these proceedings) a subset was selected to examine on-farm fumigation practice. The fumigation practice survey was conducted by the Agriculture Protection Board (APB) which has responsibility for on-farm grain insect control advice. The sample area covered 43 shires in the central wheat belt. (see Fig. 1) From the incoming samples and records returned by district officers conducting the resistance survey a selection of properties was made in two broad groups:

- sealed silos
- unsealed silos.

These two groups were divided into three subsections, comprising properties with:

(1) no insects,
(2) susceptible insects,
(3) resistant insects.

The fumigation practice survey was conducted from March to November 1992. Property owners were contacted by telephone in the evening between 7 and 9pm. The late telephone technique was used to achieve higher positive contact with the growers. No announcement of the survey was given to those telephoned. This was to ensure the responses were as close as possible to the actual practices employed rather than answers researched with the aid of literature or product labels.

All farmers contacted agreed to be interviewed. Those that did not store grain were not asked any further questions. The remainder were asked a series of questions related to their fumigation practice. The results of the interviews are recorded below. The sealed silo group was also asked if we could visit their property to test the silos. The owner was invited to be present when the test was being conducted.

In summary the questions asked were

- When do you fumigate?
- How do you fumigate and how often?
- What is the capacity of your grain store?
- How many tablets do you apply?
- Where are the tablets placed?

## Sealed Silo Group

Properties were chosen by hand from lists as supplied by the Department of Agriculture resistance testing laboratory. The list was collated from samples returned to the laboratory from the farms in the phosphine resistance survey. Selection was made from the returns received between August 1991 and May 1992.

(1) No insects — first entry every fifth page of returned labels,
(2) Susceptible insects — every entry,
(3) Resistant insects — every entry.

### No insects

44 farmers contacted and interviewed.

27 (61%) used phosphine and their silos were tested.

17 (38%) were not using phosphine in sealed silos for the following reasons. These silos were not tested.

8 farmers use phosphine but not in sealed silos where seed wheat or lupins is stored. (These growers had heard the rumour that phosphine reduced germination)

3 farmers stated there was no need to use phosphine in sealed silos.

4 farmers did not use phosphine on the property.

2 farmers used Dryacide® or lime in their sealed silo.

### Susceptible insects

44 farmers contacted.

32 (72%) used phosphine and their silos were tested.

12 (27%) were not using phosphine in sealed silos for the following reasons. These silos were not tested.

6 farmers did not fumigate because the grain is insect free and a sealed silo will protect it.

4 farmers stored only seed grain and lupins in sealed silos and did not feel it necessary to fumigate.

1 farmer did not have a sealed silo (returned sample wrongly labelled).

1 farmer did not want his silos tested.

