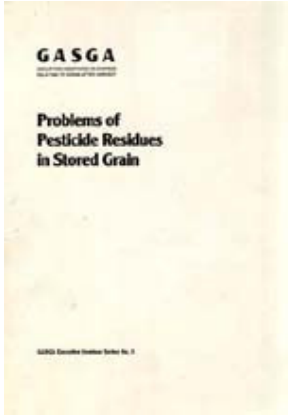

Problems of pesticide residues in stored grain

GASGA

GROUP FOR ASSISTANCE ON SYSTEMS
RELATING TO GRAIN AFTER HARVEST

GASGA Executive Seminar Series No. 3

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Preface

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GASGA - the Group for Assistance on Systems relating to Grain After-harvest - is a voluntary association of organizations primarily linked with donor operations.

These organisations all have major involvement in most, if not all, of the following:

- the provision of professional advice;
- the conduct of field projects;
- the training of developing country personnel;
- and the conduct of research and its application in relation to the problems of the

postharvest sector of the production of grain and other major food commodities in developing countries.

The association is essentially technical; it is international in character, but informal and limited in membership, so that its deliberations, aimed at the specific objectives indicated below, can take place readily.

GASGA consists of the following organisations:

- Australian Centre for International Agricultural Research, Canberra, Australia (ACIAR)
- Centre de Cooperation International en Recherche Agronomique pour le Developpement, Montpellier, France (CEEMAT/CIRAD)
- Deutsche Gesellschaft fr Technische Zusammenarbeit (GTZ) GmbH, Eschborn, Federal Republic of Germany (CTZ)
- Food and Agriculture Organization of the United Nations, Rome, Italy (FAO)
- Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas, USA (KSU)
- International Development Research Centre, Ottawa, Canada (IDRC)
- Koningklijk Instituut voor de Tropen, Amsterdam, The Netherlands (KIT)
- Natural Resources Institute, Chatham, England (NRI).

GASGA aims to stimulate improvement in the technical help given to developing countries in the postharvest handling, processing, storage and transport of grain, and to harmonise activities so that the most effective use is made of members' resources. GASGA seeks to identify and suggest ways of meeting needs for research, development, training and information in this subject field, in the light of existing or planned operations by GASGA members and other organisations.

The Group is also prepared to answer requests for technical advice put to it by developing countries.

GASGA also seeks to facilitate the appropriate dissemination of information about technical developments and activities in the postharvest sector to donors, developing countries, and other interested organisations. The last group includes, for instance, the International Agricultural Research Centres whose commodity oriented preharvest programs need links with postharvest activities and requirements.

In essence, GASGA's role lies in advice and the provision of a forum for exchange of technical information and experience.

The GASGA Executive meets annually to review progress in its activities and discuss proposals for future work.

This volume, the third in the series, publishes the papers presented at a seminar held during the 21st GASGA Executive Meeting, held at KIT Headquarters in Amsterdam from 31 May2 June 1989.

Summary

The objective of this seminar was to summarise, through an interpretive overview from various perspectives, the nature of the pesticide residue problem in stored grains, its severity, where concentrated, on what grains and why. Also to be assessed were the implications for consumers: which are the populations most at risk, where, in what way, when, and to what degree of severity? If this information is not available, how can it be determined? The aim was to produce a publication that would contribute to current appreciation and thought from an operational perspective.

The seminar opened with a presentation by Mr J. van der Kolk (Codex Committee on Pesticide Residues) on international regulation of pesticide residues in food grains. In the discussion which followed, the question was raised as to the implications for research and laboratory facilities: where does the money come from? Mr van der Kolk replied that it is the responsibility of pesticide companies to undertake research leading to toxicological and residue data in connection with the development of pesticides.

There will, in due course, be some contribution at national level as part of registration procedure. Codex, with its expert panel and publications, is funded jointly by FAO and WHO; the Codex Committee on Pesticide Residues is hosted by The Netherlands.

Of particular concern was the question of unilateral actions taken nationally: for example, India and Germany are currently seeking residue levels in relation to certain pesticides that are much lower than those recognized internationally. Mr van der Kolk agreed that individual governments can and do establish their own requirements - it is difficult to convince them that these may be lower than is necessary. However, in India, for example, grains may be consumed without complete processing there is the problem of reconciling pest control needs with requirements concerning residues. There are also observed discrepancies between rule and practice.

A paper by Mr D. Halliday (NRI) paper focused on the occurrence, sources and toxicological significance of pesticide residues in food grains. A question about the fumigant ethylene dibromide (EDB), which was not referred to specifically in the paper, led to some discussion about inorganic bromide residues. Mr Halliday pointed out that EDB is tending to be phased out because of carcinogenic implications. Although inorganic bromide levels are lower than with methyl bromide, there is also a problem with unchanged ethylene dibromide. The primary concern with methyl bromide fumigation was the question of repeated fumigations which occur in those situations

where treatments are undertaken on a 'calender' basis rather than on a basis of infestation assessment. Mr van der Kolk pointed to the additional problem of importing countries requiring a certificate of fumigation prior to export (regardless of any assessment of need) and the fact that commodities from developing countries shipped into Europe for re-export may be subject to an additional, and probably totally unnecessary, fumigation.

There is much interest in developing countries in the use of indigenous plant materials (e.g. neem); also much scientific research is diverted towards the potential use of hormones and pheromones for insect control. What is the position with such materials as regards consideration by Codex? Mr van der Kolk replied that their use is so limited at the present time that no cases have come before Codex. However, if grain treated, for example, with neem entered international trade then Codex consideration would be needed (but who would bear the cost?).

In response to a question whether it is possible to offer practical methods for residue determination for use at storage level in developing countries, Mr Halliday replied that, for fumigants, concentrations can be measured during treatment but as far as pesticides are concerned it is not possible to avoid laboratory analysis of samples. Although this can be done using simpler methods (e.g. TLC) than those used in developed country residue laboratories, the results will be less accurate. NRI was currently this problem, Mr

Halliday salt. He noted that a publication would be issued shortly giving guidelines on the establishment of pesticide residue laboratories in developing countries with details of procedures and chemical and equipment requirements. Also, a project is in progress to review less sophisticated methods such as TLC and ELISA.

