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Julius-Kühn-Archiv

International European Symposium on Stored Product Protection „Stress on chemical products“

May 25-26, 2009
in Berlin

Julius Kühn-Institut
Bundesforschungsinstitut für Kulturpflanzen

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Vorwort/Preface

Petzold, Ralf

Bereits in der AGENDA 21 der Konferenz der Vereinten Nationen für Umwelt und Entwicklung im Juni 1992 in Rio de Janeiro wird auf den steigenden Nahrungsmittelbedarf der Weltbevölkerung hingewiesen. Eine Gegenüberstellung der FAO von Nachfrage und heutiger globaler Agrarproduktion hat zum Ergebnis, dass die Agrarproduktion die auf Grund der Änderung der Ernährungsgewohnheiten, der Urbanisation, des wirtschaftlichen Wachstums in Schwellenländern und der anwachsenden Bevölkerung in Entwicklungsländern steigende Nachfrage derzeit nicht kompensieren kann. Als Konsequenz wird die Verdoppelung der Nahrungsmittelerzeugung bis zum Jahr 2050 für erforderlich gehalten.

Die steigende Nachfrage wird einerseits zu einer gesteigerten Produktivität auf dem bestehenden Ackerland führen, da ansonsten große Naturflächen mit unverzichtbarer Umweltfunktion in landwirtschaftliche Kulturflächen umgewidmet werden müssten. Andererseits kommt dem Schutz der mit hoher Intensität erzeugten Agrargüter eine wachsende Bedeutung zu, da es eine Verschwendung natürlicher und menschlicher Ressourcen, aber auch von Wirtschaftsgütern bedeutet, wenn diese nach der Ernte nicht ausreichend geschützt und den Schadorganismen überlassen werden. Die Nachernteverluste werden derzeit auf 10 bis 25 % der Menge geschätzt. Neben der Menge spielt jedoch auch die Qualität eine entscheidende Rolle. Dies gilt sowohl im Hinblick auf die Versorgung der Bevölkerung mit qualitativ hochwertigen Nahrungsmitteln zu angemessenen Preisen als auch im Hinblick auf eine einwandfreie gesundheitliche Qualität und im Hinblick auf den Handel mit anderen Ländern, um die Ein- oder Verschleppung gefährlicher Schadorganismen zu verhindern.

Umso erstaunlicher ist der vergleichsweise geringe Stellenwert des Nachernte- und Vorratsschutzes in Politik und Forschung. Einer der maßgeblichen Gründe dafür ist sicherlich die Tatsache, dass in den entwickelten Ländern die Erzeugung einer ausreichenden Menge in der Regel kein Problem bietet und für den ausreichenden Schutz des Erntegutes wirksame Pflanzenschutzmittel zur Verfügung standen.

Dies hat sich jedoch grundlegend geändert. Mit dem Wegfall von Methylbromid und der EU weiten Überprüfung aller Pflanzenschutzmittelwirkstoffe anhand höherer Sicherheitsstandards für Mensch und Umwelt hat das Arsenal an wirksamen Bekämpfungsmöglichkeiten im Vorratsschutz drastische Einschränkungen erfahren.

Zwar ist die Forschung zur Entwicklung von Alternativen zwischenzeitlich nicht stehen geblieben und hat auch Erfolge aufzuweisen, dennoch zeigen die Diskussionen um einzelne, im Vorratsschutz standardmäßig verwandte Wirkstoffe mit welch gravierenden Auswirkungen der Wegfall bereits eines einzigen Wirkstoffs verbunden ist.

Vor diesem Hintergrund ist es mehr als dringlich, das Bewusstsein der Entscheidungsträger in Politik, Wirtschaft und Forschung auf die unabdingbare Notwendigkeit für den Erhalt eines nachhaltigen Vorratsschutzes zu sichern und die erforderlichen kurz- und mittelfristigen Maßnahmen aufzuzeigen.

Es ist sehr zu begrüßen, dass dieser Prozess vom Julius Kühn-Institut mit der Veranstaltung eines Internationalen Europäischen Symposiums on Stored Product Protection „Stress on chemical products“ unterstützend aufgegriffen wurde. Nunmehr gilt es, die zusammengetragen Fakten aufzubereiten und zu vermitteln. Die Zeit eilt!

Already the AGENDA 21 of the Conference of the United Nations for Environment and Development in June 1992 in Rio de Janeiro mentioned the increasing demand for food for the world population.

A comparison of the FAO between demand and present global agricultural production results in the conclusion that due to changes in the habits of nutrition, urbanization, economic growth in countries like China and India and the growing of the human population in developing countries agricultural production is unable to satisfy the growing demand.

Consequently, a doubling of the production of food until the year 2050 is judged to be necessary.

The increasing demand will on one side lead to increased productivity on the existing agricultural land, since otherwise a transformation of large natural areas with unrenouncable environmental function into cultural land had to take place.

On the other side gains the protection of agricultural products that have been produced with high intensity a growing importance, because it would be a waste of natural and human resources and of economic goods, if these products would not be sufficiently protected after harvest and offered to pest organisms.

- Losses after harvest are presently estimated to amount to 10-25%.
- Beside the amount also quality plays an important role.

This covers the supply of the population with food of high value at appropriate price and excellent aspects for the health of the consumer as well as trade with other countries to avoid import or export of dangerous pest organisms.

In this light, the relatively low recognition of post harvest and stored product protection in policy and research is astonishing.

One of the reasons for this lack of recognition is presumably the fact that in industrialised countries production of sufficient food of agricultural origin is not a problem and effective plant protection products have been available.

This has fundamentally changed!

The phase out of methyl bromide and the EU wide investigation of all active ingredients in plant protection products for higher safety standards for man and environment have caused a significant reduction of number of effective control measures for stored product protection.

Research for the development of alternatives has not stopped but has led to some solutions, nevertheless the discussions on single substances that have widely been used have revealed the heavy consequences of the phase out of one single active ingredient.

In this light, it is more than urgent to ensure the consciousness for indispensable necessity for the maintenance of sustainable stored product protection in decision makers in policy, economy and research and highlight the necessary short and long term measures to fulfil that goal.

It is very much welcomed that this process was encouraged and supported by the Federal Research Centre for Cultivated Plants (Julius Kühn-Institut) by holding an International European Symposium on Stored Product Protection “Stress on Chemical Products” in Berlin. Now, the presented and collected facts have to be worked out and transported.

Time is scarce!

Prolog

As pointed out by Dr. Petzold, former Ministerialrat of the German Federal Ministry for Food, Agriculture and Consumer Protection, it can hardly be understood how little impact the envisageable worldwide shortage in food on the governmental support of research and development in Europe has. This symposium faced the task, after a preliminary meeting in the Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection of the Federal Research Centre for Cultivated Plants in 2008 on this subject, to draw the attention on one side on the lack of consciousness on the related deficits and on the other side on the actual state of the art and available approaches and methods to overcome the indicated shortages.

In brief, the symposium with its presentations and proceedings high-lights the biological, physical and chemical tools for modern integrated stored product protection, trying to avoid the use of chemicals when possible and feasible. Together with descriptions of building design of storages, logistics and storage technique the symposium covers the important elements and includes the constraints that are presented by national and European administration and legislation.

It was foreseeable that in the short period of two half days, not all the facets of stored product protection could be implemented. Many presentations drew attention to the two four yearly hold conferences on Stored Product Protection (IWCSPP) and on Controlled Atmospheres and Fumigation (CAF) that have helped to describe all the expert information of the field in the numerous proceedings. So, this symposium offers the opportunity to judge from the European angle the difficulties of sustainable stored product protection methods without further strong involvement of national research and development.

01 - Health risks and safety hazards related to insects and mites in stored products

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Abstract

In 2008, a publication appeared describing the health risks related to the presence of (insects, mites, fungi, rodents and birds as pest organisms in stored products. For each organism the publication listed the main species, current pest management procedures, and current control methods. The main part of each section dealt with health hazards of each organism and risk assessment of these hazards adding key actions for the future.

For all of the organisms their mere presence in the product represents a contamination and as such is unacceptable. Infestation by insects or mites can adversely affect humans and livestock and thus become a health risk by ingestion of insects or mites - rarely a real threat except at high pest densities – or by induction of allergy, which may develop after previous exposure of humans to the organism, fragments of it or to its excrements. This may be the case for insects. Especially for mites, this risk is considered to be relatively high due to the small size, ubiquitous presence of storage mites and cross reactivity between their allergens and those from house dust mites. Health risks originating from storage mites have been underestimated. It is recommended that action is taken to elucidate the role of both storage mites and insects in development of allergic reactions. Other health risks stem from pesticides applied to the products to control insects.

Introduction

In 2008, a publication appeared describing the health risks related to the presence of pest organisms (insects, mites, fungi, rodents and birds) in stored products (Reichmuth et al. 2008). It was the result of a collaboration between European experts in each their field.

For each organism the publication lists the main species, current pest management procedures, and current control methods. For all of the organisms their mere presence in the product represents a contamination and as such is unacceptable. The main part of each section deals with the health hazards each organism represents. The health hazards were identified and grouped into direct health hazards, indirect health hazards and health hazards related to control measures. Finally an assessment of the risk level found for each of these hazards was made. Recommended key actions for the future are then given. An extensive literature list is given for each type of organism.

Infestation by both insects or mites can adversely affect humans and livestock and thus become a heath risk. The following presents an overview of the findings concerning these two groups of organisms: insects (Hansen, 2008), and mites (Wildey & Hansen, 2008), both of which are common as pests in stored products. Details can be found in the publication.

Tabelle Insects

Hazard type	Specification		Risk level
Direct health hazards	Ingestion of whole insects or fragments	Rare cases of clinical illness (Dermestidae, Calliphoridae)	Low, due to low pest densities
	Allergenicity	Inhalant allergy following occupational exposure	High for relevant occupations
		Inhalant and ingestive allergy for general public	Unknown. Contaminated food may be an underestimated source of allergens
Indirect health hazards	Pathogen transmission	Transmission of mycotoxin-producing fungi	Low, due to low pest densities
		Transfer of pathogens	Low, due to low pest densities
	Toxic effects	Carcinogenic excretory products from Tenebrionidae	Low, due to low pest densities

Hazard type	Specification		Risk level
Health hazard from control measures	Pesticide residues	Effect of exposure to low levels in basic food stuffs	Authorities determine MRLs, below which hazards are estimated to be small
	Toxic fumigants	Accidental poisoning	Low, if safety procedures are followed

For insects the following key actions were identified: Allergy is a result of previous exposure to low levels of allergens. Thorough studies must be conducted to elucidate the relationship between insect contamination in food and subsequent allergic reactions in humans.

It is imperative that pest densities are maintained low, and the methods and technology necessary to prevent pest development are available. However, transfer of knowledge to the primary producers should be improved to ensure production of stored products without insect contamination.

It is evident that the risks stemming from insect infestation in stored products are low, due to general low pest densities found in European stores. However, as discussed at the symposium, new developments in the EU policies concerning pesticide registration for this sector, and the development of resistance to insecticides in insect populations are changing this situation. Thus, health hazards from insects in stored products may increase.

Tabelle Mites

Hazard type	Specification	Risk level	
Direct health hazards	Allergenicity	Inhalant allergy following occupational exposure	High for relevant occupations
		Inhalant and ingestive allergy for general public	High
Indirect health hazards	Pathogen transmission	Transfer of pathogens (E. coli O157, prions?)	Unknown (low?)

In the light of the severe consequences that mite allergies may have on human health (asthma, anaphylaxis) it is important that (key actions identified)

the frequency and level of mite contamination in stored products is monitored, edical studies are carried to elucidate the level of allergenic reaction to different degrees of exposure to mites in food, a “no effect” level for mites in foodstuffs is established, the risk of mites as vectors of high risk pathogens is reviewed.

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02 - Pest Control and Constraints in Flour mills

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Abstract

Food factories and especially flour mills are object of severe infestations of pest insects. Mediterranean flour moth Ephestia kuehniella and confused flour beetle *Tribolium confusum* belong to the prevailing pests causing expensive precautions and control measures to avoid complaints of customers. The occurrence of pest insects is not in

accordance with food laws and the expectations of buyers of food. Therefore, the biology and behaviour of these pests, the weaknesses of the construction of the premises as breeding place for the pests, the logistic of the flow of product through the machines and the factory have to be understood in the light of pest management. Despite early warning systems and monitoring, inspection of the incoming raw products for possible infestation and many precautions still infestation regularly and often occurs. The choice of possible control procedures is fairly limited. The few remaining contact insecticides lack thorough penetration into infested cracks and crevices let alone the aspect of resistance of pests toward these chemicals. The loss of methyl bromide as quick acting fumigant for thorough pest control of all stages of pests in 2005 opened a chance for sulfuryl fluoride (SF) as alternative fumigant and application of heat in certain circumstances. Also intensive sanitation and partial use of biological antagonists gained its place in the integrated pest management system. The promising use of SF as one to one replacement of methyl bromide found its limitations in the higher cost of the treatment since slightly higher amounts of gas have to be used to be effective possible together with increasing the temperature within the mill to ensure high percentage of mortality. Recently, the maximum residue value for fluorine in treated commodities was reduced in Europe down to 2 mg/kg. This concerns the treatments of large flour mill buildings with in house flour bins that can hardly all be emptied for the fumigation or sufficiently sealed towards the rest of the mill structure. The impact of the high value of the global warming potential (GWP) of SF in comparison with carbon dioxide (higher than factor 1000) is still under consideration.

Heating of all infested parts and machinery and hiding places of pest insects in walls, ceilings and floors sounds easier than it may be in practice. The laws of physics apply and require partially huge amounts of energy to elevate the temperature of concrete, insulating material or other infested parts of the construction to lethal values.

Flour mills and also some other food processing factories offer attractive conditions for surviving for a group of animals like insects, mites, rodents and birds. This group belongs to typical stored product pests. They accompany man since he started after daily hunting and looking for food to store harvested products for a while to become independent from this daily effort some thousand years ago (Reichmuth 2009). These animals are adjusted to live on fairly dry food and get their necessary water supply either outside the premises (rodents and birds) or by chemically cracking the starch into water and carbon dioxide. Together with shelter against uncomfortable weather, elevated temperature due to the electrical machineries and the milling process and plenty of hiding places behind machinery, flour mills are target of pest infestation. Simply, these factories are paradise for certain pests. The preparation of food on the other side does not allow any living or even dead animals that may end up partially in the packages. Therefore, pest management is a very severe issue and requires plenty of dedication in this branch of industry.

What kind of constraints limits pest control in Flour mills?