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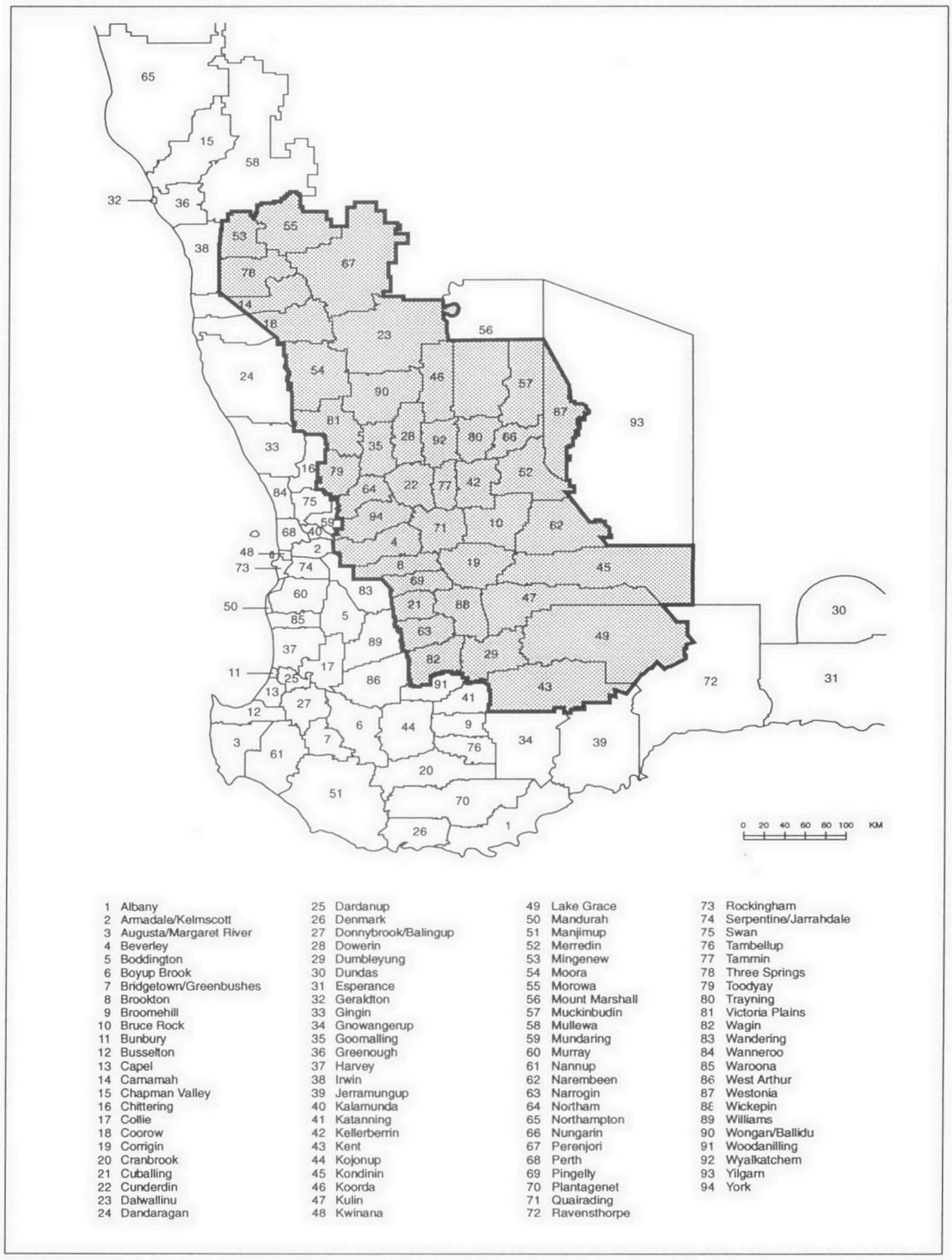


**Fig. 1.** Fumigation practice survey area.

## Resistant insects

26 farmers contacted. (every entry within the survey area)

20 (77%) used phosphine and their silos were tested.

6 (23%) were not using phosphine in sealed silos for the following reasons. These silos were not tested.

2 farmers ceased using phosphine 4–6 years previously.

2 farmers store seed grain and lupins in sealed silos and do not fumigate, but they do use phosphine in unsealed silos.

1 farmer fumigates in unsealed silos only because the grain in his sealed silos is moved through very quickly.

1 large property could not establish how much phosphine was used because the worker concerned had left.

From the comments provided by the respondents it is clear there remains a number of misconceptions regarding the use of phosphine and stored grain. Some growers believed there was a relationship between the use of phosphine and poor germination. Some still believe no further is treatment necessary once the grain has been placed in a sealed structure. The replies that fumigation was carried out only in unsealed structures give cause for concern. Farmers were asked when they carried out a fumigation on their stored grain.

| | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| At loading of the silo | 41% | 22% | 38% |
| At loading and when insects are found | 22% | 31% | 14% |
| At loading and as a routine | 11% | 3% | 14% |
| At loading and (x) months after loading | | 3% | |
| When insects are found | 15% | 19% | 24% |
| When insects are found and as a routine | | | 5% |
| Routine basis during the year | | 3% | 5% |
| (x) months after filling | 11% (8–11) | 19% (1–7) | |

From the table above it appears that most farmers apply the initial insect treatment when the silo is first filled. This is recommended practice published by the APB and other relevant authorities. A large number apply phosphine treatments only when insects are found and on an ad-hoc basis throughout the storage period.