Dr J. Pedersen (KSU) mentioned that an American company had developed a rapid test based on a colour reaction for organophosphorous insecticides - the 'Enzy Tee' method. Mr Halliday said that NRI had evaluated this method but found the results to be unimpressive. Mr Weber pointed out that the accuracy of this, and any other method, will depend upon the sampling procedure used.

Mr R. Harnisch (GTZ) commented that, although some 80% of grain produced in many developing countries is held in storage on the farm, he would estimate that no more than 1% of farmers are using insecticides. Mr Halliday responded that generally losses are insufficient to justify input costs. It is only in situations in which 'improved' varieties, with their greater susceptibility to primary storage pests, are stored, or in which the serious pest Prostephanus truncates occurs, that them is sufficient cost-benefit justification.

A presentation by Dr M. Kern (GTZ) described the objectives of the GTZ supraregional pesticide residue project and summarised the results of investigations on the

degradation of insecticide deposits in stored grain. Data presented on halflives of different insecticides led to discussion on the question of formulation. Mr Halliday pointed out that half-life would be influenced by type of formulation (e.` dilute dust, wettable powder, etc). Reference was made to problems with formulation of insecticides for use in developing countries and the supply of inappropriate formulations.

Dr Kern referred to the FAO specifications for formulations in the FAO Code of Conduct, and supplementary technical guidelines on labelling and use. Mention was also made of the problem of repackaging of pesticides.

Finally, Mr Harnisch drew attention to the special case of insecticide 'cocktails' such as are being used to control mixed populations of Prostephanus and Sitophilus in Tanzania. If marketed as a 'cocktail' the labelling should provide adequate information, including MRLs, for each component Reference was made to this question in the final paragraph of Mr Halliday's paper.

Mr J.G. Theissen (SPV Mission de Coopration) distributed copies of his report 'Control and Registration of Pesticides in Africa', describing the proposals discussed during a workshop 'Pesticide Regulation in French Speaking Africa' organised jointly by the French Ministry of Agriculture/CNEARC and the OAU Inter-African Phytosanitary Council and held in Yaounde in November 1987. The principles are based on the FAO

Guidelines/Code of Conduct, simplified in consultation with representatives of countries. GIFAP, which was represented at the Yaounde meeting, supports the FAO Code of Conduct and the need for regulation because it supports reputable manufacturers.

Dr B.R. Champ (ACIAR) referred to the fumigation 'code of practice' on which ACIAR has been working with countries in Southeast Asia. He said that countries are requesting labelling in local languages.

FAO had originally agreed to participate in the seminar with a contribution aiming to present a developing country-region perspective on the problem of pesticide residues, based upon the FAO Code of Conduct. In the event, it had not proven possible for FAO to send a representative.

The codex committee on pesticide residues

J. van der Kolk

Codex Committee on Pesticide
Residues

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The Codex Committee on Pesticide Residues (CCPR) is a committee that forms a subsidiary body to organisation of the Joint FAD/WHO Food Standards Programme, the Codex Alimentarius.

The Codex Alimentarius contains a series of standards for foodstuffs. All member-countries of FAO and WHO are invited to take part in the Codex Alimentarius Commission, which chairs the programme.

In the programme, a distinction is made between 'horizontal' standards - standards which apply to different groups of products, such as food additives, food hygiene, residues of veterinary drugs and of pesticides, end 'vertical' standards, which apply to a specific group of foods, such as cereals, cocoa products, fish, etc.

The Codex Committee on Pesticide Residues meets every year - under the Chairmanship of The Netherlands - and is attended by representatives from about 45 countries and of some 15 international organisations as observers. There is an important industry

delegation at the meetings.

By a system of priority-setting and with the help of an independent evaluation by the Joint FAO/WHO Meeting on Pesticide Residues of the pesticides on the agenda, the Committee elaborates standards for residues in foodstuffs, which are recommended to governments by the Codex Alimentarius Commission. The procedures for the CCPR and the Commission are clearly laid down in the Procedural Manual.

The CCPR is also involved in other aspects in relation to residues, including methods of analysis, methods of sampling, and specific problems of developing countries.

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Occurrence, sources and toxicological significance of pesticide residues in food grains

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Introduction

Potential hazards to consumers from contamination of food with pesticide residues is currently a major public concern in developed countries. This has led to pressure on governments to tighten legislation covering use of pesticides and increase the requirements for research data before particular uses for individual compounds can be allowed. This, in turn, has compelled manufacturers of pesticides to expand their testing programs for new products to meet the increased requirements for data from national registration authorities. The cost of introducing a new pesticide to the market has now risen to around US$100 million, because of these and other factors.

The impact of this ever-increasing demand for expanded testing programs on pesticide development costs, has sometimes led manufacturers to query the need for all the data

now required. This is a valid objection because ultimately the consumer has to meet the costs involved, through higher prices for food. If these data are not really necessary then this represents money being wasted! In fact, surveys of pesticide contamination of food in Western Europe, USA, Canada, Australia and New Zealand have revealed only low levels - well within the requirements of public safety (GIFAP 1984). This indicates that if pesticides are used properly, in accordance with 'Good Agricultural Practice', the consumer is not at risk. Unfortunately, this is not always the case in developing countries where use of pesticides is frequently poorly regulated - if at all.

Against this background it appears inevitable that the public will continue to view the presence of pesticide residues in food as a problem whatever the scientific facts. Food grains are of particular importance in this regard because they are consumed as major elements of national diets.

Potential sources and nature of pesticide residues In food grains

There are three potential sources of pesticide residues in food grains, arising from:

- application of pesticides to protect the growing crop;
- contamination of the environment by highly stable pesticides previously applied for other purposes; and
- application of insecticides to protect the harvested crop during storage and

handling.