<u>Legal Constraints (Food Law, PP Law, Biocidal Law)</u>: Flour mills are legally situated on the edge between regulations derived from the Plant Protection Law (PPL), the Biocidal Law (BL), the Food Law, the Hygiene Law and many others (Kroos 2009). Concerning pest control, the PPL and the BL are of paramount importance. The miller or pest controller has to follow stiff rules when trying to keep pests out or control them after infestation. Health and safety aspects for the workers and bystanders and side effects towards the environment have directly or indirectly reduced the number of chemical products dramatically. Hansen (these proceedings) reports on this issue. The development of a new suitable compound is with more than 100 million € extremely expensive and has to meet various requirements by various laws and authorities involved in the process. On the other side, this effort is in the interest of the European consumer (Reinhard, these proceedings).

In the case of destruction of the plant products by frass - as with pests like weevils, beetles or moths -, still plant protection regulations determine the choice of chemicals to be applicable. In food storages on the other hand, always regulations of the BL must be applied. Interestingly, the definition of food varies from law to law. EU Directive 178/2002 considers all produce from the primary production (for instance grain prior to harvest) already as food if the purpose of production is the later use as food (food grain). On the contrary, the PPL considers agricultural raw products not as food. Only if these products have been processed not by simple steps like pressing or milling but more complicated techniques like baking or mixing with other products, the end products – especially when packed as consumer package - are no more objects of the PPL but the BL. Flour in flour mills as well as the infested flour mills themselves are therefore in Germany regulated under the PPL. Some other European countries rank this differently. If cockroaches, flies, and rats are the target pests for control, that are supposed to act as vectors for microbial diseases, generally the BL or even the law against infectious diseases apply and those chemical products that are registered accordingly must be used only. In most European countries these three laws require different kinds of data packages before a registration for use of a chemical will be authorised. So, for the applicants, companies that want to earn money with selling of registered chemicals for pest control, the legal and financial situation is a severe constraint to develop effective, safe and economically feasible compounds. Bearing in mind the cost of a disinfestation it can be calculated how long it may take to gain the investment back.

Economic Constraints (price of flour, price of sanitation, plant protection products): The margin between the price for the grain to be milled and the price of the flour as end product determines the availability of investment including that for measures for pest management. As Schaub (these proceedings) points out, the price of pest management (PM) is part of the price of the final food product. The consumer must be aware that a high quality food product requires more and more investment also on the side of PM. This has to include also the aspect of sustainable use of chemical products for pest control that will consequently reduce the number of suitable chemicals and possibly lead to increased usage of appropriate physical and biological measures as well as better prevention of pest infestation. The consumer determines in the end what kind of PM will be used.

Technical Constraints (logistics, grain import, flour export): Still in the financial area, also aspects of storage, import and export of goods determine the feasibility of running a flour mill including application of PM. Grain is imported from all over the world and contains to an extend living pests. Due to climatic change, it can be expected that more tropical pests will be imported. In the future, following the concept of increased prevention, the grain trade has to be observed more carefully to avoid importation of pests. On the other side, due to global markets it may increasingly happen that flour is imported. In this context, costs for PM may contribute to the competitiveness of European flour comparing with prices in Asia or elsewhere. Transport prices may on the other hand increase and help to keep European flour competitive.

Scientific (biological, physical, chemical): The appropriate use especially of alternative measures for PM like physical or biological control is based on sound knowledge of the pest and the physical background of a building. This complexity can normally only be handled by professional biologists and engineers. The tendency is obvious, to spare money at this educational end and try to avoid high costs for academic personnel. The alternative approaches suffer to an extent from being inappropriately applied and are therefore considered to be ineffective. So, it is very important that professional academics are involved into the development and application of PM.

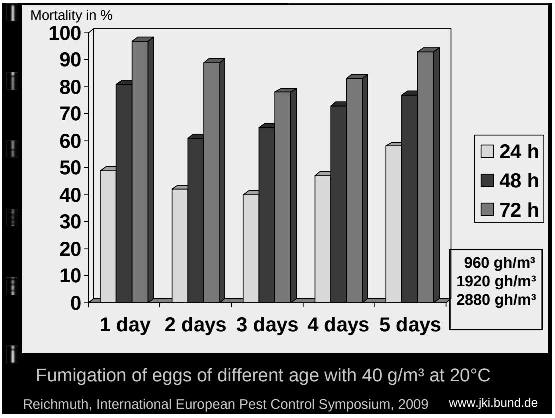
Pest organisms (microbes, insects, moisture): As pointed out, arthropods and some vertebrates form the most prominent group of pests in flour mills. Additionally, also fungi may play an underestimated role (Reichmuth CoE). The mass growth of fungi and even more important the formation of mycotoxins is considered to present a severe risk for the human health. Good storage practice of grain and other products would aim at relative humidities of less than 65% in stores. In some regions of the world this is not feasible in others it is not performed strictly enough. Due to the pronounced stability of the poisonous metabolites of moulds, it happens that toxins like ochratoxin and aflatoxin end up in food. Also insects, mites, rodents and birds play a significant role in this context (Hansen and Hamel, these proceedings, CoE). A thorough knowledge of the various pest organisms that may occur in flour mills or in storage of the raw products is absolutely necessary to overcome the constraint posed by these organisms.

Why are Flour mills so difficult to keep them free of pests? Additionally to the above mentioned aspects, these factories differ very much in size (less than 5000 to more than 200,000 m³), construction (wood, concrete, bricks, metal), function (production of flour, semolina, pasta, baking mixture etc.), various machinery, various materials (wooden furniture, plastic floors, insulation material, packed food etc.). Therefore, pests find various opportunities for shelter, food and hiding palaces.

Where do the pests come from? Logically, pest insects and mites are either imported continuously with infested grain or other raw products, package material (also rodents!) or all of the pests may invade via windows, doors, roofs, machinery or other openings into the buildings. Birds and some insects simply fly in.

Constraints linked to insufficient pest control: As an example for risks of surviving pests after inappropriate application of PM sublethal heat treatment and SF fumigation can be mentioned. Also, the occurrence of phosphine resistance (Reference) falls into this category.

The eggs of insects have been proven to be especially tolerant versus treatment with sulfuryl fluoride (Bell, Reichmuth). In intensive experiments with caged eggs of different age at 20°C it was shown, that fumigation with 40g/m³ over 1, 2, and 3 days, respectively, did not control all tested eggs of different age between 1 and 5 days. 3 days old eggs seemed to possess the greatest tolerance in these experiments with three replicates with about 500 eggs each. From the presented figures it seems obvious that the recommended dosage of 1500 gh/m³ is not sufficient to obtain a sufficiently lethal effect against the eggs of this species. A recommendation to obligatorily increase the temperature when treating against eggs of this species with SF with 1500 gh/m³ seems to offer one way to overcome this constraint or to apply more than one fumigation within a predetermined time period to control the surviving eggs after they have emerged and developed into more susceptible stages (Reichmuth, Binker).



As shown for SF and insect eggs, it is absolutely necessary to include sufficient data into any control program that is prepared for pest control in a given practical situation. If a too low lethal effect is envisaged in the first place, later complaints will most likely arise. Registrants and registration offices are encouraged to list dosages and all the pest organisms that have been investigated to exclude later disputes. The problem of protection against other registrants has to be addressed

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03 - Stored product protection in grain storage with special regard to phosphine fumigation

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Abstract

In Germany stored product protection belongs until now to the legislation field of plant protection. All stored product protection products used for controlling insect- and other pests require a legal approval of the plant protection authority. Roughly, the pesticides for stored product protection in grain storage can be divided into three groups:

- contact insecticides (spraying, fogging, powdering insecticides)
- fumigants
- rodenticides

In the last decade, the decrease of available active ingredients and compounds for stored product protection is quite obvious. Especially in grain storage more and more problems arise due to phase out and disappearance of these products. Several issues like ineffective control of pests or insect resistance against few remaining compounds contribute to the pressure in this context especially for the grain storage industry and difficulties in controlling pests. An update of all products and active ingredients that have an approval in 2009 are presented.

During the last few years considerable changes have taken place in stored product protection throughout Europe. Well-proven active ingredients disappear one by one because they do not meet the new legal requirements set up by the European Union. The situation in stored product protection as it presents itself for grain storage in Germany will be set out below.

According to German law stored product protection is part of the sector plant protection. Products used for the control of stored product pests are permitted and registered under plant protection regulations. The products used for storage protection in Germany can be roughly divided up into three groups:

- contact insecticides (sprays, fogging preparations, powders)
- fumigants
- rodenticides.

When comparing the present situation for the entire field of stored product protection regarding the number of registered active ingredients with that of the year 2000 we find that nine years ago there were 6 active ingredients for contact insecticides as to 4 today. For fumigants 5 are left against the 7 in previous years and for rodenticides the ratio is 4 to 10. The amount of registered products on the market today is as follows: while in 2000 there were 20 contact insecticides, 25 fumigants and 65 rodenticides the numbers in 2009 are only 6, 18 and 10 respectively.

As regards rodenticides the significantly reduced amount of active ingredients and preparations is due to the fact that this section will gradually be placed under a different branch of law. Therefore less and less registrations for stored product protection will be sought under plant protection legislation. The products are now generally considered preparations for the control of hygiene pests and therefore placed under biocidal legislation and are thus still available for stored product protection.

In the field of contact insecticides and fumigants the drop in the number of registered active ingredients and all its unpleasant consequences becomes plainly perceptible. When viewing the situation in grain storage with regard to the preparations still available for stored product protection the result is as follows. For contact insecticides only diatomaceous earth, pyrethrins and pirimyphos-methyl remain, and for fumigants hydrogen phosphide, carbon dioxide and sulfuryl difluoride.

Insecticides with the active ingredients dichlorvos and phoxim and fumigants with bromomethane, hydrogen cyanide, carbon dioxide and nitrogen disappeared since 2000.

Since diatomaceous earth, carbon dioxide and sulfuryl difluoride can for various reasons only be used for special fields of application the result is that for the control of storage pests in grain only one active ingredient for a fumigant (hydrogen phosphide) remains, also one only for fogging preparations (pyrethrin – generally for the control of storage moths) and pirimyphos-methyl as a spray.

What are the consequences of this shortage of active ingredients and preparations? Apart from the problem that efficient products for the control of a number of pests are lacking it often leads to misuse of the preparations still available. To fill the gaps of missing substances those available are often used for applications for which they are not approved so that neither efficacy nor the residue question are verified.

Due to the shortage of active ingredients available a change is also not given. Therefore the danger of resistance development is greatly increased and even more so by the already mentioned incorrect use and misuse of the products available.

A further negative aspect of the shortage of active ingredients is that heavier infestation and thus increased contamination of foodstuffs must be expected due to the unavailability of sufficient preventive control measures. Furthermore, there is the risk of a rise of chemical residues in the stored goods due to too frequent application of available preparations or the use of forbidden products because the number of effective and registered preparations is so limited.

The examples below show the consequences of the loss of the active ingredient dichlorvos in grain storage with a view to the resulting “gaps in control measures”, “misapplication of available products”, “danger of resistance building”, and “contamination of foodstuffs”:

<u>Gaps in control measures</u>: Up to 2008 dichlorvos preparations were successfully used as evaporators for the prevention of moth infestations and as a fogging preparation against storage moths. After removal of this active ingredient an evaporation product is no longer available which means that there is no possibility of combating the infiltration of moths with any suitable preparation. Only products based on pyrethrin are still available whose efficacy is often inadequate for heavy infestations.

<u>Misapplication of available products</u>: Due to the lack of alternatives the air space above the stored grain is often fumigated with hydrogen phosphide in low dosages without any sealing measures in order to kill the moths flying around there. Apart from health and safety concerns during such an un-workmanlike use of the gas there exists the additional danger of increased resistance-building in the pests. The low gas concentrations are generally not enough to kill all existing development stages so that there is always the possibility of survivors of these non-lethal gas concentrations.

Danger of resistance building: As outlined above resistance building can be fostered by misapplication on the one hand, on the other hand the small number of active ingredients available presents a problem in itself. Since no possibility of a change of active ingredient exists a preventive resistance management cannot be effected.

Contamination of foodstuffs: Due to the lack of effective control possibilities heavier moth infiltration often results in excessive contamination of the grain with insects and their residues (bodies, cocoons, excreta etc.). And as mentioned above these misapplications of stored product protection preparations carry the risk of substantial residues in the grain.

When considering these facts the question arises whether the reduction in the number of active ingredients for plant protection preparations does not achieve the opposite of what is intended. It should be considered whether the current problem does not stand in contrast with the ever stricter foodstuff regulations on the European level.

What possibilities remain for successful stored product protection in the future? Preventive measures like prophylactic hygiene, monitoring or biological pest control are instruments at whose research and promotion should be worked with full force. But despite all efforts in these areas an effective stored product protection as we demand it can hardly become possible without efficient preparations.

A further problem must be pointed out which may possibly contribute to the decrease of the amount of preparations for stored product protection. In Germany stored product protection will in future be placed somewhere between plant protection and biocidal legislation as regards approval and registration. Although originally entirely falling under plant protection, the control of pests in stored unprocessed agricultural commodities but also goods following simple processing (e.g. flour in a mill) will then be under plant protection legislation while the control of the same organisms in foodstuffs and animal feeds will be handled under biocidal law. Small wonder that some border areas arise here causing a lot of ambiguity. For instance, will grain used as animal feed be handled according to biocidal legislation and has to be treated with a biocide or is it an unprocessed agricultural commodity to be treated with a plant protection preparation? When is a rat a storage pest (plant protection), when is it a hygiene problem (biocide)? Is flour in the mill a basically processed agricultural commodity falling under plant protection legislation or is it a foodstuff and has to be treated with biocides in the case of infestation? Is muesli with oats, nuts and raisins still an agricultural commodity (plant protection) or is it a processed food (biocide)?

These examples demonstrate what kind of difficulties may arise. To ensure that the application of a preparation is legally safe registrations for both plant protection preparations and biocide products must be available for the same product in the same commodity. Below the example of the application of hydrogen phosphide in grain: the substance must be registered as a plant protection product for stored product protection as well as a biocide in the product groups “insecticide” and “protection for foodstuffs and animal feeds”. Because of the high costs of such double registration many companies will have to consider whether it will be economically reasonable to pursue the defense of active ingredients and further product registrations in all areas respectively.

Conclusively a proposition which may be worthy of some discussion: Would it not make sense to implement a clear division and to integrate stored product protection entirely into biocidal law? Harvest time may be the right moment to draw the separation line. In simple words: “before harvest is plant protection and after harvest the goods are protected under biocidal law”.

