

NEW OPERATIONS MANUALS FOR SAFE AND EFFECTIVE FUMIGATION OF GRAIN IN SEALED BAG-STACKS

P.C. Annis, J.E. van S. Graver* and E. Highley***

**CSIRO Division of Entomology, GPO Box 1700 Canberra ACT 2601, Australia.*

***Consultant, Australian Centre for International Agricultural Research, GPO Box 1571, Canberra ACT 2601, Australia.*

Abstract

In the ASEAN Region fumigation is used as the first, and frequently the only, means of preventing damage of stored grains by insects. Fumigation is widely perceived to be a rapid process requiring minimal resources and preparation. This convenience has led to the adoption, into fumigation operations, of many misconceptions and unsound practices that are frequently the cause of fumigation failures. Specific examples illustrate the need to create an awareness of the minimum requirements for good and effective fumigation. The paper emphasises the urgency to eliminate bad practices that have become established into current fumigation operations in the region.

The potential consequences of substandard fumigations have provided the impetus that led the ASEAN Food Handling Bureau (AFHB) and the Australian Centre for International Agricultural Research (ACIAR), in collaboration with appropriate national agencies, to develop a code of practice for fumigation. This is an open-ended series of publications, directed at providing comprehensive instructions for the conduct of effective and safe fumigations to modern standards. Part I of the Code, "Suggested Recommendations for the Fumigation of Grains in the ASEAN Region" (1989), gives the general background to the principles of modern fumigation practice. One further part, "An Operations Manual for the Fumigation of Sealed Bag-stacks with Carbon Dioxide" has just been published, with two others: 1) "An Operations Manual for the Fumigation of Sealed Bag-stacks with Phosphine", and 2) "An Operations Manual for Carbon Dioxide Fumigation of Shipping Containers", in an advanced stage of preparation.

INTRODUCTION

In the ASEAN region, as in many other parts of the world, fumigation is commonly the first, and frequently the only, means of minimising damage by insects to stored grains and other commodities. Fumigation is perceived to be a rapid and inexpensive method of insect control. Even poor fumigations frequently kill most of the adult insect, the most visible stage and in many

species the most susceptible stage, but they may leave many immature insects surviving thus giving an illusion of success. This illusion of success along with the techniques convenience and apparent simplicity have led to the incorporation of many unsound practices into routine fumigation operations. These bad practices are the cause of many fumigation failures that have led to grave concern about fumigant resistance developing and spreading in the ASEAN Region (Banks 1987, Champ and Highley 1986, GASGA 1986).

In recent years, however, there has been a growing awareness of the proper requirements for effective fumigation - those that give a 100% kill. Furthermore, techniques to attain these requirements have now become available. Unfortunately, many of these techniques have their origins in research establishments and consequently are only well known to those researchers and their collaborators who developed them. The purpose of the AFHB/ACIAR operations manuals is to transfer this knowledge as a fully developed code of practice to the end users of fumigation technology and at the same time present it in a user friendly form.

The first manual in this series "Suggested Recommendations for the Fumigation of Grains in the ASEAN Region: Part 1" (AFHB/ACIAR 1989) presents the principles and general practices underlying modern fumigation. It is addressed mainly to policy makers concerned with grain and commodity storage and to management involved with fumigation and pest control.

The second manual just published "An Operations Manual for the Fumigation of Sealed Bag-stacks with Carbon Dioxide" (AFHB/ACIAR 1990), and those planned for the near future, are directed at fumigators and their direct supervisors - people who are more closely involved in fumigation. They have been written to give explicit instructions for applying the principles presented in Part 1 in specific fumigation situations.

SUBSTANDARD FUMIGATION

The urgent need for manuals of this kind becomes obvious when fumigation practice is observed in the tropics. In tropical climates the consequences of poor fumigations pose a greater threat than in temperate climates because tropical conditions generally favours the rapid growth and development of stored products insects. While fumigations in the major facilities of centralised commodity handling systems may be adequate, those undertaken away from these specific situations are frequently very poorly carried out, with little chance of success. The reasons for this (van S. Graver 1990) vary widely, however, the most common are a lack of understanding:

- * that a fumigation must meet rigorous standards to work properly
- * of the consequences of a poor fumigation.

To place the problem of substandard fumigation into context, the following examples of fumigation bad practice, drawn from the authors' experience in the ASEAN Region, illustrate the urgent need for explicit operations manuals. Even though these examples refer to the ASEAN Region, it is well known that similar bad practices and misconceptions occur in many other parts of the world where fumigation is used.