Large quantities of herbicides, fungicides and insecticides are routinely applied to grain crops in more developed countries. However, provided they are used so that there is an adequate period between last application and harvest, it is unlikely that significant pesticide residues will be found in the crop. Pesticide registration authorities are very much aware of the need to ensure that excessive residues from preharvest application do not arise. For this, they require appropriate experimental data indicating the minimum period that can be allowed between last application and harvest - the withholding period. Pesticides are used much less to protect growing food grains in less developed countries, but the same principles apply!

Residues arising from environmental contamination are mostly due to widespread application of highly stable organochlorine insecticides, over some three decades prior to the 1980s to control migratory and agricultural pests, and insect vectors. Their use has now largely been phased out in developed countries and residues in the environment (e.g. soil and inland waters) are gradually declining, with consequent reductions in residues detected in food grains. However, organochlorines such as DDT and benzene hexachloride (HCH) are still used in large quantities in countries such as India and China, maintaining or possibly increasing the potential for environmental contamination of grains and other food crops. While it is unlikely that residues from this

source are likely to pose a serious hazard to consumers of food grains they could cause problems for exports to developed countries where stringent maximum residue limits for organochlorines are imposed.

The most likely source of significant levels of pesticide residues in food grains is postharvest application of contact insecticides and fumigants. Contact insecticides are applied at levels designed to protect the commodity from attack over as much of the storage period as possible, taking into regard the need to ensure that initial residues do not exceed the limit regarded as being the maximum for consumer safety. As the insecticide is gradually lost due to breakdown or volatilisation the residue remaining on the food grain at the end of the storage period is always substantially less than that originally applied. Clearly, only insecticides of low mammalian toxicity should be applied to food commodities during storage, so the list of compounds approved for this purpose is limited. Additionally, as the market for grain protectants is very small compared with the total market for insecticides, use is invariably made of compounds developed for general application that are later also found to be suitable as grain protectants. No insecticide has ever been developed specifically to protect stored grains!

Fumigants differ from contact insecticides because they come into contact with insects in the gaseous, rather than the solid or liquid phase. While they are sorbed onto commodities during the course of fumigations, most of the sorbed fumigant is lost

during subsequent aeration, unless there is some form of chemical reaction with components of the commodity. This is just as well, as most fumigants currently used to treat food grains have a high mammalian toxicity. Of the two fumigants currently mostly used to treat food grains, only methyl bromide reacts chemically with the commodity. This reaction results in fixed residues of inorganic bromide while residues of sorbed unreacted methyl bromide remain low, as do residues of phosphine, the other fumigant that is widely used.

Residues arising from postharvest treatment of food grains

Most significant pesticide residues detected in food grains arise from contact insecticides or fumigants, deliberately applied to protect the grain from postharvest insect attack. The range of compounds used for this purpose is not large: contact insecticides currently used are mostly either organophosphates of low acute mammalian toxicity, such as malathion, pirimiphos-methyl, fenitrothion and chlorpyrifosmethyl, or pyrethroids such as permethrin, deltamethrin and (in Australia) bioresmethrin. Organo-phosphates have been found to be effective against most of the beetles that commonly infest stored food grains except Rhyzopertha dominica and Prostephanus truncatus, for which treatment with pyrethroids is preferred. Treatment with a mixture of a pyrethroid and an organophosphate provides an effective way of protecting food grains against the complete range of insect pests.

Residues arising from fumigation are generally negligible when phosphine is used but can reach quite high levels in commodities that have been repeatedly fumigated with methyl bromide.

Contact insecticides may be applied to grains as sprays, mists, fogs or dusts. Spraying, misting or fogging of stores containing bag-stacked commodities is commonly used as a means of holding insect populations down to sub economic levels, or to minimise re-infestation after fumigation. Residues arising from such treatments generally have low overall significance and are confined to the peripheral layers of stacks. Significant residues are likely to be found only when insecticides are admixed with bulk grain or as they are loaded into silos, or farmers' stores. Application rates used for such treatments are determined by laboratory experiments to establish the minimum dose needed to control the target pests. The rate at which the insecticide subsequently breaks down is established and a figure is then set for the maximum residue of a particular compound that is likely to be found when the commodity is given the recommended treatment. This figure, called the maximum residue limit (MRL), is used by regulatory authorities as a guide as to whether the treatment has been properly carried out in accordance with good agricultural practice.

Most developed countries have established maximum residue limits for food grains and their processed products, in statutory schemes that control marketing and use of

pesticides. In addition, the Codex Alimentarius Commission of the FAO recommends maximum residue limits for commodities which move in international trade, in the hope that these MRLs will be accepted by national governments. Less developed countries which do not currently possess facilities to develop their own maximum residue limits often use those set by the Codex Commission as a basis for their own regulations. Current Codex recommendations for maximum residue limits of the more important grain protectants and fumigants on cereals and cereal products are given in Table 1. It should be noted that these include some proposals still to be adopted as full Codex maximum residue (FAO 1989).

Toxicological evaluation of pesticides

Pesticides must be subjected to two types of toxicological evaluation before they can be registered for particular uses. The first is a determination of acute toxicity to mammals by means of laboratory feeding trials. In these, single doses of the pesticide are fed to groups of animals and the dose required to kill 50% of the group is determined (as mg of pesticide per kg body weight). This is the LD50, which is used as an indication of likely acute toxicity to man. Pesticides with an LD50 less than 50 mg per kg may be regarded as highly toxic; those between 50 and 500 mg per kg as moderately toxic; and those with an LD50 of more than 500 slightly toxic. Table 2 gives the LD50 values for insecticides commonly used to protect food grains (British Crop Protection Council 1987). Most may

be regarded as only slightly acutely toxic to mammals while none is highly toxic.

There has been criticism of the continued use of the LD50 value as an index of acute toxicity as it depends on the experimental conditions and the way in which test material is fed to test animals (GIFAP 1988a). These uncertainties are reflected in the spread of values reported for some pesticides in Table 2. However, the LD50 continues to be widely used. Fumigants, which as respiratory poisons are not covered by the concept of the LD50, are always highly acutely toxic to all forms of animal life.