04 - Adoption of sulfuryl fluoride for the control of stored product insects in Europe and future development

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Abstract

The strong commitment to protect the ozone layer by European governments has resulted in the complete phase out of methyl bromide (MB) use in the flour mills and food processing plants. Following the phase out the industry has successfully adapted, maintained its production capacity, hygiene standards and economic viability. This has been achieved through increased focus on sanitation and utilizing alternatives control procedures such as fumigation with sulfuryl fluoride (SF) with the tradename ProFume containing 99.8%. The fumigation is frequently accompanied by additional heating. Recent research on stored product pest insects in treated flour mills confirmed long lasting control effects 8 to 12 weeks after the fumigation. ProFume gas fumigant is now established as an alternative fumigant to MB. It has been granted registration for the control of SPIs in structures in ten European countries. Since its first approval in 2003, the number of ProFume fumigations has increased each year. In 2008, over 200 fumigations were completed in Europe and due to performance satisfaction, the growth trend is expected to

continue. A range of structures have been fumigated, some exceeding 60,000 m3 for flour mills and 100,000 m3 for food processing plants. Dow AgroSciences is continuing to invest in supporting SF to meet future regulatory requirements. In addition, label extensions are being developed on dried fruits and tree nuts, cocoa beans and quarantine pests. The original use of SF on wood boring insects is also supported and is now listed in Annex I of Biocide Directive 98/8 EC for product type 8.

Introduction

Control of stored product insects (SPIs) is a key element to keep the high level of hygiene standards required in the milling and food processing industries. Fumigation with Methyl bromide (MB) was widely used historically in Europe for disinfestation, but over the past five years, major changes in pest management practices have occurred. This paper provides an update on the evolution of practices in insect control , current status of the replacement fumigant ProFume® (99.8% sulfuryl fluoride) in terms of its market adoption, registration, practical performance and environmental fate.

Evolution of insect control in milling and food industry with the phase out of Methyl bromide in Europe: Following Montreal Protocol implementation, MB volumes used in the milling and food industry have declined in Europe from an estimate of 640.000 tons in 1991 to zero in 2008. Despite this dramatic reduction in MB, the European industry has been able to maintain its hygiene standard and economical viability by implementing several alternative control methods. Increased sanitation has been implemented through more effective practices, reducing access of insects in plants and increased control of raw materials. In addition, use of targeted curative methods has been implemented like heat treatment, application of contact insecticide in fogging and fumigation with ProFume. Since ProFume was approved in the countries that requested Critical Use Exemptions (CUEs) for their milling industry in 2005 (UK, Italy, Belgium, France, Germany, Ireland, Greece), it has contributed to the decrease and final end of CUE's and helped EU governments reach their Montreal protocol goals. This fumigant does not contribute to ozone depletion and its contribution as an alternative to MB was recognized in 2007 with the United Nation's Montreal Protocol Innovators award presented to Dow AgroSciences LLC.

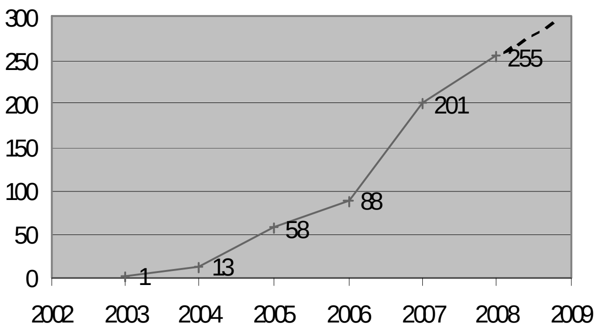

Fig. 1 number of structures fumigated in Europe with ProFume since 2002 (Source ProFume distributors)

The first European registration of ProFume and commercial mill fumigation took place in Switzerland in 2003.Additonal registrations followed, from 2004 through 2008, in Germany, Italy, UK, France, Belgium, Austria, Ireland, Spain and Greece. The number of mills and food processing structures annually fumigated with ProFume in Europe has grown as new registrations have been achieved and in 2008, 255 structures were treated (Figure 1). Fumigated structures varied in age, construction material and size, from village mills to large industrial mills of 100.000 m3, and pasta plants of up to 140.000 m3. A high level of satisfaction was reported by millers and food processing managers following fumigation with ProFume of structures of all types.

Studies on SPIs populations following ProFume fumigation and heat: Monitoring stored product insects (SPIs) populations within flour mills or food processing establishments is a valuable procedure for determining the location of infestations and population dynamics. Regular monitoring, record keeping and correct species identification can determine if a population is increasing or decreasing and is of economic significance. In addition monitoring SPIs improves the precision of the timing of treatments and the evaluation of their effectiveness.

ProFume fumigation and heat treatment are in commercial use for the disinfestation of SPIs in structures in the food industry. Each method has been considered as a valuable SPI management 'tool' for inclusion in integrated pest management (IPM) strategies to replace MB (Drinkall, 2007). The impact of ProFume compared with heat treatment on SPI populations has been compared in commercial flour mills in Germany (Mück and Böye, 2007) and in the UK (Small, 2008) by trapping insects before and after treatment. In both countries one mill was treated with ProFume and one with heat treatment (Table 1). The target insect species for capture in the studies were the stored product beetles *Tribolium castaneum* (Herbst) and *T. confusum* (Jacquelin du Val) [Germany and UK] and moths *Plodia interpunctella* (Hübner), *Ephestia elutella* (Hübner) [Germany] and *E. kuehniella* [UK].

Tab. 1 Building and treatment details of studies comparing ProFume and Heat

Mill	Treat-ment	Construction material	Volume (m3)	Date of treatment	Dosage (CTP in g-h/m3)	Temp. (°C)	Exposure time (h)
Mill A (Germany)	ProFume	Brick and ferroconcrete	23000	31/08/07-02/09/07	1013	21	50
Mill B (Germany)	heat	Brick /concrete+wood	40000	2-4/11-07	-	>50	24
Mill A (UK)	ProFume	Brick	15455	27-28/05/06	271-755	35-40	48
Mill B (UK)	heat	Brick-Timber	10947	9-11/06/06	-	>50	24

The German study concluded that both ProFume and the heat treatment were effective at controlling SPIs under commercial conditions and that they were valid replacements for MB but the rebound of insect population to pre-treatment was faster with heat (Table 2). These results were achieved in mill buildings which were of 25-150 years old and provided a vigorous test for both technologies.

These results were in contrast to those reported in the UK. In this study based on insect trapping data ProFume achieved good efficacy of SPIs but control with heat was very variable. The explanation for reduced efficacy was considered as being due to uneven temperature distribution within and among floors during the heating process leading to some insect survival.

Tab.2: date of monitoring and insect population in Mill A and B in Germany (in bold: monitoring immediately following the treatment, in grey: post-treatment insect population significantly below prefumigation level)

Mill A (ProFume)		Mill B (Heat)	
Date of monitoring	**Total number of *Tribolium* sp**	**Date of monitoring**	**Total number of *Tribolium* sp.**
23.08.07	155	16.08.07	28
31.08.07	42	17.09.07	58
02.09.07	0	17.10.07	59
04.10.07	2	02.11.07	22
08.11.07	0	04.11.07	0
21.12.07	1	09.11.07	2
12.02.08	31	18.12.07	18
11.03.08	38	22.01.08	16
08.04.08	81	26.02.08	43
05.05.08	83	26.03.08	43
16.06.08	148	29.04.08	67
11.08.08	204		

Regulatory status and future developments: ProFume is currently approved on emptied flour mills and emptied silos in the following European countries: Austria, Belgium, Germany, France, Greece, Italy, Ireland, Switzerland and UK, and on dried fruits and tree nuts in Germany and Greece. Label extensions on dried fruits and tree nuts have been submitted in all countries using ProFume on emptied mills, and in Turkey.

It has been identified that there was a need of an alternative fumigant on cocoa beans and development work is carried out currently in Germany and the Netherlands.

A new potential use for ProFume is to eradicate quarantine pests transported in wood packaging in shipping containers used in international trade. Some of these wood destroying pests are highly damaging to forestry and amenity trees.

Sulfuryl fluoride is also marketed under the trade name Vikane® in France, Finland, Germany, the Netherlands, Norway, and Sweden to control wood destroying insects in historical buildings and artifacts. Sulfuryl fluoride has been submitted under EU Directives (91/414/ EEC)Plant Protection and (98/8/EC biocide). It has been listed in Annex I of the Biocide Directive for Product Type 8 (wood preservative). 91/414/EECAnnex I listing and the listing in product type 18 (insecticide) under the Biocidal Products Directive are still pending.

Conclusion

The strong commitment to protect the ozone layer by European governments has resulted in the complete phase out of methyl bromide (MB) use in flour mills and food processing plants. Following the phase out, the industry has successfully adapted and maintained its production capacity, hygiene standards and economic viability. This has been achieved through increased focus on sanitation and utilizing alternatives control procedures such as fumigation with ProFume and heat. ProFume has been adopted by the industry with 255 fumigations of flour mills or food processing plants in 2008 in Europe. Product performance has been shown to be effective through monitoring studies of insects and commercial user satisfaction.

Dow AgroSciences is committed to secure and maintain the legal right to sell and where possible to extend registrations in areas of use whilst ensuring the high Stewardship standards are maintained. This will able this valuable fumigant to continually be available for years to come for control of SPIs in the food industry and to eradicate wood destroying pests.

Questions and answers during presentation: Q Could the decrease in insect population in the studies presented be explained by natural decline of population ?

A: When we consider the dates of application: except the mill in Germany that was treated with heat in November, (but it reached the pre-treatment level in February) all other application shown took place in summer (July, August), in the peak of insect reproduction, so the very low level of insect catches following application can only be explained by effectiveness of the treatment. ® Trademark of Dow AgroSciences LLC

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05 - Rodents – health risk and control measures

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Abstract

Rodents beside damages they make to stored products and any food also cause health risk to humans and domestic animals. Hazard can be direct or indirect.

Direct hazards to humans are rodent attacks, revulsion, shock or fear due to rodent presence, rodents' parts found in food, damaged wires gnawed by rodents that can be cause of fire or hurt one.

Indirect hazards include transmission of parasites or pathogens like *Salmonella enteritidis* and *S. typhimurium* or fleas transmit plague or murine typhus from infected rodents on humans. Unstable damaged bags and scattered grains may be hazardous to workers in storages.

Different methods might be used to prevent damages or health risk caused by rodents. Beside sanitation measures and rodent proofing important role has application of rodenticides especially at present high populations of rodents. Anticoagulants chlorophacinone, coumatetralyl, warfarin called first-generation compounds, brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen placed in the second-generation of rodenticides are used for rodent control in most European countries. In some cases carbon dioxide, phosphine and hydrogen cyanide are used for rodent control.

Introduction

Rodents, *Rattus norvegicus*, *Rattus rattus* and *Mus musculus* due to their life beside people often are called commensal rodents. They make damage in and outside of buildings, living under bushes in gardens or inside everywhere were there is any kind of food.

The damage they cause is dangerous to humans living or working in buildings. To prevent damages and to protect people it is necessary to provide rodent control.

Damages and danger: Rodents get access to the storehouse with different commodities or by entering the storage from the field. The establishment of rodent populations depends on the availability of food, harbourage and climatic conditions.

Rodents cause damage to wooden, metal or concrete objects and they gnaw wires. Besides doing damage they eat and pollute agricultural products and processed food. They pollute much more of the products with urine, feces or fur by movement and feeding than by eating part of the grain. Due to their activities also humans are in danger.

Rodents cause financial losses in millions by damaging stored products as well as buildings and equipment.

Health aspect: Rodents can directly or indirectly transfer different diseases on humans and domestic animals and endanger human lives.

Direct hazard: Direct hazard to humans is consequence of rodent activity in buildings including any storehouse.

Rodents do damage to packed commodities in storehouses, where damaged piles may become instable and threaten workers. Scattered grain may make floors slippery and lead to accidents. Presence, as well as appearance and running of rodents in the storehouse can cause shock or fear to people, high blood pressure, heart problems, broken legs or hands due to the fast reaction etc.

Rodents often gnaw power wires causing interruption of power supply or even fires. People unintentionally touching broken wires can be injured.

Rodent remnants like urine, feces or body parts make food or some commodities useless and dangerous for human consumption. Companies might have problems if rodent parts are found in processed food loosing image on the market.

The psychological effect has seeing rodent parts, teeth, hairs or droppings or traces of rodent bites in any kind of food. The consequence might be by refusing buying these products.

Indirect hazard: Indirect hazard is due to the transmitting disease from rodents to humans.

Rodents move mostly on dirty places, disposal sites, sewage and eat food rests. They can be transmitter of parasites or pathogens like Salmonella enteritidis and S. typhimurium.

The most famous is transmission of plague by fleas that caused thousands of deaths in the medieval times. In ports if rats were running out it was known that plague started. To prevent spreading of plague in Dubrovnik, in Croatia, in 14 century quarantine was introduced for all sailors and travellers.

Also murine typhus from infected rodents can be transmitted on humans.

Control measures: There are non-chemical and chemical methods for rodent control.

Non-chemical measures include sanitation that consists of cleaning of the storehouses and surroundings, prevention of access to food and water for rodents and removal of shelter and harbourage, also, rodent proofing is often used method that includes closing of all openings around and beneath doors to prevent rodents from entering the storehouse. Door bottoms should be made of metal or covered with wire-mesh. Windows should be protected with wire nets. Holes around pipes, on floors and walls must be closed, whereas drains have to be tightly covered. Bottoms of the walls should be oblique, smooth and slippery to prevent climbing.

Rodent proof and tidy buildings with sealed walls, doors and protected other openings are the prerequisite for successful rodent control.

Physical methods - ultrasound, electromagnetic devices and traps as well as biological control that uses parasites, diseases and predators are not so common in use. The reasons are mostly poor efficacy or restricted places where it can be applied.

Chemical methods usually have to be applied once a rodent population has become established. The most popular chemical method is use of rodenticides of anticoagulant origin. They have to be applied following the directions for use to avoid danger to non-target species as well as to applicators and the environment.

Anticoagulants are the dominant rodenticides used for rodent control in European countries. They are divided in two groups:

Chlorophacinone, coumachlor, coumatetralyl and warfarin are placed in so called first-generation multiple dose compounds. They have to be consumed repeatedly, over several days, to be effective.

Brodifacoum, bromadiolone, difethialone, flocoumafen belong to the second-generation compounds. These anticoagulants can sometimes act on single day’s in take.

In some cases carbon dioxide, phosphine and hydrogen cyanide are used for rodent control.

Conclusions

Rodent control is vitally important due to direct and indirect danger rodents might cause to humans. Efficient rodent control is needed and is an integrative part of good agricultural and public health practice. Important is to perform proper sanitation, to exploit all available rodent proofing methods and remove all water and food sources for rodents. Rodent control has to be carefully planned. The most suitable rodenticide formulation has to be applied.