The following table indicates how the fumigation is carried out. The farmers were asked how they applied the tablets to the silo.

| | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| Auger % | 30 | 28 | 38 |
| Auger and top of grain % | 22 | 3 | 19 |
| On top of grain % | 18 | 21 | 9.5 |
| Inserted with a probe % | 11 | 17 | 14.5 |
| Auger and probe % | 11 | 7 | 9.5 |
| Placed in boot % | 4 | | |
| On top and boot % | | 24 | |
| Bag chute and boot % | | | 9.5 |
| Placed in containers % | 4 | | |

From the respondents replies 56% use the auger as a method of application for all or part of the phosphine dose. The APB recommends only one method of application of the tablets to a sealed silo. This is on top of the grain after filling and before the lid is closed and the silo sealed. This method prevents gas loss either when the tablets are placed in the auger or if the farmer takes more than one day to load the silo. When the tablets are placed on top of the grain, the air currents created by temperature gradients carry the liberated gas around the silo. Placing the tablets in the bag chute or boot removes the gas from the main air currents in the silo which may limit circulation of the liberated gas.

From the table it is noted some farmers place the tablets in containers in the silo. This is a highly dangerous practice which can lead to the generation of an explosive atmosphere inside the container.

Probing the tablets into the grain is difficult and unnecessary in a sealed silo. However it is noted this is the practice of 23% of respondents when applying later doses of phosphine.

Farmers were questioned on the amount of phosphine tablets applied to a silo and the frequency of application.

| | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| Average dose (g/t) | 1.47 | 1.5 | 1.4 |
| Range g/t | 0.09–3.1 | 0.16–6 | 0.08–6 |
| Frequency of application (average/year) | 1.5 | 1.4 | 1.8 |
| Range | 1–3 | 1–3 | 1–3 |
| Average annual application (g/t) | 2.2 | 2.1 | 2.5 |

Regardless of grouping, the application rates of phosphine are remarkably similar. There is no statistical difference in the annual application rate. The most disconcerting statistic is the range of dosages of phosphine. Applications rates of 0.08 g/t up to 6 g/t indicate a failure to read the label or adhere to published and label recommendations of 2 g/t of silo capacity .

From this information it could be suggested that the dose rate has not had any impact on the presence or absence of a phosphine resistance.

## Silo Testing

An important aspect of the survey was to determine the gastightness of the respondents' silos. This statistic could then be compared to the level of resistance in insects.

All respondents were asked for permission to visit their property to test the silo from which the initial sample was obtained. Some 99% of property owners agreed to the farm visit and test. The property was visited in company with the officer who collected the sample and the farmer where possible. This turned the silo test into a demonstration and problem solving exercise in many cases.

| Test results (%) | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| Pass | 33 | 25 | 24 |
| Fail | 66 | 75 | 76 |

There appears to be no significant difference in silo failure between the different groups. This suggests there is no relationship between phosphine resistance and the gastightness of the silo.

On average failure could be attributed to:

- leaking seals (57%)
- leaking seals and low oil level in the pressure relief valve (13%)
- low oil levels (15%)
- damage (13%)
- damage and seals (4%)

Causes of failure were similar to those found by Newman (1989).

## Unsealed Silo Group

Properties were chosen by hand from lists as supplied by the Department of Agriculture resistance testing laboratory. Selection of properties was made from the returns made to the laboratory for their phosphine resistance survey from August 1991 to May 1992.

(1) No insects — first entry every fifth page of returns.
(2) Susceptible insects — every fifth entry
(3) Resistant insects — every entry

**No insects**

41 farmers interviewed by telephone.

18 (46%) did not fumigate.

**Susceptible insects**

32 farmers interviewed by telephone.

12 (37.5%) did not fumigate.

**Resistant insects**

37 farmers interviewed by telephone.

2 (5.4 %) did not fumigate.

Some farmers did not want to be interviewed but this did not adversely affect the result. One owner could not be contacted despite considerable effort.

Farmers were asked when they carried out a fumigation on their stored grain.

| | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| At loading of the silo | 4% | 30% | 17% |
| At loading and when insects are found | 18% | 10% | 26% |
| When insects are found | 61% | 35% | 43% |
| When insects are found and as a routine | | | 6% |
| Routine basis during the year | 13% | 10% | 8% |
| (x) months after filling | 4% (11) | 15% (7–11) | |

Results suggest farmers tend to use phosphine in reaction to insect infestation instead of as a prevention measure.