Except in very rare cases of accidental contamination of foods, possible chronic toxicity through ingestion of small quantities of pesticide over a long period is generally regarded as the major potential hazard to consumers of food grains treated with grain protectants insecticides. Assessment of potential chronic toxicity requires major investment in long-term studies with laboratory animals aimed especially at identifying possible carcinogenic, mutagenic or teratogenic potential. Such studies also may identify neurotoxic or reproductive effects. The amount of pesticide ingested daily over a long period which has no significant toxicological effect on test animals, is determined as the 'No Observed Adverse Effect Level' (NOAEL). The NOAEL is then used as a basis to calculate the acceptable daily intake (ADI) which is the amount of pesticide (as mg/kg body weight) that a healthy adult can consume daily over his, or her, complete life-span without any adverse effect to health. The ADI is normally calculated by applying a safety

factor of 100 to the NOAEL of the most sensitive species of animal used in the testing program. It is sometimes possible to use information obtained on the direct effect of pesticides on humans when calculating the ADI but, in general, it is based on the extrapolation of data from laboratory animals. Table 3 gives ADIs for insecticides commonly used to protect stored food grain (FAO 1989).

Table 1 Codex maximum residues limits for insecticidal protectants and fumigants in food grains and their processed products

Table 2 Acute mammalian toxicity of contact insecticides used as protectants for food grains

Oral LD50 (mg/kg body weight)					
	Rats	**Mice**	**Rabbits**	**Guinea pigs**	**Dogs**
Bloresmethrin	7070-8000a	-	-	-	-
Bromophos	3750-8000	3311-5900	720	-	-
Carbaryl	850b	-	-	-	-
Chlorgyrifos-	1630-2140	-	2000	2250	-
methyl					

Deltamethrin	135-5000	-	-	-	-
Dichlorvos	56-108	-	-	-	>300
Etrimfos	1800b	-	-	-	-
Fenitrothion	800a	-	-	-	-
Fenvalerate	451	-	-	-	-
Lindane	88-270	59-246	-	-	-
Malathion	2800	-	-	-	-
Methacrifos	678	-	-	-	-
Methoprene	>34600	-	-	-	5000-10000
Permethrin	430-4000	540-2690	-	-	-
Pirimiphos-methyl	2050a	1180	1150-2300	1000-2000	-
Pyrethrins	584-900	-	-	-	-
Piperonyl butoxide	7500	-	7500	-	-

a Female;
b male

Toxicological significance of maximum residue limits In relation to acceptable dally Intakes

Full Codex maximum residue limits are never assigned unless it has been possible to calculate an ADI for the pesticide concerned. However, the basis for estimating MRLs is unrelated to the toxicity of the pesticide. This has at times caused considerable problems for national governments which fear that acceptance of a Codex MRL may result in daily ingestion of residues at levels approaching or even exceeding the ADI. This was expressed in relation to residues on staple items of national diets such as food grains (and their processed products) and was based on the calculation of theoretical maximum daily intakes (TMDI) by multiplying maximum residue limits by estimated daily consumption of the commodity and its products.

This problem was reviewed by a joint FAD/WHO Consultation which developed guidelines for predicting dietary intake of pesticide residues arising from treatment of produce in accordance with good agricultural practice (WHO 1988). The consultation pointed out that it was inappropriate to predict daily intake of pesticides on the basis of the TMDI, and it was necessary to take into account a range of factors that diminish residues at the point of consumption.

Table 3 Acceptable Daily Intakes (ADis) of contact Insecticides used to protect food

grains

Insecticide	**mg/kg body weight**
Bloresmethrin	-*
Bromophos	0.04
Carbaryl	0.01
Chlorpyrifos - methyl	0.01
Deltamethrin	0.01
Dichlorvos	0.004
Etrimfos	0.003
Fenitrothion	0.003
Fenvelerate	0.02
Lindane	0.01
Malathion	0.02
Methacrifos	0.0003
Methoprene	0.1

Permethrin	0.05
Pirimiphos-methyl	0.01
Pyrethrins	0.04
Piperonyl butoxide	0.03

*** No ADI currently assigned.**

These include the following.

1. Only a proportion of daily consumption will be derived from treated grain
2. Only a small proportion of treated grain is likely to contain pesticide residues at the MRL
3. A proportion of the residue at time of application will dissipate during storage, transport, preparation, commercial processing, and cooking
4. Some of the residue may be discarded with inedible portions.

The consultation has suggested that an estimated maximum daily intake (EMDI) be calculated which takes factors 3 and 4 into account and provides a more realistic assessment of potential hazards to consumers. This may be further refined into an estimated daily intake (EDI) which also takes account of factors 1 and 2 together with

other factors affecting the amount of residue which may be consumed. Calculation of the EDI is only likely to be possible for countries possessing an adequate data base on the following factors:

- **food consumption including that of sub-groups;**
- **known uses of the pesticide concerned;**
- **known residue levels;**
- **percentage of commodity treated;**
- **homegrown/import ratio; and**
- **disappearance of pesticide residues during storage.**

It has been suggested that the TMDI be calculated in the first instance and that the EMDI should be calculated only if the TMDI is found to exceed the ADI. The much more onerous task of assessing the EDI would only be undertaken if the EMDI were also found to exceed the ADI.

So far, all these assessments of potential hazards to consumers have been for single pesticides. Concern has also been expressed about possible additive or interactive affects of pesticide combinations. This is of particular importance with regard to grain protectants, as combinations of pyrethroids and organophosphates are being used increasingly to provide protection for food grains. If data were to be required on the

long-term toxicity of such combinations it could cause problems for registrants, though there are suggestions that such data may be unnecessary (GIFAP 1988b).

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Use of grain protectant insecticides in developing countries

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During the late 1960s and early 1970s it became apparent that pesticide residues in agricultural produce were becoming a growing problem in developing countries. This was first recognised in industrialized countries where pesticide residue controls were enforced. As commodities imported from the tropics were also analysed and found to contain residues above the permitted national tolerance levels, many shipments were rejected.