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06 - EcO2 controlled atmosphere® & heat for stored product protection (incl. structural disinfestation)

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Abstract

The EcO2 Controlled Atmosphere treatment (CA), based on low-oxygen in combination with increased temperatures (e.g. 35° Celsius), is commercially used world-wide to control insects in post harvest commodities, structures, silos, and container cargo (imported and exported and treated according Quarantine and Pre-shipment regulations). CA treatments have gained industry and government acceptance as the non-toxic fumigant technology for a variety of applications. EcO2 applies it in the market on a practical basis, making it available for the industry. Treatments are carried out by applying them in climate controlled rooms, silos, barges or containers with fixed or mobile installations. CA has shown to be effective in controlling eggs, larvae and pupae, present in different sorts of (dried) commodities.

CA treatments have many advantages over traditional fumigants, including no pest resistance, residue-free and safe. In addition, installations equipped to carry out CA treatments are yet available in 13 countries serving a wide variety of industries.

CA treatments are applied to control insects in a wide variety of post harvest commodities like dried fruits, nuts, spices, seeds, rice, grains, tobacco etc.

Keywords: Stored product pest control, controlled atmospheres, heat, disinfestations, post harvest, environmentally-friendly, Methyl bromide, Phosphine and Sulfuryl Fluoride.

Introduction

EcO2 Controlled Atmosphere® (CA):

CA is based on the establishment of a low-oxygen environment which kills pests. The Dutch company EcO2 BV is using CA to control all stages of insects, rats and mice in food, associated products, artefacts, silos, food (processing) facilities, airplanes and barges.

CA is designed by EcO2 is established by means of the EcO2 converter which is able to create levels varies between 0% and 1.5% O2. It can be applied in airtight environments which will be designed on customs needs. Insects in all stages are eliminated (99,996% Lt) because of the lack of oxygen which causes the insect to dry out and suffocate.

The use of CA on post-harvest durables is growing rapidly and replacing Methyl Bromide and Phosphine more and more. The phase out of Methyl Bromide pushed the increase of world-wide Phosphine use. The product is easy to use and affordable although this product takes long exposure times to be effective. Unfortunately the product is meeting increased levels op pest resistance and requires more investments to be applied on an acceptable level. This is in line with chemicals such as Sulfuryl Fluoride that can not guarantee an effectiveness level of 99,9% Lt , take long treatment times, need elevated temperatures and considerable investments in fumigation rooms and information technology, and as latest research showed in the USA it is also an ozone depleted substance even 4800 times more then CO2.

The treatment times of a CA treatment now vary from 24 hrs till 7 days. The treatment time depends on the type of product (density level) and type of insect (exposure level). These treatment times are faster than chemical alternatives for Methyl Bromide (including defumigation).

With CA treatments there is a 100% effective control of insects, rats and mice in every stage of development. There is no change of resistance in pest population and the treatments are independent of atmospheric influences. Beside this, CA can be used for quality preservation purposes for long term storage of food commodities.

During each CA treatment, there is full online control of each treatment and parameters based on a full database of insect control data. After each treatment date is recorded using software programmes for full traceability.

EcO2 Converter system and machinery are always constructed in a moveable 20ft container. The prices of the treatments are at expectable levels and units are available for small and medium sized companies. Prices of treatment of commodities, treated in treatment centers (based on lease) range from € 1,00 to € 10,00 p/mt based on yearly capacities of 20.000 and 2.500 tonnes. Prices are exclusive local energy costs which depend on local energy costs and climate.

EcO2 treatment facilities are customized to the need and desires of the customers and designed according:

- yearly required treatment capacity (containers, tonnage)
- available area for construction
- products to be treated

Applying EcO2 Controlled Atmosphere® in Silos:

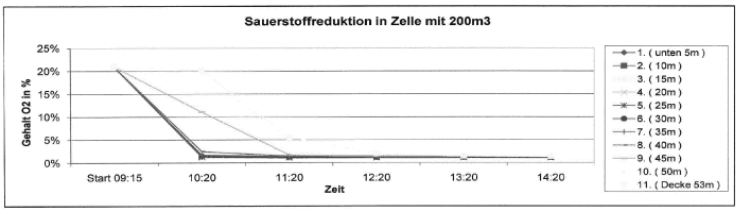
Since a very large portion of the storage of food is done in silos, it is a natural way to progress the application of EcO2 Controlled Atmosphere® in silos. This brings new challenges to the table. For instance the various ways that silos are constructed. There are many different shapes, seizes, used materials. Some silos are only used for storage and some are used for storage and as a treatment facility. Also the location can be an influence in this process.

The most important aspect is the air tightness of the silo. This can be an established after conducting a pressure test. The more the silo is air tight, the quicker it will be to reach the right low oxygen level within the silo.

EcO2 has conducted several tests together with Desinfecta AG. The subject of the tests was to make it insightful how long it would take to reach certain oxygen levels thought-out different heights within the silo (see figure 1)

EcO2 Versuchszelle 200m3 13.Mai 2009

Messpunkte	Start 09:15	10:20	11:20	12:20	13:20	14:20
1. (unten 5m)	21%	1.1%	1.0%	1.0%	1.0%	1.0%
2. (10m)	21%	1.1%	1.0%	1.0%	1.0%	1.0%
3. (15m)	21%	1.1%	1.0%	1.0%	1.0%	1.0%
4. (20m)	21%	1.2%	1.1%	1.1%	1.1%	1.1%
5. (25m)	21%	1.3%	1.1%	1.1%	1.1%	1.1%
6. (30m)	21%	1.5%	1.3%	1.2%	1.2%	1.2%
7. (35m)	21%	1.7%	1.4%	1.3%	1.3%	1.2%
8. (40m)	21%	2.5%	1.5%	1.3%	1.3%	1.3%
9. (45m)	21%	11.1%	1.7%	1.5%	1.4%	1.4%
10. (50m)	21%	20.1%	5.0%	1.9%	1.5%	1.3%
11. (Decke 53m)	21%	20.3%	5.6%	2.1%	1.5%	1.4%



B.Boitier Desinfecta AG 1

Fig. 1 Oxygen levels thought-out different heights within a silo

EcO2 Heat Technology (HT):

This technology is used for the control of insects in flour mills, historical buildings and storage centres.

Heat treatments consist of raising the temperature of the structure to at least 56°C for an average of 36 hours. It can be used to control all stages of insects in different types of buildings and structures, including historic buildings. Mobile heating equipment that also controls humidity is used to distribute heat as uniformly and as slowly as possible to avoid damage to the building. The mobile equipment is generally not expensive and the energy costs are modest.

In The Netherlands, heat treatments have replaced MB for disinfestation of flour mills and aircraft. Heat applied over a period 24 hours, in compliance with ISPM-15, is also an approved disinfestation treatment for the treatment of pallets, SWPM and dunnage. The same heat treatment can also control fungi on wet timber. Although heat requires investment in specialised facilities, it is a safe, non-toxic, environmental-friendly and effective substitute for MB.

Heat combined with controlled atmospheres:

Heated-CA is commercially available as “EcO2 Quarantine and Pre-Shipment Treatment®” (“EcO2 QPS treatment”) for controlling insects in a range of products. It is a proprietary system which is specifically developed for the treatment of containers, general cargo and big bags, containerised wooden pallets, packaging materials and dunnage. The treatment combines heat with low-oxygen and takes 24 hours. The temperature is controlled in strict compliance with ISPM-15 while the low-oxygen concent

Commercially, “EcO2 QPS Treatment” is applied in service terminals or at container terminals where full containers, loaded with packaging materials together with the goods, can be treated together. Located in the Port of Rotterdam, the REST provides a total solution for the treatment of import and export containers. Containers treated with the “EcO2 QPS Treatment”, or heat alone, are vented in a closed circuit in order to conserve heat and gas mixtures (Figure 2). The process runs automatically and toxic gases are filtered with the use of a sophisticated filter system in a fast and safe way. ration protects the product from oxidation.

Approximately 3,500 containers will be treated with the QPS treatment in 2004. “EcO2 QPS Treatment” can handle more than 95% of all export containers (depending on the heat sensitivity of the cargo). The treatment treated 77% of the containers that had to be fumigated in the Port of Rotterdam in January – June 2004 (Roteb 2004).

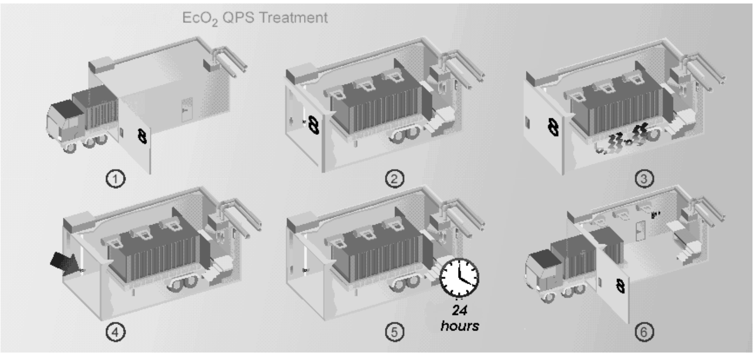


Fig. 2 Schematic of the “EcO2 QPS Treatment” that complies with the ISPM 15 norm (EcO2, 2004)

Conclusion and discussion points

EcO2 Controlled Atmosphere® is competitive against chemical fumigants and available world wide. Barriers of treatment time, price, usability and availability have been lowered. Chemical alternatives for Methyl Bromide and Phosphine share the problem of causing resistance, leaving residues, affect the ozone and a negative image; they become overall less competitive in comparison to natural alternatives. CA and HT (all combinations) reduce the risk for working personnel and consumers. All systems are used without waiting for a fumigator.

Without oxygen no insect will survive and although the system is toxic to insect and risks are reduced for working personnel and consumers, prudence is in order when operating the EcO2 systems since it can be toxic to people as well. Each insect stage of the insect species is controlled, taking into account that pupae and eggs are the most difficult ones. Each treatment is adjusted to the insect specie to control.

Large structures and objects are treated with HT, using steam heating systems to avoid the necessity of large electric power.

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07 - Five economic principles applied to stored product protection

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Abstract

Society has long recognized the critical importance of stored product protection for welfare of humans and domestic livestock. Economists note additional benefits in terms of more efficient resource use, facilitated trade, and market stability. Estimates of the stored product losses vary greatly but are large in aggregate and potentially economically devastating to individual enterprises. Economic principles can be applied to stored product protection to understand current practices and to indicate potential pathways to refine strategies for stored product protection. The appropriate selection of the adaequate method in stored product protection will choose the alternative that provides the greatest net benefits. Cost-benefit analysis is a powerful tool for rationalizing the resource allocation. The decision should focus on ”how much” or ”which one”. Economic threshold models offer insight into discrete choice problems. The good storage protection practice should recognize and deal with externalities. Protection activities may be driven by economic externalities and may themselves general externalities impinging on others. Economic theory discusses which goods should be provided privately and which publicly (by government). Economic theory identifies the circumstances where government supported research is sound policy. Minimize transactions costs to improve market efficiency. Contracts, voluntary industry standards, government regulations, and treaties, if properly formulated, can reduce transactions costs and improve commerce and trade.

Introduction

Society has long recognized the critical importance of stored product protection for the welfare of humans and domestic livestock. Protection technologies vary greatly across the globe. In some places protection technologies are very sophisticated and effective; in others losses are huge. Estimates of stored product losses vary greatly, but are large in aggregate and potentially economically devastating to individual enterprises (Grolleaud, World Resources Institute).

Economists note that successful stored product protection provides benefits beyond basic food security. Benefits include productivity gains from more efficient resources use, gains from trade, and market stability.

Economic principles can be applied to stored product protection to understand current practices and to indicate pathways to refine storage strategies. Five economic principles of general applicability are succinctly stated as: compare costs and benefits; model continuous and discrete choices; externalities exist; consider transactions costs; and public versus private goods.

Participants in the business of stored product protection are probably applying these principles. Presenting this information from the perspective of an economist may help storage practitioners refine their application. Each of these is now described more fully.

<u>Compare Costs and Benefits</u>: Cost-benefit analysis (CBA) is a powerful tool to guide decisions. All costs and benefits are quantified and monetized and the course providing the greatest net benefits is the preferred alternative. Benefits in stored product protection are the value of physical product at the end of the storage cycle for each storage regime. A baseline storage outcome is needed for making comparisons. Stochastic cost-benefit models can provide additional insights when certainty parameters can assume different values and there is some knowledge of the probability distribution of these values. Parameters that might vary include the initial pest pressure, efficacy of

treatments, and the product's value at the end of storage. Cost-benefit ratios are only helpful when the alternatives being compared either have identical costs or identical benefits. The important measure is the expected net benefits.

A related approach is cost-effectiveness analysis (CEA) which compares alternatives involving different costs and their outcomes measured in terms other than monetized value. CEA might be used when benefits are difficult to monetize or monetization is controversial, e.g., valuing extending a life. CBA appears to be more useful for questions of stored product protection.

Model Decision as Discrete or Continuous: The analytical models used are much different if the decision involves a variable that can assume a limited number of discrete values rather than a continuous range of values. The question is which action versus how much of a particular action. Optimization is generally straightforward calculation when deciding how much of an input to use, be it a chemical or a non-chemical alternative. In competitive output markets, the optimization paradigm is use an input up to the level that its value of marginal product turns negative. On the other hand, modeling the choice between a chemical based control strategy and a nonchemical strategy must account for preferences and ultimately subjective utility of the decision maker. Yes, cost-benefit analysis can rank a discrete alternative according to a maximum net benefits criterion. The shortcoming is that CBA does not explain the simultaneous existence of multiple discrete alternatives. Part of the answer is that firms and society consider values beyond what is typically captured in CBA.

Deal with Externalities: In economics an externality or spillover of an economic transaction is an impact on a party that is not directly involved in the transaction. Externalities can be positive (benefits) or negative (costs). A classic example of an externality cost is a train's smokestack emissions depositing soot on someone's laundry hanging to dry.

Fumigation of stored products means release of fumigants into the air. This might have immediate negative effects on neighbors if the exposures are high enough. Economists suggest various mechanisms to address externalities. One approach is for government to compel the source to compensate the injured third party or for the injured party to negotiate a payment from the source that is sufficient to cover the damages and possibly curtail the actions creating the externality. Another is to outlaw the activity that causes the externality. In the case of methyl bromide, the externality is the global ozone depletion which in turn impacts on human health but not just in the vicinity of the emissions. Compensating injured parties or paying the source to cease emissions is not practical. The Montreal Protocol addresses the externalities arising from the use of ozone depleting substances. Not every externality requires a multi-national treaty. Where the externalities are local, solutions such as buffer zones large enough to dissipate emissions on the source's own property can work.