It must, however, be stated that the fumigators (and their employers) involved in these examples were making the best effort within the limitations of the information and resources available to

them. After each example there is a brief synopsis of the views expressed in the manual concerning that particular aspect of substandard fumigation.

1. Almost all fumigations in the Region are carried out on unsealed floors with no attempt made to prevent gas loss downwards. Fumigant retention may sometimes be adequate but where a concrete floor is badly cracked, or even worse, when stacks are built on bare sandy soil, there is little chance of retaining a lethal concentration of fumigant over the required exposure period and achieving a successful fumigation.

The fumigator-in-charge should ensure that gas loss downwards is prevented, or minimised. The use of a gas proof floor sheet has been widely advocated for this purpose.

2. A sheeted bag-stack in a godown. Godown staff were observed working on the floor, hand sorting commodity within 1-2 meters of the stack while it was being dosed with methyl bromide.

Full consideration must be given to worker safety at all times. Prior to applying a fumigant dose, the fumigator-in-charge must identify and clearly mark the hazard area surrounding a fumigation site. Access to the hazard area must be restricted to fumigators until it has been declared safe by the fumigator-in-charge on completion of the fumigation.

3. Sheeted bag-stacks being fumigated with phosphine. The sheets enclosing the stack were weighted down and "sealed" to the floor with sheets of corrugated cardboard (and in another case with empty jute bags). Godown staff were observed working around the base of the stack while the fumigation was in progress.

Successful fumigations can only be carried out in well sealed enclosures. If "tailored" plastic stack covers and floor sheets are unavailable or sealing with solvent based glues is impossible, loose dry sand or sand contained in "sand snakes" are the preferred means of ensuring a good seal of fumigation sheets to the floor.

The need to demarcate hazard areas in the interests of worker safety is referred to in 2 above.

- 4 Fumigant concentrations within an enclosure are seldom measured during the course of a fumigation. In situations when there is a contractual requirement to measure fumigant concentrations, many fumigation contractors become wary of undertaking the job.

In one instance fumigant concentrations were not measured because "the Department of Health considered it to be dangerous".

Fumigant concentrations must be monitored for two essential reasons:

** to ensure worker safety - by measuring fumigant concentrations in the hazard area*

** to ensure the success of the fumigation - by monitoring the concentration of fumigant inside the enclosure throughout the exposure period.*

- 5 The observation (made by an export Quarantine Officer) "that the majority of contract (or mandatory) fumigations, carried out (in his country) before commodities are exported are substandard, because gas retention is inadequate for effective fumigation".

He added that "The official certification requires a verification that a defined dose of fumigant has been applied - but there is no provision on the certificate to indicate the final gas concentration at the end of the exposure period, or indeed, whether there had been any gas retention at all!"

The concentration of fumigant inside a fumigation enclosure must be measured to ensure the successful outcome of the fumigation (see above).

To ensure confidence in international trade it would be desirable to indicate on fumigation certificates, not only the dose of fumigant applied, but also:

- * the duration of the exposure period*
- * the final concentration of fumigant at the end of the exposure period*
- * the concentration x time (ct) product, where applicable.*

6. To identify and prevent losses, it is standard practice in one central storage organisation to collect all spillage and floor sweepings from around a stack, bag them, then stand it alongside the stack from which it was collected. However when the stacks are fumigated the bags containing the sweepings are not enclosed under the fumigation sheets with the stack - but placed away from the stack, along the godown wall. After the fumigation the bags are replaced against the stack.

Storage hygiene is a vital aspect of good storage practice. However, it is essential to identify all potential sources of insect infestation in a storage. The spillage and sweepings recovered from stacks represent an important source of cross infestation that must not be overlooked by management and godown supervisors. When stocks in a godown are disinfested it is necessary to include all possible sources of cross infestation, such as bags of spillage that, for management purposes, might have to be separated from the main bulk of the commodity.

7. The statement, "that it is possible to reduce the exposure period for phosphine fumigations to two days", was made by a wholesale/retail supplier of a magnesium phosphide, phosphine generating preparation.

With a final target of achieving a phosphine concentration greater than 80 ppm throughout the enclosure at the end of the fumigation; an exposure of seven (7) days is essential to ensure all developmental stages are killed.

THE EXPOSURE PERIOD CANNOT BE REDUCED WHEN USING THIS FINAL MINIMUM CONCENTRATION TO DEFINE A SUCCESSFUL FUMIGATION.

8. In one country phosphine is considered to be too dangerous to use as a fumigant, whereas methyl bromide is considered to be safe! In another country in the Region the contrary view was expressed.