This paper summarises some of the results from investigations on the degradation of insecticide deposits in stored grain, illustrating the main factors affecting residue formation in these commodities.

The climatic conditions surrounding stored grain are much more uniform than those to which field crops are exposed. For example, temperature and moisture content of stored grain are relatively stable, and stored grain is sheltered from wind, rain, and light Desmarchelier (1978) showed that the loss of fenitrothion from postharvest application to wheat, oats, paddy rice, and sorghum followed a second-order rate process. At fixed temperatures, the rate of loss is proportional to both the amount of fenitrothion applied and the grain water activity.

Similar results have been obtained with a wide range of other grain protectant insecticides. These findings agree with data obtained by extensive monitoring of field application of grain protectant insecticides. The rate at which insecticides break down on grain is independent of grain type and follows a first order reaction with respect to water activity (FAO 1982).

Thus, under conditions of constant temperature and grain water activity, it is possible to make a direct comparison of the half lives (the time required for an insecticide to degrade to half the original applied dose) of different insecticides (Table 1). This makes it possible to predict the fate of insecticides during storage.

Loss of insecticide can be predicted from the mean grain temperature and its water activity. So, in practice, application rates can be selected to ensure that grain will be

protected from insect attack over the full storage period - and ensure that residues at the end of this period will not exceed the internationally accepted limits.

After grain has been treated the insecticide may move from its covering (the husk in the case of paddy) or outer surface (the seed coat or bran layers), into its internal tissues (the germ and endosperm). The extent of movement ranges from complete retention at the surface of the grain to near equilibrium throughout the whole grain. However, most insecticides used as grain protectants do not move, to any great extent, into individual grains.

Table 1 Half - lives (in weeks) of grain protectant insecticides at 50% relative humudity, and 30 and 36C

Insecticide	Temperature	
	30C[a]	36C[b]
Bioresmethrin	38	25
Bromophos	-	34
Carbaryl	21	-
Chlorpyrifos - methyl	19	17

Deltamethrin	> 50	>50
Dichlorvos	2	-
Etrimphos	-	42
Fenitrothion	14	12
Fenvalerate	> 50	-
Heptenphos	-	2
Iodofenphos	-	46
Malathion	12	9
Methacrifos	8	6
Permethrin	> 50	-
Phenothrin	40	-
Pirimiphos - methyl	70	32
Pyrethrins	55	38

a FAO Plant Production and Protection Paper (1982)
b Wohlgemuth et al. (1987)

- = no information available

When grains are finally processed for human consumption (by removal of husk, bran, and germ during milling and by exposure to high temperatures during cooking) most residues are removed or destroyed. In the case of wheat and polished rice much of the residue is removed along with the bran and germ during milling (73X in the case of pirimiphos-methyl and 92X for fenitrothion). Similarly, when wheat flour is converted into wholemeal bread, losses of insecticide residues range from 46% in the case of phenothrin to 100% for bioresmethrin and methacriphos (FAO 1982).

Unfortunately, physical, mechanical, and operational difficulties make it impossible to apply grain protectants uniformly over grain. Grain segregation resulting from movement, blending, and transportation further increases the likelihood that any samples taken from discrete sections of a bulk of insecticide-treated grain will yield varying residue levels. FAO makes allowance for such variations when residue limits for grain are set. Usually a factor of about two is regarded as appropriate.

Therefore, even under extreme climatic conditions, grain protectants can be used safely, because their behaviour and the residues they form are predictable and can be controlled.

The problem of postharvest crop losses has arisen in developing countries largely

because they have been disregarded and underestimated. There is also a lack of know-how for developing potential storage protection measures. GTZ thus focuses its aid programmes in this field on the following topics.

To overcome the knowledge deficit, priority is given to training and advising agricultural extension workers, plant protection technicians, and officials from government and non-government organisations in all aspects of loss-minimising storage, adequate protection measures, and safe and efficient use of pesticides.

It is stressed that good storage practice combined with a high standard of hygiene are essential for effective application of grain protectant insecticides. Similarly, emphasis is placed on the requirement to apply insecticides in accordance with good agricultural practice. This means that staff using insecticides must be:

- **well trained;**
- **able to read and understand the information on labels, especially the hazard and first aid messages;**
- **understand the specific requirements for applying individual insecticides; and**
- **understand the 'withholding period' concept.**

Also, precaution has to be taken that no seeds dressed with pesticides are redistributed for consumption, which can lead to serious poisoning.

When pesticides are used, the quality of the product has to be monitored continuously. This is usually done by the respective national authorities. It is important to ensure that formulations and labels are accurate and in accordance with international standards. Particularly in hot climates, certain active ingredients can degrade very rapidly if they are stored improperly. There might also be incorrect labelling of the concentration of active ingredient or even indication of the wrong active ingredient.

Because local pesticide registration schemes in developing countries are often not sufficiently comprehensive, GTZ promotes implementation of the international 'Code of Conduct' through organisation of proper control systems based on legislation and pesticide registration. These involve biological efficacy tests, monitoring of pesticide residues, formulation control, and introduction and regulation of appropriate pesticide packaging and labelling.

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Pesticide legislation and regulations

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The harmonisation of legislation and regulations on pesticides is an objective found at various levels:

- **FAO international code and its guidelines for application;**
- **multilateral or bilateral cooperation projects;**

- **recommendations by donors, advisers, and industry; and**
- **the preoccupations of various regional organisations, the OAU's Inter-African Phytosanitary Council (IPC), the EEC, etc.**

The drafting of standard laws and regulations for countries in a continent such as Africa, with extremely diverse technical, economic, social, and political features, is impossible.

I shall describe here the technical points to be examined in laws and regulations in order to achieve a certain degree of harmonisation. The concepts and principles proposed concern the drawing up of a law on 'Pesticides' and its edict of application.