Publically versus privately supplied goods: There is substantial economic theory regarding so-called public goods. I focus on a particular question that is still frequently debated. Which goods and services should be provided by the government and which by the private sector? Consider research, some research is very basic, costly, and takes many years. Such research may be risky in the sense that great effort may not result in discoveries leading to commercially viable products. Private enterprise may undertake similar research, but economists predict that relying entirely on the private sector would result in less than the socially optimal amount of research. Public subsidies, patent systems, and in some cases limits on liability, can encourage private research.

Private research tends to be applied research, that is, practical research with strong expectation of commercial success. Even here, venture capital looks for fast returns and protecting stored products probably does not attract a lot of investor interest.

Private firms have few incentives to develop things that can't be protected by patents, licenses, or trade secrets (propriety knowledge). Discoveries that are freely adoptable will provide the maximum social benefit, but the entity that devoted resources to the discovery won't be rewarded by the market. These characteristics points to the type of research that should be funded by the government.

In reality, there is no sharp division between the types of research funded by government and that funded by the private sector. Federal research such as the our host, the Julius Kühn-Institut, and the Agricultural Research Service in the United States have core research programs in basic research and elements of applied research of Stored Product Protection and Crop Protection and Quarantine. Private firms and governments both have interests in protecting stored products and in research that improves that protection.

Markets and the potential for profit determine the allocation of funds for applied research, but how does society ensure basic research is adequately funded? The short answer is it that it must happen within the political process.

Transactions Costs: Economic exchanges generally involve costs in addition to the purchase price of the commodity. In economics these are called transactions costs. The type of costs include search and information costs—finding out where you can get the services you want and who provides the service at the best price; negotiation costs—it takes valuable time to bargain over the price and other contract provisions; and enforcement costs—cost to make sure the other party performs as agreed in the contract.

When stored product protection involves contract services rather than doing everything internally, there will be transactions costs. The goal is to minimize these costs. Government and industry standards such as EPPO in contracts avoids negotiations cost over certain technical matters. Government licensing of suppliers to ensure minimum quality and recourse for poor performance, and infrastructure that makes market information readily available (directories and advertisements are examples) can reduce transactions costs. Search costs can be avoided by using a contractor who has proven reliable and affordable in the past. The more valuable in total the product being protected and the greater the price for say fumigation or packaging, the more willing you should be to engage in additional search. The economic principle telling you when to stop incurring search costs is marginal search costs should never exceed expected savings on the transaction.

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08 - Prospects for biological control of stored-product pests

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Abstract

Natural enemies are applied commercially against stored-product pests in Central Europe. In this contribution, an overview about the fields for application of the beneficial insects are given. The mode of action of beneficials is compared with the application of chemical pesticides. Examples for successful biological control include the retail trade, the food processing industry, storage on farms, bakeries and mills. Both conventional and organic producers apply beneficials. The main target pests are moths and beetles. Pest control companies gain in importance as operators of biological control. The prospects for biological control as a component of IPM is discussed.

Introduction

Do natural enemies exert stress on chemical products? Fewer synthetic chemical insecticides are available for the protection of stored products (Reichmuth, this volume; Arthur & Rogers, 2003). This leads to an increased interest in alternative control options, including biological control by mass-reared natural enemies that are now commercially available (Prozell & Schöller 2003). But does the availability of beneficials again result in a decrease of synthetic chemical insecticide application? To shed ligth on this aspect, three questions have to be adressed: (1) is there an overlap of fields of application of beneficials and chemical insecticides? (2) is the control effect comaparable? and (3) are there enough laboratory-reared natural enemies available to replace chemical insecticides? Let us first look at the main areas of commercial application to see if an overlap of fields of application exists.

The main areas of commercial application of natural enemies: In stored products, parasitoids are mainly applied against stored-product Pyralid moths and stored product beetles (Stengård Hansen, 2005; Schöller et al., 2006). The natural enemies are reared in the laboratory (augmentative release strategy) and released as pupae or adults in the target sites (Prozell & Schöller, 2003). Typically, inundative releases are advisable, i.e. relatively large numbers of beneficials are repeatedly released.

Control of stored product moths: Both parasitoids against stored product moths eggs and larvae are commercially available. Egg parasitoids of the genus *Trichogramma typically* have a fairly broad host range and attack the Indian meal moth, the Mediterranean flour moth, the warehouse moth as well as many other moths species. The egg parasitoids are usually released as pupae attached to egg cards at the rate of at least 500 females per linear meter of shelving, although higher release rates may be needed for situations where shelving is more than 2 m in height (Grieshop et al., 2006a). The individual *Trichogramma-wasp* is shortlived (2-6 days). Modern release units contain a mixture of developmental stages resulting in the staggered parasitoid emergence over a period of three weeks, or in the case of *Trichogramma evanescens* allow even the presence of egg parasitoids over 4 weeks. Given a release period in unheated storage buildings in Central Europe from mid of April to mid of October, a total of only 9 or 7 releases are necessary, respectively (Fig. 1).

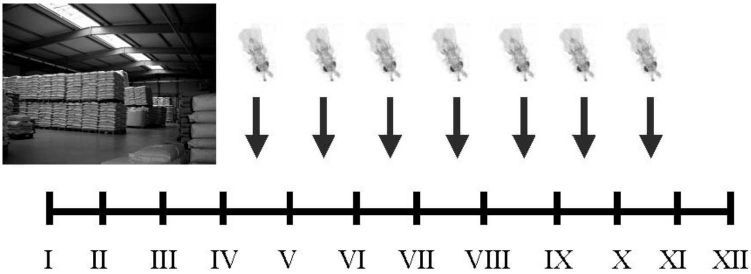

Fig. 1 Timing of release for *Trichogramma evanescens* from 4-week activity release units against moth eggs in a bag store.

Trichogramma spp. are typically released to prevent previously uninfested packaged products from infestation by moths (Grieshop et al., 2007). It is therefore a preventative method. A potential limitation of Trichogramma spp. is that their foraging success may be severely limited in situations such as spills or bulk product where small scale habitat complexity hinders the finding of the moth eggs. In this situation *Trichogramma* spp. can be combined with the larval parasitoid *Habrobracon hebetor* (Grieshop et al., 2006b). H. hebetor attacks the "wandering" last instar larvae and diapausing larvae and is relatively larger than Trichogramma spp. (about 5 mm in length). *H. hebetor* are released as adults or pupae at a rate of 25-50 females per 10 square meters of storage room. As *H. hebetor* are strong fliers with good long-rage searching ability (Strand et al. 1989) and females can live up to two weeks they provide a relatively good "residual effect". *H. hebetor* is capable of penetrating compromised packages and parasitizing wandering larva prior to their exit, potentially reducing the spread of moth infestations within a faciltiy (Schöller et al., 2006). An example for the combination of the egg parasitoid with the larval parasitoid is given in Fig. 2, e.g. for heated mills and bakeries.

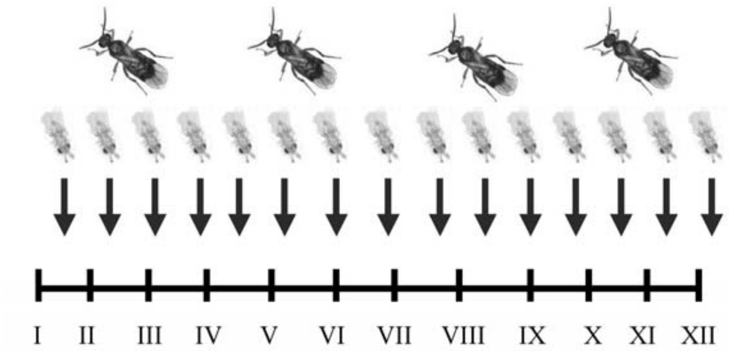

Fig. 2 Timing of release for *Trichogramma evanescens* from 3-week activity release units against moth eggs (15 releases) and *Habrobracon hebetor* (4 releases) in a bakery.

Biological control of stored-product moths allows the presence of workers or clients during the treatment time. The major advantage of *Trichogramma* spp. in this context is their extremely small size (> 0.5 mm in length) making the parasitoids virtually invisible to the casual observer.

In bulk grain, a combination of *Trichogramma* spp. and *H. hebetor* is recommended, too. Experience with this system is available for small-scale farms, with silos or boxes with grain ranging from 10 to 100 tons. Habrobracon hebetor is released in early spring when temperatures reach 12-15°C, and again in July to October depending on the presence of wandering larvae. *Trichogramma evanescens* is released from June to August depending on the presence of adult moths (Fig. 3). The relase of parasitoids in large warehouses (800 t to 1200 t grain) is currently under study.

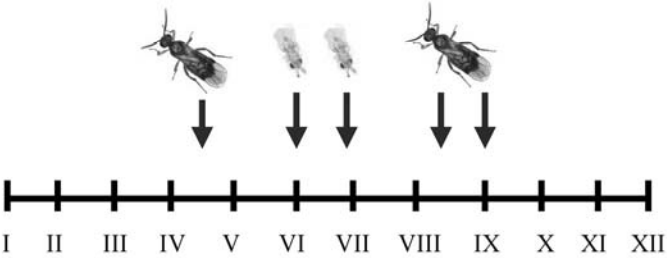

Fig. 3 Timing of release for *Trichogramma evanescens* from 3-week activity release units against moth eggs (2 releases) and *Habrobracon hebetor* (3 releases) in bulk grain.

Control of stored product beetles: The commercial application of natural enemies against stored product beetles diversified in recent years. The main application is still in grain storage on organic small-scale farms, but control of material pests is gaining importance, too.

Females of the pteromalid wasps *Lariophagus distinguendus*, *Anisopteromalus calandrae* and *Theocolax elegans* lay their eggs on host larvae or pupae inside grains or cocoons. For this purpose, the ovipositor is inserted and the host larva is paralysed prior to oviposition. After emergence from the egg, the parasitoid larva feeds on the host larva from the outside, thereby killing it. The bethylid wasp *Cephalonomia tarsalis* parasitises larvae of Oryzaephilus spp., the eggs are laid externally on host the larva after paralysation, too.

Empty room treatment: A mixture of the chalcid parasitoids *Lariophagus distinguendus* and *Anisopteromalus calandrae* is recommended at a dose of 30 females per 10 m2 against beetles. Empty grain stores are best treated 2 - 6 weeks prior to loading of grain. Herb stores were treated between mid April and mid of October against the warehouse beetle Stegobium paniceum, and pasta factories all year round against *Lasioderma serricorne* and Sitophilus zeamais.

Similarly, the bethylid wasp *Cephalonomia tarsalis* is applied against the sawtoothed grain beetle *Oryzaephilus surinamensis* in stored grain environments, and against *Oryzaephilus mercator* in chocolate-producing companies.

Bulk grain: The parasitoid *Lariophagus distinguendus* alone or in combination with Theocolax elegans is recommended at a dose of 30 females per 15 t grain against *Sitophilus* spp. weevils. These two parasitoids were proven to enter into the grain bulk. The host-finding ability of *L. distinguendus* was examined under realistic conditions of application. In a silo bin and a flat storage grain box, adult parasitoids were released at the surface. The parasitoids were able to find and parasitize hosts located up to 4 m vertically and horizontally from the release point (Steidle & Schöller, 2001). The parasitoids are either released in spring when temperatures reach 15°C, or 4 weeks after loading the grain until autumn (Fig. 4), or according to the modeling software Sitophex (Prozell et al., 2004). Similarly, the bethylid *Cephalonomia tarsalis* is applied against the sawtoothed grain beetle *Oryzaephilus surinamensis*.

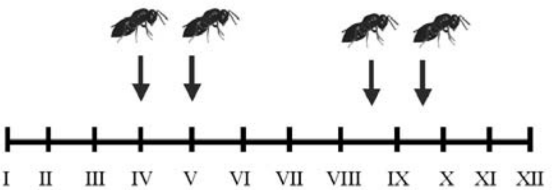

Fig. 4 Timing of release for adult *Lariophagus distinguendus* against weevil larvae (4 releases) in bulk grain.

Most recently, the biological control of the golden spider beetle *Niptus hololeucus* and the hump beetle *Gibbium psylloides* in historic buildings reached the commercial stage after years of tests in practice. The parasitoid applied is the store chalcid *Lariophagus distinguendus* that was known as natural enemy of the respective beetles for many years (Kashef, 1961), but never evaluated for biological control.

Efficiency: Is the control effect of parasitoids and chemical products comparable? In case an egg, a larva or a pupa of a stored product pest insect is stung by a parasitoid, it does not recover and dies. This is typically even the case when no eggs are deposited by the parasitoid (e.g. Hase, 1924). In this case, the control efficiency of the parasitoid is 100%. Consequently, for the evaluation of the biological control effort the crucial question is wether the parasitoid and its host, the stored product pest, meet or not. Two important criteria in this respect are temperature limits for activity of the parasitoid and its host, and host-finding behaviour of the parasitoid. For some parasitoid-host systems, it was shown that the parasitoids tolerate similar low and high temperatures as their hosts. In Central Europe, the lower temperature limit is of special importance because it is important to supress the pest population early in the storage season. For example, in laboratory trials the granary weevil parasitoid *Lariophagus distinguendus* was found to completely develop at 15.8°C (Stengård Hansen, 2007a). Recent investigations in the laboratory and in stores indicate an even lower temperature limit of 9°C to 10°C for parasitisation and therefore control of the weevils (Niedermayer & Steidle, 2009). The lower temperature limits for complete development of the granary weevil *Sitophilus granarius*, the maize weevil S. zeamais and the rice weevil S. oryzae are 15°C, 17°C and 17°C, respectively (Weidner, 1983). Different species and strains of the genus *Trichogramma* differ significantly concerning their tolerance for low temperatures. One of the reasons for the selection of *Trichogramma evanescens* euproctidis for the control of stored-product moths in Central Europe was its parasitisation activity at 15°C (Schöller & Fields, 2003). Performance at low temperatures is only one of many potential parameters to select a suitable beneficial for biological control. A list of criteria to select natural enemies for inundative biological control of stored-product moths was suggested by Schöller & Flinn (2000). The selection of the most effective natural enemy is a step prior to commercialisation of natural enemies undertaken to ensure a sufficient efficiency. So far, no case of resistance of stored product pests to natural enemies is known, but there are many examples of a loss of quality of mass-reared natural enemies. Consequently permanent quality control is necessary to keep the control efficiency.

In case natural enemies are applied as a prophylactic treatment and no infestation of the products occur, it is hard to determine if this is due to the control effect of the natural enemies or not. However, if the stored product pests were present e.g. on a farm for many years and no more infestation is detected after the release of parasitoids, this is generally attributed to biological control.

Tab. 1 Comparison of selected biological and chemical control strategies in Central Europe.