Farmers were asked how they applied tablets to the silo.

| | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| Probe | 70% | 50% | 46% |
| Auger | 9% | 30% | 20% |
| Probe and auger | 9% | 10% | 9% |
| Top of grain | 3% | | 9% |
| Silo boot | | | 3% |
| Door | | 5% | |
| Probe door and top | 3% | | 3% |
| Fixed tubes | | | 6% |
| Boot and top | | 5% | |
| Probe and boot | | | 3% |
| Probe and top | 3% | | 3% |

A wide variety of techniques was chosen to apply the tablets. The most popular is the probe method, followed by application via the auger as the grain is being loaded. These techniques are acceptable as the most efficient method of tablet insertion in an unconfined airspace. This will assist gas development in the grain bulk and give a degree of insect control. A proportion of the surveyed groups persists in applying tablets to the periphery (top, boot, doors, etc.) of the grain bulk which is of limited benefit and may help select for resistance.

Farmers were asked how they applied phosphine and the frequency of application. (Replies received in terms of pack sizes. This has been converted to g/t)

| | No. insects | Susceptible insects | Resistant insects |
|---|---|---|---|
| Average dose (g/t) | 3.6 | 3.1 | 2.8 |
| Range (g/t) | 0.5–10 | 0.4–10 | 0.07–10 |
| Frequency of application (avg /year) | 1.7 | 1.6 | 2.3 |
| Range | 1–4 | 1–4 | 1–8 |
| Average annual application. (g/t) | 6.1 | 4.96 | 6.4 |

Considerable variation in rates of phosphine applied were noted. From 0.07–10 g/t were quoted by respondents. When asked more specifically how they calculated how many tablets to add to the silo, the answer was invariably 'by the amount of grain in the silo'. This conflicts with APB recommendations to dose by the capacity of the silo. It will be noted that the average annual application rate is considerably higher than that for the sealed silo group. The farmers in the unsealed silo group applied 3.5 g more phosphine per annum than those with sealed storage.

## Summary

Sealed silo maintenance has decreased since an earlier survey: 27% passed the standard APB test compared with 44% found in the previous survey. (Newman 1989)

Poor rubber seals were again the major reason for failure, followed by low oil levels. Both of these problems can be remedied quickly at low cost to the farmer.

It appears the application rate of phosphine and silo failure rate has not influenced the number of phosphine-resistant properties in the sealed silo group. The unsealed silo group demonstrated more frequent use of phosphine than the sealed silo group.

A comparison of the treatment times of the two groups demonstrates a difference in the reasons for fumigation. In the sealed silo group, an average of 43% apply phosphine when insects are found, or in a combination with loading or routine measures. Some 67% apply the fumigant as a preventative treatment. In the unsealed silo group 66% apply phosphine in response to insect infestations. This action has allowed a large population to evolve, increasing the number that will be selected for resistance. Thirty-seven farmers were found to have resistant insects in the unsealed group compared with 26 farmers in the sealed group.

The majority of farmers in both surveyed groups applied phosphine in a suitable manner. However, a small proportion applied the tablets in a manner that could help select for phosphine resistance.

Despite extensive publicity since the original survey was released it appears few farmers have recognised the importance of maintaining a silo in a sealed condition. Application techniques and dose rate recommendations are two areas that require increased extension input. Fumigation in unsealed storage is impossible to achieve. The recommendation to fumigate in this manner should be removed from publications. More effective insect control can be achieved by placing phosphine tablets under a tarpaulin covering grain in a truck or stacked on a plastic sheet. A recommendation to fumigate only when grain is being removed from the property needs to be reinforced on a local level.

This survey has not demonstrated any relationship between phosphine resistance and faulty fumigation techniques. The

presence of insects may then be due to the importation of insects from other sources.

Further research is suggested to study more closely:

- exact degree of gastightness of silos which failed the standard test
- hygiene of the property
- movement of resistant insects from unsealed to sealed storages.
- movement of grain onto the property.

## Reference

Newman, C.R. 1989. Sealed grain storage in Western Australia: a progress report. In : Champ, B.R., Highley, E. and Banks, H.J., ed., Fumigation and controlled atmosphere storage of grain: proceedings of an international conference, Singapore 14–18 February 1989. ACIAR Proceedings, No. 25, 272.