With regard to the practical aspects, I should like to stress two recommendations drawn up for francophone Africa at the seminar held in Yaounde in November 1987 (organised by France and the OAU's IPC, with assistance from the EEC). The recommendations concern:

- **the registration file; and**
- **the labelling scheme.**

1 The legal basis for 'registration and control of pesticides': technical aspects

The basic law drawn up by the legislature should specify the general line of conduct to

be followed with respect to pesticides. It is followed by an edict of application. The two documents make it possible for the executive (the ministries concerned) to promulgate the regulations, decrees, circulars, memoranda, etc. required for their practical application.

1.1 Contents of the bill

The text can be drawn up using four headings:

1.1.1 Generalities

These cover

- **The subject of law:**

'the putting into practice of the national policy on pesticides and particularly concerning the supervision of imports, sales, packaging, labelling, use, storage and disposal of out of date products, and manufacture, repackaging and transport.'

Products destined for export only and which have been prepared and packaged in conformity with the specifications and instructions of the purchaser do not fall within the scope of this legislation.

- **Definition of the key words used in the legislation and regulations:**

pesticides, plants, plant products, sales, harmful organisms, authorisation of experimentation, provisional sales authorisation, approval or registration, etc.

1.1.2 Management of pesticides

(Principles must be laid down by the law)

- **Any unauthorized, non-approved or noncertified pesticide is forbidden.**
- **Setting up of a body (generally a committee) for approval and registration and which will advise the minister concerned.**
- **Approval or registration procedure and determination of the possible stages:**
- **- refusal or postponement, authorization of experimentation;**
- **- provisional sales authorisation, approval or registration;**
- **- modification of prior authorisation; and**
- **- appeal procedure, with the setting of time limits.**
- **Consequences of chemical, biological or physical modifications or any change in use necessitating re-examination by the Committee,**
- **Regulations for various points: packaging, labelling, utilisation, experimentation, transport, storage and disposal of pesticides. It is planned that these would be covered by regulations (generally by decree),**

- **Advertising either forbidden for unauthorized products, or restricted to information contained in the authorisation or approval-registration and in conformity with the laws and regulations in force,**
- **Fees in payment for examination by the Committee and the attribution of these fees to the ministry concerned; the sum will be laid down by decree,**
- **Exceptions to approval provisions for research and experimentation requirements,**
- **Awarding of a licence to manufacturers, formulators, repackers and possibly approval of distributors,**
- **Register of pesticide management to be kept by the beneficiary of authorisations or approvals and which will enable subsequent verification,**
- **Diffusion of the conditions and methods of use of pesticides by the ministry entrusted with control**
- **Professional secrecy obligatory for persons with access to the files submitted to the Committee.**

1.1.3 Establishment of offences, penalties

The following points are defined under this heading:

- **the personnel entrusted with seeking and recording offences against the law and edicts of application,**

- **the conditions under which these personnel can exercise their task of verification, and giving them the possibility of:**
- **- confiscating products which are not in accordance with the law,**
- **- taking samples for verification purposes,**
- **- examining all licences, approval documents and registers,**
- **the sum and nature of the penalties to be applied in case of infringement of the law or the regulations,**
- **the possibility of settlement,**
- **the consequences of repetition of the offence.**

1.1.4 General provisions

These will make it possible:

- **to specify that statutory measures will be taken by the ministry concerned for application of the law,**
- **to repeal all previous conflicting provisions,**
- **to indicate that the- law will be published officially.**

1.2 Edict of application of the law

This is the first stage in the application of the law. The text defines the responsibilities

and missions of each of the partners of the state concerned by the law.

Part I: The Plant Protection Service

The articles under this heading will:

- **1. enable the Plant Protection Service (or similar), and other services which may be concerned, to be entrusted with the control of pesticides, and**
- **2. ensure that the Plant Protection Service has competent technical staff, land, laboratories and other installations for carrying out its job.**

This provision will make budget negotiations easier.

Part II: The Pesticides Committee

The heading will cover, in conformity with the law, the missions of the committee assisting the Minister, generally carrying out the following tasks:

1. proposal of principles and general guidelines for pesticide regulations,

2. examination of risks of toxicity for man, animals and the environment,

3. perhaps drafting of a list of products whose use in agriculture is forbidden or limited in the light of the risks in point 2,

4. proposal to the Minister concerned of all measures likely to contribute to the standardisation, definition and drawing up of the conditions and methods of use of the pesticides concerned by the law with respect to their biological effectiveness and their disadvantages of all kinds,

5. definition of methods of monitoring the composition, quality and evaluation of the products submitted for authorisation or approval,

6. examination of requests for authorisation and approval/registration for further action,

7. keeping of a public register of authorisations and approvals,

8. giving an opinion on requests for licences or approval planned by the law,

9. requesting, if necessary, expert appraisals by laboratories approved by the administration,

10. giving an opinion on all questions on pesticides submitted by the ministers

concerned and drawing up all recommendations within its scope concerning the products.

An article specifies that the composition of the Committee is fixed by interministerial order and that the committee may call upon outside experts.

Part III: Approval/Registration procedure

This part describes the practical procedure for approval and registration:

- **requests are forwarded to the committee,**
- **requests are presented in a prescribed manner:**
- **- a specific form,**
- **- summary of toxicological file and packaging specification,**
- **- effectiveness file,**
- **- specimen label**
- **- descriptive note on methods of analysis for monitoring the active ingredient,**

(The contents of the files are laid down by interministerial order.)

- **pesticide samples are to be provided to enable study of their physical, chemical and biological properties,**

- **the committee will examine the file and issue:**

  - an unfavourable opinion, or
  - notification of postponement for complementary studies and information, or
  - authorisation of experimentation or provisional sales authorisation or approval/registration. Notification may be accompanied by specific conditions.