Target site	Biological control	Chemical control	Pest / Stage	Application time in Central Europe	Prophylactic treatment
Empty room, Bag store	*Trichogramma evanescens*		pyralid moths / eggs	April - October	yes
		contact insecti-cide, e.g. Pyre-thrum + PBO	pyralid moths / adults	April - October	no
	Habrobracon hebetor		pyralid moths / larvae	March - December	yes
Bulk grain and empty room grain store	*Lariophagus distinguendus*		some beetles / larvae	April - October	yes
		diatomaceous earth	beetles / adults and larvae (partly)	April - October	yes
		contact insecti-cide, e.g. Pirimi-phos-methyl	beetles / adults and larvae (partly)	April - October	no

Capacity - are there enough natural enemies produced? Macroorganisms for biological control like parasitoids and predators are still produced by rearing the host or prey species in the laboratory or in green houses first. Artifical media for rearing of natural enemies are still not effective enough for commercial application. This fact and the limited shelf-life of the products, i.e. the short time parasitoids and predators can be kept refrigerated without loosing their viability severly limits the mass-production of beneficials. Beneficial insects and mites are manufactured, not produced on an industrial scale. This migth be one of the reasons why comparatively few companies produce natural enemies. The world-wide production of beneficials for stored product protection is currently restricted to the three European countries Germany, the Netherlands and Switzerland. However, the recent example of the remarkable increase in the use of beneficials for protected crops located in the South of Spain within only few years showed that the biocontrol market is able to respond to the need of customers.

Conclusions

Typically, biological control acts slowly as one or few developmental stages of the pest are attacked only. Moreover, most beneficials are specialised on the attack of few pest species. The exact determination of the pest species is therefore necessary. Constant monitoring of the pest population is also required. An advantage compared to chemical control is the possibility to produce while natural enemies are active, because neither the production process nor the workers are affected by the presence of beneficials. Several application strategies of beneficials are not paralleled by those of insecticides, like the protection of packages from infestation by moths, the control of diapausing moth larvae by Habrobracon hebetor or the application in organically producing companies (Schöller & Prozell, 2007). Among the few applications that migth be completely replaced by the release of beneficials due to imcomaptibility (Perez-Mendoza et al., 1999) are diatomaceous earth and/or powder formulations of contact insecticides for the control of spider beetles in historical buildings.

At the last international forum on stored product protection, Helbig (1996) estimated the potential of biological control methods for various pest species and types of stored products. At that time, biological control agents were not commercially available yet. Tab. 2 compares the 1996 estimate with the current commercial application of parasitoids. The most striking difference concerns food for human consumption, the acceptance of the release of living insects for biological control close to food items in private households, wholesale stores and processing plants was not expected. The application of parasitoids in these areas reflect a change in attitude in part of the public, rating the risk of contamination of food with parasitoid wasps less dangerous to health compared to the risk of contamination of food with synthetic insecticides. In fact, scientific studies (Flinn & Hagstrum 2001, Ambrosius et al., 2005) have shown that the appropriate application of natural enemies does not lead to contamination of food with parasitoid wasps, either because raw materials for production of food are cleaned prior to processing or because the pests are controlled outside packaged food.

Tab. 2 Criteria for the use of biological control of stored product pests. Estimation for the potential of application by Helbig (1996) and current commercial application; + = high potential, 0 = intermediate potential, - = low potential

Criterion	Category	Potential according to Helbig, 1996	Current commercial application
Pest species	Lepidoptera	+	+
	Coleoptera	0	+
	mites	-	-
Beneficial	parasitoid	+	+
	predator	+	0
	pathogen	-	-
Type of product	fodder	+	0
	raw material for industrial processing	+	+
	raw material for production of foods	0	+
	foods	-	+
Type of store	Large scale store	-	+
	Small scale farmer store	+	+
	Processing industry	0	+
	Food wholesale trade	0	+
	Food retail trade	+	+
	Private household	-	+
Type of storage	Bulk	+	+
	Packed products	+	+

While the release of the parasitoids itself is easy and does not require skilled workers, the decisions when and where to release are not. Like with any other control technique, the storage situation has to be analyzed and the foreseen storage or processing steps taken into account. Currently pest control companies gain in importance as operators of biological control. If the situation is appropriate, biological control is a valuable option differing in the mode of action from physical or chemical methods mostly by the fact that natural enemies actively forage for stored product pests in hidden places.

As many more natural enemies of stored product pests are known (Schöller 1998) than are currently commercially reared for biological control, there is still a lot of potential for new biological control strategies. Biological control can reduce the number of pesticide applications rather than replace existing chemical control strategies. Chemical products are not expected to vanish due to their replacement by natural enemies, but due to the lack of sustainability of the concept of neurotoxic contact insecticides (health risks) or due to adverse effects on the environment as in the case of some fumigants (MBTOC, 2002). In contrast, more potential of integration of chemical and biological control exists for conventional stored product protection.

The European working group funded by the COST system (2000-2005) identified three situations were biological control would be a valuable component of integrated pest mangement: (1) empty room treatment (2) preventative treatment of bulk commodities, in particular grain, using parasitic wasps and predatory mites against weevils and storage mites and (3) preventative application of egg-parasitoids of the genus Trichogramma to protect packaged products from infestation by moths (Stengård Hansen, 2007b).

Modern pest control operations combine or ideally integrate different control methods. A wide variety of different control methods support therefore the possibility to find solutions for complex control situations (Stengård Hansen, 2007b). The definition given by Reichmuth (1996) at the last international forum on stored product protection still sets the frame for the prospects for biological control of stored-product pests: „An Integrated Pest Management System (IPM) in stored product protection comprises hygiene, technical, technological and biotechnical methods, physical control, biological control and chemical control. These methods should be harmonised in a way granting highest priority to the protection of the human health as well as the environment. Moreover, commercial policy is a possible further element of IPM".

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09 - Some like it hot – some not: Differences in temperature preference of two parasitic wasp species

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Abstract

Insect pests not only cause damage to crops in the field but also to stored products. One of the major pests in stored grain in Europe is the granary weevil *Sitophilus granarius* (L.).

The most commonly used biocontrol agent against this and other pests developing inside kernels or cocoons is *Lariophagus distinguendus* (Förster) a parasitic wasp belonging to the family of Pteromalidae. Another parasitic wasp of that family is *Anisopteromalus calandrae* (Howard). Even though the two wasp species show very similar host finding and parasitisation behaviour, field experiments reveal that *L. distinguendus* and *A. calandrae* have different temperature requirements. Whereas parasitisation in *L. distinguendus* can already be observed at weekly mean temperatures of 9°C to 10°C, *A. calandrae* needs weekly mean temperatures of at least 11°C to 12°C. On the other hand, *L. distinguendus* is affected by high temperatures more easily than *A. calandrae*. Laboratory experiments under different constant temperatures confirm this finding. These findings suggest a temperature dependent release of either *L. distinguendus* or *A. calandrae*. At mean temperatures below 19°C, *L. distinguendus* should be used, at higher temperatures *A. calandrae* performs better.

Introduction

Insect pests are a threat to stored products. Despite preventive methods such as ventilation and cleaning infestations with stored product pests can not always be avoided. These pests are not only responsible for losses in weight and quality but can also cause health problems. With the rapid decline of available active substances against stored product pests in the last couple of years, especially the phase out of methyl bromide in 2005, a huge challenge is posed for pest control in the future. Alternative methods such as the use of sulfuryl fluoride, controlled atmospheres and heat treatment require sealed buildings or bins with a high degree of gas tightness and are often cost and energy intensive. Therefore these methods are only applicable in the food processing industry or large mills and storages. A good alternative for small scale farms is the biological control of the storage pests. Thereby, the use of beneficial insects against storage pests has many advantages. There is no registration required, there are no resistances and beneficials are easy to apply. Today a number of beneficials against different stored product mite, moth and beetle species is commercially available.

One of the major pests in stored grain in Europe is the granary weevil *Sitophilus granarius* (L.). The most commonly used biocontrol agent against this and other pests living inside kernels or cocoons is *Lariophagus distinguendus* (Förster), an idiobiontic ectoparasitic wasp belonging to the family of Pteromalidae. Another parasitic wasp of this family is *Anisopteromalus calandrae* (Howard). They both use their ovipositor to drill holes in e.g. grain kernels, paralyse the host larvae within the kernels and place an egg on the outside of the host larva. The wasp larva develops on the outside of the host while sucking it out. Finally the wasp larva pupates and hatches. This life-cycle makes these wasps good biocontrol agents.

Whereas the general suitability of *L. distinguendus* and *A. calandrae* for the biological control of stored product pests has been demonstrated (Steidle et al., 2002; Reppchen et al., 2002;) , there are still a number of open questions. Therefore, the present study aims to look at the temperature preferences of *L. distinguendus* and *A. calandrae* and the consequences for their application in biocontrol.

To gain information about temperature conditions in storage buildings, temperature measurements where conducted in different storage buildings in southern Germany for more than three years. It could be shown that there are huge variations in temperature during the year reaching from -10°C in the winter (Fig. 1) up to +48°C in the summer (Fig. 2) mostly in poorly insulated buildings. Even during the day high variations of about 20°C were measured (Fig. 2).

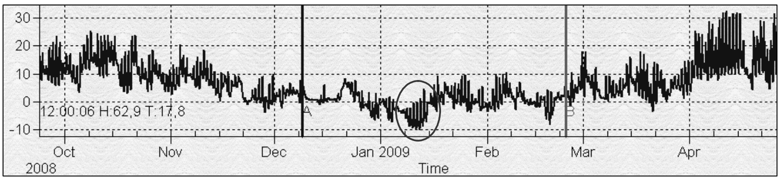

Fig. 1 Temperature data from a storage building in Stuttgart/Germany recorded from October 2008 to April 2009 with an PCE-HT110 data logger showing temperatures down to -10°C in January 2009

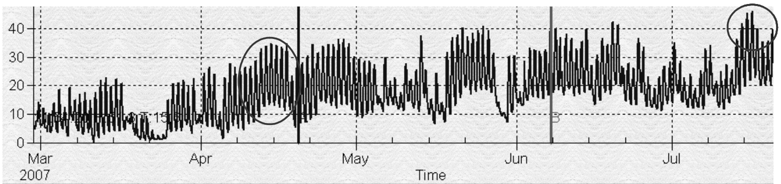

Fig. 2 Temperature data from a storage building in Stuttgart/Germany recorded from March to July 2007 with an PCE-HT110 data logger showing temperatures up to 48°C in July 2007 and temperature variations of more than 20°C at one day in e.g. April 2007

To investigate the behaviour of the wasps at different temperatures the reproduction rate of the wasps plotted against temperature was investigated in field and laboratory experiments. Therefore fertilized females of *L. distinguendus* as well as fertilized females of *A. calandrae* where kept in Petri-dishes with 10g of grain infested with *S. granarius* larvae. Adult wasps were removed after one week and the grain containing parasitized *S. granarius* larvae was incubated at 25°C. Afterwards the number of offspring was counted. Temperature conditions where either natural conditions in storage buildings, recorded with a temperature-humidity data logger or constant temperatures in an incubation chamber. It could be shown that L. distinguendus performs better at lower temperature whereas *A. calandrae* performs better at higher temperatures.

These results of this study suggest a temperature dependent release of *L. distinguendus* and *A. calandrae* to guarantee the best results in the attack of stored product

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10 - Physical control of stored product insects

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Abstract

Given the declining number of chemical agents for pest control, non-chemical methods gain importance in stored product Integrated Pest Management. Physical methods play an important role not only in pest control, but also in pest prevention (e.g. product cooling, drying, insect-proof storage and packaging) and pest monitoring (e.g. measurement of temperature, product density, movement or bioacoustics). In pest control, heat disinfestation has become an established method for empty structures. A difficulty is that insulators such as large amounts of flour, dust or bag stacks with products need to be removed prior to treatment. Freezing at temperatures of minus 18°C is a method to disinfest high-value products without the risk of deteriorating product quality. However, energy costs may be the limiting factor. For fine and powdery goods such as flour, sieving and milling is the only choice because just mechanical methods can lead to effective pest control in this substrate. In future, processing steps leading to pest control (e.g. heating, milling, extrusion) should be combined with pest exclusion, ventilation and temperature management in order to keep product quality high and pest control efforts at a minimum.

Key words: control, heat, cold, impact, sieving

Introduction

In the last decades, chemical means of pest control in bulk products have been the most important methods of pest control. However, the development of resistance is a threat to phosphine fumigation in grain. Recently, dichlorvos (DDVP) used in insecticidal fogs and evaporation strips was banned by the European Union due to the wish to reduce residue levels on treated products. Furthermore, new concerns on fluoride residues prompted the European Union to reduce the tolerated maximum residue levels in nuts, grain and grain products and dried fruits which reduced the availability of sulfuryl fluoride in stored product protection mainly to structural treatments. Because stored product protection is a rather small market for pesticides with stiff requirements regarding workers safety and residue levels, a significant increase in chemicals available for this purpose seems not probable in the near future. The lack of chemical means of pest control increases the need to prevent and detect pests and renders non-chemical methods of pest control more attractive.

Physical methods to prevent or detect infestation: Physical methods are important means to prevent, detect and control stored product pest within the concept of Integrated Pest Management (IPM) and Integrated Stored Product Protection (see fig. 1). If one thinks of staple food such as grains or pulses, cleaning, drying, and cooling are physical processes essential to keep a durable product in good quality during prolonged storage periods (Vincent et al. 2002). The drying process could be utilized to control pest arthropods that may have found their way into the grains provided that a uniform temperature above some 55°C is achieved for 60 min or 60°C for about one minute. Cooling to temperatures below 13°C prevents insect development and is thus another method to provide safe storage conditions (Fields 1992). This method is used for grain storage not only by organic farmers and its importance may increase due to the loss of dichlorvos emitting strips for stored product moth control in 2007.

Insect-proof or hermetic storage structures or enclosures prevent the immigration of pests and thus could reduce efforts for pest control provided the stored goods are free of living insects at the time of reception. Insect-proof packaging is the only means of pest prevention on the way from processing to consumption, and e.g. some chocolate bar producers have improved the quality of their packages in recent years changing from a wrap with aluminium foil and paper to a gas-tightly sealed plastic film. A recent test of different packaging films to the attack by various stored product insects was published by Riudavets et al. (2007).

For pest monitoring and detection, thermometers are used widely in commercial bulk grain storages to detect heat produced by metabolic activity. Further physical parameters that could be used for pest detection are product moisture content, and movement. In rice grains, optic systems using the NIR spectra are used to remove discoloured kernels from the bulk with the darkening of kernels corresponding to fungal infestation and increased levels of mycotoxins. In some cases, bioacoustics are utilised to detect feeding larvae hidden in grain or adults moving in dry and hard bulk goods (Welp and Reichmuth 1994, Hagstrum et al. 1996).