Both fumigants are very toxic to humans, therefore equal care must be exercised to ensure worker safety. Industrial hygiene standards for worker exposure to fumigants have been established. These are based on a time weighted average concentration for a normal 8-hour workday and a 40 hour working week, to which all workers may be repeatedly exposed, day

after day, without adverse effects. The daily threshold limit values-time weighted averages (TLV-TWA) have been established, in many countries, for methyl bromide at 5 ppm and for phosphine at 0.3 ppm.

9. The commercial fumigation contractor who mentioned in conversation that he could, and did, cut costs in a phosphine fumigating by reducing the applied dose by half

The only acceptable dose for a successful phosphine fumigation is one that gives a final concentration at, or above, 80 ppm on completion of a 7 day exposure period.

10. Finally the ultimate cost saving - phosphine fumigation of bag-stacks where no sheeting has been used at all.

No further comment!

These examples serve to demonstrate that fumigations will continue to be:

- * at best - less than perfect - in terms of insect mortality
- * at worst - dangerous to fumigators and other personnel

unless there is a substantial improvement in the knowledge base and facilities available to fumigators and their supervising managers.

THE CONSEQUENCES OF SUBSTANDARD FUMIGATIONS

The effects of substandard fumigations are not so obvious as the bad practices that are their cause. Fortunately the effects are usually potential rather than actual, nonetheless the risks remain and a few cases can be documented and followed from cause to effect. One instance is related to examples 3, 4 and 5 above. All three refer to the same commodity exported from one country to a range of markets.

Case One

One of these markets, (outside the ASEAN Region), recently made the commercial decision to cease importing the commodity from that country. This decision was taken as result of consistent detections of insects in the commodity, on outturn in the importing country over a number of years, despite the fact that the commodity was always accompanied by a fumigation certificate. In this case the bad practice led to the total loss of a market.

Case Two

In another country, (within the ASEAN Region this time), it has been found necessary to refumigate all consignments of that commodity immediately after importation. Again all consignments were reportedly fumigated at, or shortly before, export and accompanied by fumigation certificates. In this case there was no loss of market, but the refumigations are a direct cost penalty on the importer - and indirectly on the exporter.

Case Three

Regular detections of insect infestations, by the Australian Quarantine Inspection Service, in commodities imported into Australia indicated that standard fumigations were being carried out overseas. In at least one instance the fumigation certificates had been issued by a pest control company with significant Australian connections! This caused the company to upgrade its fumigation operations in its overseas subsidiaries to meet the Australian Quarantine requirements and - protect the reputation of its Australian operation.

AIM OF THE OPERATIONS MANUALS

The aim of the operations manuals is to:

- * increase the information available to fumigators and their supervising managers to ensure that fumigations can be carried out effectively,
- * by providing explicitly defined, reliable and safe techniques, which when properly applied will result in effective fumigations.

With these objectives, the operations manuals are written to provide operational information on specific proven fumigation techniques. The contents include:

- * information about determining the appropriateness of the fumigant,
- * ensuring adequate and provable gastightness,
- * applying the correct dose (concentration and exposure period) of fumigant,
- * facilitating the safety of fumigators and other personnel who might be exposed to the fumigant.

What then is the difference between these operations manuals and the various fumigation manuals (Anon 1974, Anon 1985, Bond 1984, Friendship 1989, Stout 1983, TDRI 1983) that have been published previously?

The main differences are:

1. Most importantly the techniques recommended take cognisance of the basic fact that unless a fumigation enclosure is appropriately sealed, there is only an unpredictable and limited chance of a successful outcome to the fumigation, ie. one in which all insects present are killed. As the level of sealing increases, so the probability and predictability of success will increase.
2. That the first two manuals clearly indicate that dry disinfested commodities left inside a sealed enclosure remain:
 - * protected from reinfestation and
 - * in good condition for a long time.

Thus in these cases the techniques described also provide long-term protection as well as disinfestation.

CONCLUSION

Modern techniques for carrying out fumigations that attain the requirements for effective disinfestation have been developed. These techniques are based on the principle that a fumigation should not be attempted if a stack or storage cannot be sealed to an appropriate level of gastightness.

The first in a series of fumigation operations manuals presents explicit instructions for undertaking carbon dioxide fumigations of sealed stacks. The manual clearly defines the limitations of the technique, labour and equipment requirements and details instructions for implementing fumigations. By presenting clearly defined goals, in terms of sealing, fumigant dose, duration of the exposure period and the final gas concentration the manual makes it possible to predict the success of a fumigation.