- **duration of the validity of authorisations and approval/registration is laid down in the edict.**

The following durations are generally recommended for Africa:

- **authorisation of experimentation: 1 year, renewable,**
- **provisional sales authorisation: 4 years, renewable for 2 years,**
- **approval/registration: 10 years, renewable possibly once for a further 10-year period.**

Part IV: Obligations

These concern the beneficiary of the authorisations and of approval/registration (the

industry):

For authorisation of experimentation:

1. program of trials with supervision and control by the authorities,

2. the forbidding of all advertising,

3. labelling in conformity with the standard type laid down by order of the ministry concerned,

4. submission of a note for medical use on treatments in case of poisoning,

5. forbidding the use of the products harvested for human or animal consumption without permission.

For provisional sales authorisation and approval/ registration:

1. an undertaking to put on the market under the specified trade name only the substance defined by:

- **its trade name,**

- **the name of the holder of the trade name,**
- **the number of the authorisation or approval/registration issued by the Committee,**
- **the composition of the product, with specification of**

  - authorised use, doses and methods of application,
  - the precautions to be taken by users and the contraindications mentioned in the decision;

2. conformity labelling with the model laid down by the edict.

- **The procedure for removal from the market must be planned for products which have been withdrawn or for which renewal of authorisation or approval/ registration has been refused; this procedure depends on the reasons for such withdrawal or refusal.**

(Removal is generally carried out immediately in case of problem of public or veterinary health, of the environment or phytotoxicity; products are generally removed after two years if the reasons are different from those above.)

Part V: Establishment of offences, penalties

This lays down in particular that

- **the persons entrusted with control should be issued with a professional identity card,**
- **offences will be the subject of reports,**
- **a receipt will be given for samples taken,**
- **the offences concerning the provisions of the edict will be punished as provided for by the law.**

Part Vl: General provisions

It is laid down that orders may be issued as required in order to apply the edict and that the edict will be published officially.

2 Measures for practical application

These consist of a set of legal standards which complement the Law and the Edict putting it into application and enable the administration to lay down the technical rules required for approval/registration and for the control of pesticides.

The measures comprise orders, circulars, memoranda, models for forms and registers, etc.

Two points are examined more particularly here as they seem to us to be fundamental

for African countries which wish to set up legislation and regulations on pesticides.

The two points are taken from the recommendations drawn up by participants a the seminar on Control and Approval of Pesticides organised by France and the

OAU's Inter-African Phytosanitary Council (IPC). The recommendations concern:

- **the establishing of a registration file for francophone Africa,**
- **labelling, packaging and technical sheets for phytosanitary products.**

The texts of each of these recommendations, drawn up by our African colleagues in conformity with the corresponding FAO guidelines, are provided as annexes.

2.1 Registration file

The aim of this recommendation is to provide countries with full, accurate information on the 12 points mentioned without obliging the industry to provide the full studies carried out, which are generally extremely voluminous.

The complete studies must of course be available on request as soon as special interest in a specific point emerges.

These data will be completed by a biological effectiveness file on the product. No standard plan has been designed for this second file.

2.2 Labelling, packaging and the technical card

A desire for harmonisation guided the participants at the seminar during the drawing up of this recommendation, which has resulted in particular in the proposing of a standard label for francophone Africa.

Annex 1 Workshop 'control and registration of pesticides in french speaking Africa' Yalounde, November 1987

3RD RECOMMENDATION

INTRODUCTION OF A REGISTRATION DOSSIER IN AFRICAN COUNTRIES

The registration dossier should be composed of two separate dossiers:

- the first dossier is the actual registration dossier and should include all information on the identification and the physico chemical properties of the formulated product and

the active ingredient(s), the toxicology, the effects on the environment, on wildlife and flora, the residues, as well as all aspects relating to the safe use of the product

Since the study reports are very voluminous, we propose that they are not submitted in their entirety, but rather in the form of summaries, which will facilitate their understanding.

The full studies should however be made available on request, in case particular interest on a certain aspect would arise.

This registration dossier, in French and English in the case of bilingual countries, would be in the form of a questionnaire containing the main information on the formulated product and the active ingredient(s). The information on each point would be brief and the completed questionnaire would provide a good general appreciation of the product

A certain number of basic registration documents will be attached as enclosures. Summaries of the main studies would also be included.

- the second dossier includes everything related to the biological effect of the product efficacy, phytotoxicity, etc., and includes results of trials carried out locally and/or in countries with similar climatic and agronomic conditions.

The registration dossier is to be completed with a 'Registration Request' drawn up on a simple form covering the following items:

- Registration number and date
- Name and address of the petitioner
- Name and address of the formulator
- Name and address of the trade mark owner
- Trade name
- Uses (target pests, methods of application, dosage rates, contraindications).

Registration Dossier

1. Information on the physico-chemical properties of the formulated product

1.1 Trade name

1.2 Name of the product manufacturer

1.3 Type of formulation

1.4 Active ingredient(s) content (composition, cf. enclosure)

1.5 Analytical method and reference (details, cf. enclosure)

1.6 Physico-chemical characteristics depending on the type of formulation: appearance of the product, density (liquid products), bulk density (solid products), wettability (wettable powders), suspensibility (wettable powders and suspension concentrates), fineness of the particles (wettable powders, suspension concentrates, granules), emulsion stability (emulsifiable concentrates), viscosity (ULV formulations), flash point, pH in a 1% dilution (products to be diluted in water)

1.7 Storage conditions and shelf life

2. Information on the identity and the physico-chemical properties of the pure active ingredient(s)

2.1 Common
2.2 Chemical designation
2.3 Structural formula
2.4 Empirical formula
2.5 Molecular weight
2.6 Appearance
2.7 Density at 20C

2.8 Melting point/decomposition point/boiling point
2.9 Vapour pressure
2.10 Volatility
2.11 Hydrolysis
2.12 Solubility in water
2.13 Solubility in organic solvents
2.14 Partition coefficient between water and n-octanol
2.15 Absorption spectra (W. IR etc.)
2.16 Photolysis

3. Physico-chemical information on the technical active ingredient(s)

3.1 Appearance
3.2 Odour
3.3 Density
3.4 Minimal purity
3.5 Maximal content of by-products
3.6 Analytical method: (details, cf. enclosure)