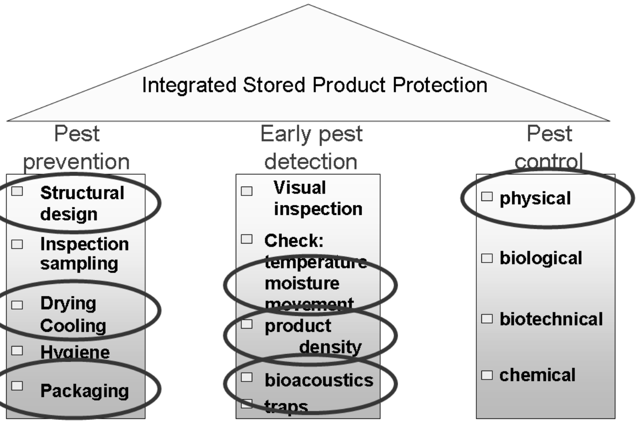

Fig. 1 Physical methods to prevent detect and control stored product pests within the frame of Integrated Stored Product Protection

Physical methods are also applicable for the control of pests. Generally, extreme temperatures and mechanical methods are used for pest control at present. A vacuum can be applied to products packed into a flexible structure in order to remove oxygen from the inter-granular space. Especially at higher product temperatures this can lead to fast and reliable pest control as reported from cocoa storage (Finkelman et al. 2003). On the other hand CO2 can be applied in pressure chambers at high pressures of up to 35 bar in order to achieve rapid control of stored product insects in exposure times of a few hours. Of the almost 7000 t of inert gases used in 2006 for stored product protection in Germany (BVL, see table 1) the majority probably was carbon dioxide used at high pressure for the treatment of products such as herbs, teas, medical drugs, spices, dried fruits, nuts and breakfast cereals.

Heat for structural treatment: Another method that has gained importance in industrialised countries in recent years is the heat treatment of empty structures (Beckett et al. 2007). The high temperatures needed for pest control can be achieved by burning oil or gas and fanning the heated air into a building from outside through air ducts. Another method is the recirculation of air within a building and heating with mobile electrical heaters (Hofmeir 2000). High temperatures above some 50°C need to be achieved in all parts of a building and a thorough vertical and horizontal air circulation during the treatment is essential for the even distribution of temperatures. Insulation material such as corrugated cardboard or large amounts of grain, dust or flour need to be removed prior to a heat treatment because insects would find a save refuge from where to re-infest a structure after the treatment (Adler 2006). Heat was also tested successfully by the tobacco industry for the disinfestation of cigarette producing machines (unpublished data).

A combination of heat and controlled atmospheres is tested for the large scale treatment of tobacco in the countries of origin and for the treatment of medical herbs and spices in Germany as an alternative to carbon dioxide at high pressure or phosphine fumigation.

Cold for product treatment: Some companies apply freezing temperatures to disinfest raw products such as spices, teas, medical herbs, and dried fruits prior to processing. While in some cases cold chambers at constantly minus 20°C are used and products are spread out in trays for a treatment of some 24 h, one company in Germany has run a cooling chamber using liquid air or nitrogen that can provide chamber temperatures of minus 80°C for a more rapid disinfestation in the core of a bigbag. In both cases a temperature of minus 18°C is aimed for in order to achieve complete control. Recent laboratory studies with eggs, larvae, pupae and adult Plodia interpunctella and larvae and beetles of Stegobium paniceum showed that 60 min exposure time was needed for complete control in 5ml of wheat bran. Eggs appeared to be most tolerant which corresponds to the results by Carrillo and Canon (2005) who studied various strains of P. interpunctella. At minus 14°C first results seem to indicate that at least 240 min are needed for a similar level of control. Not all of the tested eggs of S. paniceum were controlled at this exposure time. A preliminary experiment at minus 10°C showed that up to 480 min did not lead to complete control in S. paniceum while all moth stages could be controlled at the longest exposure time tested.

Sieving and milling for pest control in fine powders and flour: Flour mills have a special problem due to the fact that flour and large amounts of dust or powder cannot be disinfested without movement. Powders due to their fine structure are perfect insulators to render extreme temperatures, gases, contact insecticides and other means of pest control ineffective provided the product volume exceeds some 20L. Only mechanical techniques such as sieving may be used for pest control. Sieving has the advantage of separating the contaminant or insect from the flour while milling can be used to destroy living insects prior to packaging. In a number of mills rotary mills (e.g. Bühler Entoleter) are used for this purpose (Plarre and Reichmuth 2000).

Advantages and disadvantages of physical methods for pest control: The methods described here are usually at least as rapid as chemical methods. All of them imply simple laws of physics that render the development of resistance in pests highly improbable. All the methods mentioned do not alter the quality of the treated product and can be regarded as rather safe in terms of workers safety. Physical control methods do not require authorization and leave no residues. A disadvantage of some methods could be the energy input required that could render e.g. freezing too costly for bulk goods such as grain as long as other methods are more feasible.

Conclusion

In general, physical methods are established and widely used methods in stored product IPM. While they may not be feasible in all cases, the loss of chemical compounds may lead to a revival or increased utilisation of physical methods. Improvements in the structural design of bakeries, pasta factories and other processing plants could help to prevent re-infestation after processing steps leading to pest control such as extrusion, drying or milling. Heat treatments could gain importance for the residue-free treatment of machinery or structures

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11 - Heat treatments, state of the technology

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Abstract

From over 400 uses of the ThermoNox system in various customer environments a wealth of experience has been accumulated. Additionally, extensive knowledge on using heat as an insect control method was gained through biological research over the last years. Collaboration with a number of engineers and plant constructors with regard to the suitability for heat treatments of buildings and different installations used in the food processing and other industries has confirmed the technical feasibility of this approach, within certain defined limits. Particular characteristics of thermal treatments in general and the ThermoNox system in particular are outlined, the efficacy as well as the limitations of the technology are shown based on theoretical considerations and practical key figures.

An outlook into the premises to a wider use of thermal methods in the future is discussed, as are opposing factors.

Introduction

For the treatment of stored product pests in buildings, empty silos and storages as well as in food production premises preventive measures have gained enormous importance. Especially cleaning and maintenance of buildings and processing equipment has proven efficient, as these measures can significantly reduce the amount of available food and harbourages. Unfortunately, due to their nature, production residues (dusts) can enter deep into the fabric of a building and into dead space inside machinery. Even the most diligent cleaning can not sufficiently remove these residues because they are not physically accessible.

It is these deep seated sources of latent infestations that cause the necessity for regular treatments. Only two treatment methods can be applied in order to eradicate (= kill pest insects in all development stages) deep seated infestations: fumigation with toxic fumigants and the application of high temperatures. This essay deals with heat treatments.

Thermal treatment: The application of extreme heat intended to kill stored product insects is a relatively old technology, but could not really get a hold in the market since it was replaced by the (fast and relatively cheap) use of toxic fumigants throughout the past decades.

Over ten years ago ThermoNox was introduced and has been put to use in more than 400 premises to-date. During these years knowledge gaps were filled in and a wealth of experience in the practical application has been collected.

Critical questions concerning the efficacy of heat treatments and mortalities of a variety of common SPI can today be answered, thanks to fundamental works done by C. Adler (2005) (Tab.1).

Tab. 1 Lethal effects on heat on various insects

Species		45 °C	50 °C	55 °C
Grain weevil	*S. granarius*	540 min (9 h) (L)	40 min (L)	30 min (L)
Corn weevil	*S. zeamais*	660 min (11 h) (L)	45 min (A)	30 min (A)
Flat grain beetle	*C. pusillus*	1200 min (20 h) (L)	65 min (L)	20 min (L)
Red flour beetle	*T. castaneum*	1800 min (30 h) (L)	35 min (L)	20 min (L)
Tobacco beetle	*L. serricorne*	2400 min (40 h) (L)	370 min (U)	45 min (U)
Lesser Grain Borer	*R. dominica*	6000 min (100 h) (L)	370 min (L)	45 min (L)

In brackets the most sound stadium: E = egg, L = larvae, A = adult beetle Source: www.bba.de

Additionally, reasons for failure, limitations of the technology and causes for building damage were addressed in order to avoid future problems. Time and energy requirements as well other cost relevant parameters can now be properly calculated and prognosticated.

<u>What can go wrong during a heat treatment</u>?

- Various physical processes may occur during a thermal treatment, namely:
- Reversible / irreversible deformation due to unequal temperature (homogenous material)
- Reversible / irreversible deformation due to unequal extension (different material)
- Evaporation of components: water, softeners etc.
- Reduction of strength: modules of draw, pressure
- Initiation of phase transitions
- Initiation of chemical reactions

In order to avoid damages due during warming of different materials, their respective coefficients of extension have to be regarded. Some important coefficients are shown in Tab. 2:

Tab. 2 Thermal coefficient of extension (B. Keller, 2005)

Concrete	$10\ .\ 10^{-6}\ K^{-1}$
Brick	$6\ .\ 10^{-6}\ K^{-1}$
Wood	$15.\ 10^{-6}\ K^{-1}$
Steel	$12.\ 10^{-6}\ K^{-1}$
Aluminium	$24.\ 10^{-6}\ K^{-1}$
Glass	$9.\ 10^{-6}\ K^{-1}$
Plastic materials	$80 – 200.\ 10^{-6}\ K^{-1}$

It is vitally important that combined materials with differing extension coefficients are capable of extending independently – care should be taken to separate (e.g. loosen or remove locks, screws, etc.) such materials wherever possible.

The deformation of a slab of concrete due to difference in temperature is shown in the following:

<u>Concrete slap</u>:

- Thickness: 30 cm, Difference in temp.: 40 K, a = 10. 10 -6 K-1, length: 10 m
- Difference in extension: 4 mm
- Radius of curvature: 750 m
- Strength: 14 N / mm2 << compressive strength (30 – 50 N / mm2)

<u>Occurring differences in temperature are not critical</u>:

- No cracking
- No inacceptable deformation
- Time too short for dehydration

<u>Wood behaves in a characteristic way when heated, in general it can be stated that</u>:

- wood is very temperature resistant
- thermal extension is anisotropic (natural wood)
- wood warps (“works”) below 30% r.h.
- wood is strongest deformated by dehydration >> thermal deformation
- thermally occurring forces << compressive strength
- close to wooden installations is necessary: r.h.> 30%

<u>According to (B. Keller, 2005) different plastic materials display the following behavior</u>:

- **Duroplastics**: non soften, non melt, decompose only at T > 100°C (epoxy, polyester, Teflon, “Bakelite”)
- **Thermoplastics**: can soften, glass point, melt only at T > 100°C (PU, PE, PVC etc)
- **Elastomers**: are already soft elastic, decompose only at T > 100°C (gum, caoutchouc)

Some thermoplastics have a softening temperature in the range of between 50-60°C (heat treatment):

- They can soften: Permanent impressions by resting vertical load.
- Susceptible to shear stress: particular adhesives, soft-PE, soft-PVC
- Plastic materials: Duroplastics, elastomeres and most thermoplastics do not pose a problem below 60°C.

Conclusions for heat treatments:

- Most of the widely used materials are heatable to 55 – 60 °C without problems
- The duration of 24 – 48 h is too short for causing structural damage
- As a precaution: preceding tests can be helpful
- The presence of wood requires humidification

Usually, thermal treatments follow three phases: heating, maintaining target temperature, and cooling.

Heating phase: Energy requirements are highest during the heating phase because all materials of a building including everything inside has to be brought up to the target temperature. During this phase heat is carried exclusively by the air inside the building. Room air is heated not once but is recycled through the heating apparatus, thus kept at the maximum achievable temperature. Since the specific warmth in air is relatively poor high volumes of air have to be circulated.

Heat transmission from air on to a solid body (i.e. building material, equipment, machinery and, subsequently, infested residues) is described with this formula:

$$Q = \alpha\ A\ t\ \Delta\delta$$

$$\alpha \text{ (air on smooth surface, } v < 5 \text{ m/s)} = 5.6 + 4\ v$$

The amount of warmth transmitted through surface A is directly dependent on the heat transmission coefficient α, the duration of transmission t and the temperature gradient between the heated room air and the surface of the object to be heated $\Delta\delta$.

On the right of the equation two values appear given: A the surfaces and $\Delta\delta$ the temperature difference. Since the temperature of the room air must not exceed 60°C the maximum temperature difference can be regarded given. Adjustable are only α, contained within the air velocity v. The time needed for the heating phase t is derived from the other parameters.

Conclusions for a safe thermal treatment:

- Room air max. 60°C , heated through recirculation
- Move heated air with a high velocity to reduce overall heating up time
- Distribute heated air evenly throughout the treatment area to ensure a synchronous, slow and therefore secure heating of everything inside the area
- Avoid local overheating (possible damage!), this requires a sufficiently exact temperature control in the heat generating equipment

Buildings, machinery and other equipment are made from different material, taking up, storing and conveying heat at different rates. This means that there could be a variation in "heat demand" in different rooms, as well as within a single room. It is important to generate the necessary heat in small, independent devices rather that at one central source in order to be able to react to local specifications. To operate several small generators a versatile and efficient system to deploy electric energy is needed (as shown in fig. 1).

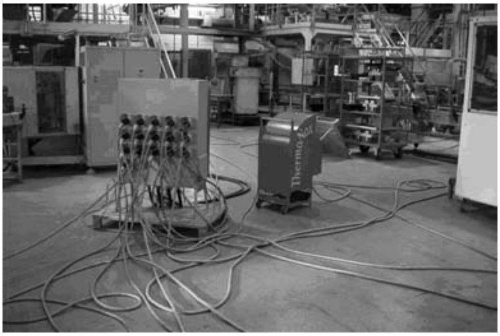

Fig. 1 Distribution of Energy

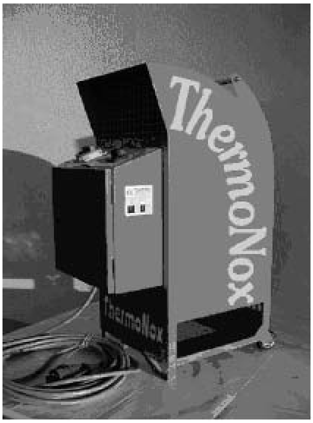

Fig. 2 ThermoNox heater with 18.75 kW (0.75 kW for the fan)

The heater is equipped with an axial fan. Air is sucked into the unit through the bottom sides and fed through the damper registers. Warm air leaves the heater unit horizontally at the top. The temperature of the circulated air is controlled by integrated thermostats.

- The heater is fitted with two wheels and a handle which makes it easy to reposition it during the heating period.
- Depending on nature and amount of material in the room one heater is necessary per each 100 – 500 m^3.

A typical heating curve is shown in Fig. 3. The graph represents a time span of 48 hours, in which the first 24 hrs were needed in the heating phase. Sharp variations in the graph represent repositioning of heaters (sensors were not repositioned). The second 24 hours are the maintaining phase. At the far right of the graph heaters were switched off at the beginning of the third (cooling) phase.