If, and only if, there is a general increase in the standard of fumigations undertaken, particularly in developing countries, will fumigation be maintained as a mainstay of stored products insect control.

REFERENCES

- AFHB/ACIAR 1989. Suggested recommendations for the fumigation of grain in the ASEAN Region. Part I Principles and general practice. Kuala Lumpur, ASEAN Food Handling Bureau, 139 pp.
- AFHB/ACIAR 1990. Suggested recommendations for the fumigation of grain in the ASEAN Region. Part II Carbon dioxide fumigation of bag-stacks sealed in plastic enclosures: an operations manual. Kuala Lumpur, ASEAN Food Handling Bureau, 58 pp.
- Anon 1974. Fumigation with methyl bromide under gas proof sheets, 3rd ed. U.K. Ministry of Agriculture, Food and Fisheries. London. HMSO.
- Anon 1985. Manual of pest control for food security reserve grain stocks. FAO Rome. Plant production and protection paper No 63.
- Banks, H.J. 1987. Research and development opportunities for fumigation in the ASEAN Region as a component of integrated commodity management. In Evans, D.E. and Wellisch, P.K. 1987 eds. Grain storage in ASEAN : some research and development options. Division of Entomology Report No 42 CSIRO Australia 1987 29-35.
- Bond, E.J 1984. Manual of fumigation for insect control. FAO Rome. Plant production and protection paper No 54. xi, 432 p
- Champ, B.R. and Highley, E. eds Pesticides and humid tropical grain storage systems: proceedings of an international seminar, Manila, Philippines, 27-30 May 1985. ACIAR Proceedings No 14, 364 p.
- Friendship, R. 1989. Fumigation with phosphine under gas proof sheets. Overseas Development and Natural Resources Institute Bulletin, No 26,iii +22 pp.

- GASGA 1986. GASGA Seminar on fumigation technology in developing countries. Tropical Development and Research Institute, Storage Department, Slough, England, 18-21 March 1986. 189 p
- Stout, O.O. 1983. International plant quarantine treatment manual. Based on the work of Oliver O. Stout, as revised by Herbert L. Roth; editors Joseph F. Karpati, Charles Y. Schotman and Kathleen A. Zammarano. Rome, FAO, Plant Production and protection paper.
- TDRI 1983. Food storage manual second edition. World Food Programme xviii 263 p
- van S. Graver, J.E. (1990). Fumigation and controlled atmospheres as components of integrated commodity management in the tropics. In Champ, B.R., Highley, E. and Banks, H.J. 1990 eds. Fumigation and controlled atmosphere storage of grain: proceedings of an international conference, Singapore, 14-18 February 1989. ACIAR Proceedings No 25, 38-52.

**DE NOUVELLES NORMES POUR PRATIQUER AVEC SECURITE
ET EFFICACITE LA FUMIGATION DU GRAIN**

P.C. ANNIS

Stored Grain Research Laboratory
GSIRO Division of Entomology
GPO Box 1700 Canberra 2601, Australia

RESUME

Dans les pays asiatiques, la fumigation s'utilise comme le premier moyen et, la plupart du temps comme le seul, de prévention contre les ravages dus aux insectes des grains stockés. La fumigation est considérée comme étant rapide et demandant un minimum de ressources et de préparation. En principe, ce confort a, cependant, conduit à introduire de nombreuses et mauvaises pratiques ayant abouti à des fumigations mal faites et inefficaces. Cet article donne des exemples précis pour mettre en lumière le besoin de diffuser la connaissance de ce qui est nécessaire à une bonne fumigation. Il vise également à démontrer qu'il faut éliminer les préjugés déjà ancrés sur la fumigation.

Ces fumigations hors normes ont créé le besoin de développer un code de bonne pratique établi par le ASEAN Food Handling Bureau et le Centre International de Recherche Agricole Australien (ACIAR), en collaboration avec les ministères concernés. Il s'agit de publications non exhaustives visant à donner des conseils pour pratiquer, en toute sécurité et avec efficacité, la fumigation aux normes modernes. Les "Recommandations" portant sur la Fumigation du Grain des Pays Asiatiques, publiées en juillet 1989, donnent un aperçu général des principes des pratiques modernes de fumigation. Deux autres parties, concernant la fumigation des piles de sacs sous bâche: (au dioxyde de carbone et à la phosphine), ont été récemment publiés sous forme de manuel. Enfin, un troisième ouvrage concernant la fumigation des conteneurs est en voie de publication.