4. Toxicity of the formulated product

4.1 Acute oral LD50 in the rat

4.2 Acute dermal LD50 in the rat
4.3 Acute inhalation LD50 in the rat
4.4 Skin irritation, rabbit
4.5 Eye irritation, rabbit
4.6 Toxicological classification according to FAO/WHO

5. Toxicity of the active ingredient(s) (summary, cf. enclosure)

5.1 Acute oral LD50 in the rat
5.2 Acute dermal LD50 in the rat
5.3 Acute inhalation LD50 in the rat
5.4 Skin irritation, rabbit
5.5 Eye irritation, rabbit
5.6 Sensitizing effects, guinea pig
5.7 Sub chronic toxicity
5.8 Chronic toxicity
5.9 Carcinogenicity
5.10 Mutagenicity
5.11 Teratogenicity
5.12 Effects on reproduction
5.13 Supplementary toxicological studies (neurotoxicity, potentiation,

accumulation, depending on the nature of the substance)
5.14 Metabolism in animals

6. Information on residues (summary, cf. enclosure)

6.1 Metabolism in plants
6.2 Behaviour of the residues in plant
6.3 Method of residue analysis (details, cf. enclosure)
6.4 Maximum residue limits (MRL)
6.5 Withholding period

7. Effects on wildlife (summary to be enclosed)

7.1 Toxicity to birds
7.2 Toxicity to fish
7.3 Toxicity to bees and other pollinating insects
7.4 Toxicity to other organisms, for instance beneficial insects

8. Behaviour in the environment (summary to be enclosed)

8.1 Degradation in the soil
8.2 Mobility in the soil

8.3 Absorption/desorption by the soil particles
8.4 Half-life in the soil
8.5 Behaviour in the water

9. Therapy and precautions.

9.1 Poisoning symptoms
9.2 First-aid measures
9.3 Antidote
9.4 Safety measures
9.5 Disposal of surplus pesticides and pesticide containers

10. Packaging profile

Size and type of packaging (details to be enclosed) and label draft

11. Registration status in other countries

Reference to the countries where the product has been registered, preferably EEC or OECD countries (copies of the registration certificates to be enclosed)

12. Biological dossier

separate dossier Date and signatures

ENCLOSURES

1. **Composition of the formulated product**
2. **Analytical method for the formulated product**
3. **Analytical method for the active ingredient(s)**
4. **Method of residue analysis**
5. **Absorption spectra, IR, UV etc**
6. **Toxicological evaluation of the active ingredient**
7. **Assessment on behaviour in the environment**
8. **Assessment on toxicity to wildlife**
9. **Assessment on the residue situation in the requested crops**
10. **Product data sheet (2-4 pages of general information on the product, particularly precautions for safe handling)**
11. **packaging specifications**
12. **Copies of registration certificates in other countries**

NB: Informations required in

- **French for French speaking countries**
- **French and English for bilingual countries**

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Annex 2 Workshop 'control and registration of pesticides in french speaking Africa' Yalounde, November 1987

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6TH RECOMMENDATION

LABELLING, PACKAGING AND TECHNICAL CARDS FOR PESTICIDES

Considering that labelling is the writing to medium including basic information clear and concise for a safe use of the product and with guarantee of efficiency during shelf life, it has been wished that the following directions should be mentioned by manufacturers, the setting in complement for a good understanding according to the context (translation into the local dialect, transposition in pictorial symbols more discernible ...)

1. Description of the contents

- **Trademark Name and active ingredient(s)**
- **Type of formulation**
- **Net content**

2. Information very visual of the risk by using a coloured strip at the bottom of the label:

- **red with 'skull and crossbones' symbol for 'very toxic' and 'toxic' products;**
- **yellow with 'dangerous' in black for harmful products.**

In addition, concise information for precautionary measures to handle and use products safely and first aid if necessary.

3. Information for a good use of the content:

How, when and where using the products on the crops, pests and stage of treatment to be specified.
Contraindication for use (e.g.: do not treat during blossoming time …)
Precise details about delay if necessary (last treatment before harvest).

4. Product manufacturer by (name and address) and site of manufacture (country).

Products delivered by (name and address if possible of the national distributor; if not, the regional one).

5. Information on the registration number, or references with regard to the country involved.

6. Physico-chemical incompatibilities, if known by the manufacturer.

7. Date of manufacture of formulation and information on the conditions of stability when storage in the Tropics.

It is essential that the label should stick completely to the packaging if possible waterproof and remain perfectly legible at anytime of use. The information on transport are on the overpackaging and big packaging according to the international symbol carried for air, sea, railway and land traffics.

Considering that packaging should keep its qualities during all the duration of storage, it has been recommended:

- the selected material should be completely suitable for the physico-technical properties of the content considering the local conditions of storage, in particular to avoid corrosing effect;

- if the content should be used in very low doses for liquids especially a measure cap should be an additional guarantee for a good dosage and safety of use;

- the unit volume of packaging should be, if possible, quibble for surface unit to treat, in order that all of the contents should be used once only;

- the overpackaging especially made of cardboard, should be the strongest possible to make easier transport and storage.

In relation to the empty packaging the study group is facing a practical dilemma: if it is necessary advisable not to use packaging again, in reality farmers are more and more disposed to use packaging again, in particular to make containers for food products. Most certainly, it could be a logical attitude to give more sensible advice for a better washing (before using) but if an incident occurs, the farmers might turn against the technical advisers, accusing them of inciting reutilization.

So it is necessary, obviously, to note a deadlock in this kind of situation. Each country has its own solution.

Considering that the information on the label cannot be detailed, there is reason for inciting manufacturers to produce a card or technical booklet from one to four pages

maximum, in addition of information on:

- **physico-chemical identity of active ingredient(s) and formulation;**
- **toxicological data;**
- **detailed informations for use;**
- **and precautionary measures including how to destroy empty packaging if directions known.**

Besides, the availability of specific informative cards for g.p., hospitals or antipoison institutes, giving posology in case of poisoning is recommended.

Yaounde, 20 November 1987
The Seminar

Label draft

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