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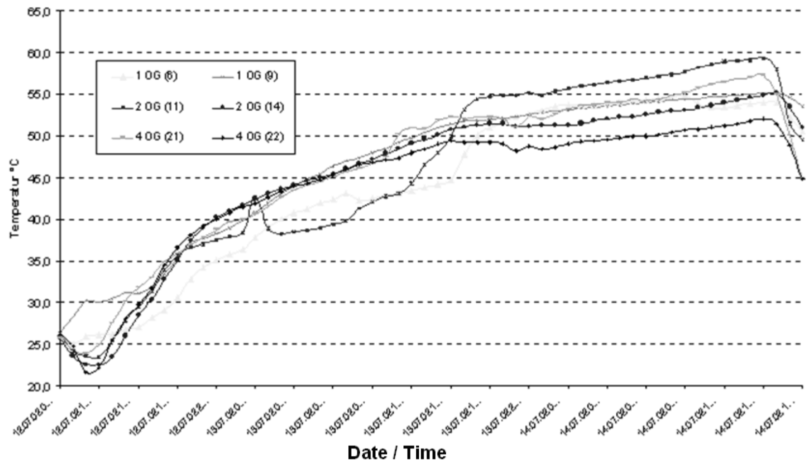

Fig. 3 Temperature curves

Maintaining temperature: During the maintaining phase it is made sure that the target (kill) temperature is reached in all parts of the treatment area and maintained throughout the duration of the treatment. The longer the temperature can be maintained in that phase better heat dissipation is guaranteed a higher treatment efficacy can be achieved. During this phase heaters cut back automatically to 50% capacity and alternate on and off, because only heat loss hast o be compensated.

Cooling phase: Towards the end of the maintaining phase doors and windows are opened, the heaters are switched off but the axial fans are left running. The effect is a "reversed" heat transmission supporting the cooling of building and installations.

Advantages of ThermoNox treatments:

- Absolutely non-toxic pest control in sensitive areas
- No residue, odourless
- Effective against adults, larvae and even eggs
- No resistance in insects possible against heat
- Deep penetration of cracks and crevices and otherwise inaccessible areas
- A secure procedure because of the slow-rising temperature and the maintenance of steady 55 – 60 °C
- Discreet treatment, independent from outside temperatures (year-round method)

Limitations:

- As all treatment methods, the ThermoNox-System has certain limitations and drawbacks. Some of these are:
- Not applicable in locations without a sufficient electrical power source
- Temperature sensitive raw material or products
- Filled containers, silos and plants inside the treated area (heat does not reach infestation > insects survive > recalls)
- Special floor constructions (materials with very different thermal coefficient of extension)
- Big, empty concrete silos, high concrete staircases, humid ground-floors
- Outer walls with outlying isolation
- Insects escaping to an area not heated and survive (barriers!)
- ThermoNox requires trained and experiences application technicians (just like modern precision fumigations)
- Thermal treatments "as such" do not have a lasting effect, therefore they have to be carefully planned and executed – the aim is eradication (no survivors).

The ThermoNox System is not a panacea but very close

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12 - Residues of Biocides and Pesticides in Stored Product Protection (SPP) Available active substances, specific problems

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Abstract

To meet the high quality criteria for food, very effective methods are needed to control insects and other pests during storage. Chemical SPP products are widely used for this purpose. However, the number of active substances which may legally be used in storage protection is very limited. High efficacy of the substances is often linked with high toxicity also towards humans. This gives rise to concerns for the safety of workers and/or consumers. A large variety of food and food products comes in contact with SPP products and consumers may be exposed to these chemicals via residues in food. Storage protection is an area that falls both under the biocide and the pesticide legislation. An an overview is given on available active substances (biocides and pesticides) and some specific residue problems including the current state of discussion in the EU.

Introduction

To meet the high quality criteria for food, very effective methods are needed to control insects and other pests during storage. Storage protection is an area falling both under the biocide and the pesticide legislation. Chemical SPP products are widely used for this purpose. A large variety of food and food products gets in contact with SPP products and consumers may be exposed to these chemicals via residues in food.

The number of active substances which is available for storage protection is very limited. High efficiency of the substances is often linked to a high toxicity for humans that could give rise to concerns for workers and/or consumers. This contribution is focused on consumer protection issues and highlights specific SPP chemicals and their problems from the residues point of view.

Legal Background: The EU Pesticide legislation is mainly based on Regulation (EC) No 396/2005 on maximum residue levels (MRLs) of pesticides in or on food and feed of plant and animal origin and on Council Directive 91/414/EC concerning the placing of plant protection products on the market. The Directive provides data requirements and criteria for including substances in Annex I of 91/414 ("positive list").

A similar regulatory framework has been established for biocides. Council Directive 98/8/EC lays down rules concerning the placing of biocidal products on the market. It contains data requirements and criteria for including substances in Annexes I and Ia ("positive lists"). No MRL legislation is in place for biocides yet. However, it is currently discussed to include MRLs for biocidal substances which lead to the presence of residues in foodstuffs of plant origin in Regulation 396/2005. MRLs for products of animal origin might be regulated elsewhere (e.g. in Regulation (EC) 2377/90 for the establishment of maximum residue limits of veterinary medicinal products in foodstuffs of animal origin). This discussion is ongoing.

Currently Available Chemical Substances in SPP (Pesticides and Biocides)

Pesticides: The following active substances are contained in pesticide products which are currently (25.05.2009) authorized for SPP uses in Germany:

Area of use	Active Substance	Consumer relevance
Products against mites and insects	Phosphides (Al, Mg), phosphane Kieselgur (diatomaceous earth) Carbon dioxide Pirimiphos-methyl Pyrethrins Sulfuryl fluoride	residues in stored products have to be considered
Products against rats and house mouse	Brodifacoum Bromadiolon Difenacoum Zinc phosphide	usually bait application, "no-residue" situation for consumers

In addition, lambda-cyhalothrin may be used for the treatment of wooden containers against insect pests.

In order to reach all parts of a storage facility, most of the insecticides and acaricides used in SPP are applied as a gas or a fumigant. One exception is diatomaceous earth which is applied as a dust. Another one is pirimiphos-methyl which is either sprayed in empty rooms or directly mixed into the grain during loading (admixture). All these applications might leave residues in treated food and feed and require a detailed assessment of the residue situation and the potential risk for consumers.

Rodenticides are usually applied as a bait. Most of the rodenticides listed in the table belong to the group of anticoagulants. When following the directions of use, normally no residues occur on food and feed and no consumer exposure has to be considered.

Biocides: Under the biocide legislation, no national authorizations have been granted yet, because the active substances have to pass the EU assessment first and have to be included in Annex I or Ia of Directive 98/8/EC. The review process proceeds product type by product type and up to now, only substances belonging to the wood preservatives (product type 8) and to the rodenticides (product type 14) have been included in Annex I. These are:

Wood preservatives: Clothianidin, dichlofluanid, etofenprox, IPBC (3-iodo-2-propynyl-butylcarbamate), K-HDO (cyclohexylhydroxydiazene 1-oxide, potassium salt), propiconazole, sulfuryl fluoride, tebuconazole, thiabendazole, thiamethoxam Rodenticides (which includes uses in storage protection):

- Carbon dioxide, difenacoum, difethialone.

Wood preservatives not necessarily get in contact with stored food items. Therefore they are not further discussed in this context.

Rodenticides are usually applied as baits thus giving rise to a “no-residue” situation for consumers. As already mentioned for the pesticides, consumers are not considered to be at risk if the products are used according to the directions of use.

The evaluation of active substances belonging to product type 4 (“Food and feed area disinfectants”) is still ongoing. From this group, benzoic acid is intended to be used for disinfection of storage facilities. Residues in stored products can not be excluded and therefore a consumer risk assessment is required.

Also under evaluation are active substances belonging to product type 18 (“Insecticides, acaricides and products to control other arthropods”). A couple of active substances from this group is intended to be used in storage protection, e.g. aluminium phosphide, magnesium phosphide, sulfuryl fluoride, dichlorvos, flufenoxuron and imidacloprid. Most of these applications might leave residues in treated food and feed and – as already mentioned for the pesticides - require a detailed assessment of the residue situation and the potential risk for consumers.

Borderline pesticide/biocide: It is not always easy to decide if a storage protection use falls under the pesticide or the biocide legislation. The following examples are supposed to illustrate the borderline.

Area of Use	**Pesticide**	**Biocide**
Rodenticide	Use to protect plants from rodents in plant growing areas (agricultural field, greenhouse, forest)	Use to control rodents for reasons of human hygiene (in farms, cities, industrial premises or in plant growing areas if the aim is not plant protection)
Insecticide in storage protection	Target organism is detrimental to plants or plant products Storage goods are plant products in unprocessed state or having undergone only simple preparation (milling, drying, pressing)	Use as a hygiene disinfectant (general biocidal purpose) Storage goods having undergone more advanced food processing

The treatment of empty rooms may fall under both regulatory frameworks depending on the kind of storage goods which is stored in the rooms after treatment.

Discussion of specific chemicals: To make some of the latest decisions and discussions on EU level more transparent, some important SPP chemicals will be highlighted in the following with respect to residues in food, MRL setting and consumer risk assessment.

Sulfuryl fluoride

Biocide Use: Sulfuryl fluoride has been included in Annex I of 98/8/EC as a wood preservative, but not yet as an insecticide, national authorisations for biocidal products with sulfuryl fluoride have not been granted yet.

Pesticide Use: Under the pesticide legislation, inclusion of sulfuryl fluoride in Annex I of 91/414/EC is still pending. From the residues perspective, there are no problems expected, because the only use supported for Annex I inclusion is the use in empty rooms leading to a “no-residue” situation in food and feed. The national authorisation of the sulfuryl fluoride containing product ProFume has been prolonged recently. The registered uses comprise applications in empty rooms as well as in the presence of selected storage goods (dried fruit, tree nuts). The former use in the presence of cereals is no longer supported.

As from 01.09.2008, Regulation (EC) No 396/2005 entered into force. Harmonized European MRLs have been set for the active substance sulfuryl fluoride and also for its main metabolite fluoride. Fluoride is a common nutritional component. Fluoride intake via food adds to the intake from other sources (e.g. tooth paste, fluorinated salt, drinking water). The ingestion of fluoride is recommended on a low level, but the intake of higher amounts of fluoride may pose a risk to consumers. To restrict the fluoride level in food to an acceptable level, MRLs were set for fluoride. Relatively high LOQs were applied to distinguish between natural background level and residues from pesticide application.

- With regard to the registered or formerly registered uses, the following MRLs are relevant:
- Dried fruit: commodity not covered by Regulation (EC) No 396/2005, no MRLs set
- Tree nuts: sulfuryl fluoride: 10 mg/kg, fluoride: 25 mg/kg. Residues resulting from the registered uses in Germany comply with these MRLs.

Cereals: sulfuryl fluoride: 0.05 mg/kg, fluoride: 2 mg/kg. The formerly intended cereal use would have resulted in a much higher fluoride residue than 2 mg/kg and would have given rise to an MRL of 15 mg/kg. Any MRL lower than this would most likely have been violated following the sulfuryl fluoride treatment of storage rooms in the presence of cereals.

A fluoride MRL of 15 mg/kg for cereals was not considered safe for consumers. Taking into account the cereal consumption data from European and relevant WHO diets (as compiled in the EFSA model PRIMOi)), a fluoride residue of 15 mg/kg led to a calculated intake of fluoride corresponding to more than 200 % of the ADI value (ADI 0.12 mg/kg bw/d, WHO 2003). To this point, the calculation has not taken into account the additional fluoride intake from other sources (tooth paste, fluorinated salt, drinking water etc.). Since cereals form a big part of the overall food consumption, an MRL of 15 mg fluoride/kg was not tolerable and it was lowered to the LOQ of 2 mg/kg. With this low MRL in place, currently no sulfuryl fluoride treatments of storage rooms in the presence of cereals (according to typical application conditions) are possible, because the residues in treated cereals would most likely violate the MRL and the cereals would not be marketable. Thus, no respective authorisation is granted.

Dichlorvos

Biocide Use: Under the biocide legislation, dichlorvos has not yet been included in Annex I of 98/8/EC, the peer review is currently ongoing. National authorisations have not yet been granted. The representative use in the context of Annex I inclusion is the control of insects in storage protection or animal housings by means of a strip application.

Pesticide Use: Under the pesticide legislation, the non-inclusion in Annex I of 91/414/EC has been decided two years ago (2007/387/EC, 07.06.2007ii)), because no safe use could be established. The last remaining use in the context of Annex I inclusion was the control of insects in storage facilities in the presence of flower bulbs by using fogging vaporising equipment. This use has no relevance for consumers. Since all other formerly supported uses in presence of consumable stored products have been withdrawn by the applicant, there was no need to complete the consumer risk assessment on EU level. Main reason for non-inclusion was the incomplete data package in the toxicology section. Due to uncertainties concerning genotoxic and carcinogenic properties of dichlorvos, very low toxicological reference values were established tentatively: an ADI of 0.00008 mg/kg bw/day and an AOEL of 0.0005 mg/kg bw/day. Based on these values, no safe use could be established for operators, workers and bystandersiii). As a consequence of non-inclusion in Annex I, the MRLs for dichlorvos were lowered to the respective LOQ in all plant matrices (which was 0.01 mg/kg in most matrices) and all national authorisations for pesticide products containing dichlorvos had to be withdrawn.

Phosphides (Al, Mg), phosphane

Biocide Use: Under the biocide legislation, aluminium and magnesium phosphide have not yet been included in Annex I of 98/8/EC, the work is ongoing. National authorisations therefore have not yet been granted. Some of the representative uses of the phosphides listed in the EU biocide dossiers are comparable to those listed in the pesticide dossiers, apart from lower application rates for the latter.

In preparation of national product applications for phosphide containing biocidal products, the uses will have to be defined accurately and should refer only to those stored products which are not under the scope of pesticide legislation (e.g. chocolate products, milk powder, natural fibres, packing materials). These phosphide applications might leave residues in stored products and the residue situation has to be addressed appropriately. It is not yet clear how to describe and group potential “biocide” storage goods (i.e. storage goods in the presence of which the use would be considered a biocidal use) and which data requirements for residue trials will apply.

Data requirements have to be developed on EU level. A new biocide working group with members from several EU member states, EFSA, EMEA and COM has been established in May 2009. It is called DRAWG (Dietary Risk Assessment Working Group) and it is chaired by Germany. The mission of this group is:

- to develop appropriate, use-specific exposure scenarios for biocides which allow for an estimation of biocide residues in/on animals (and in a later work stage of the group also in/on plants),
- the definition of data requirements for the refinement of exposure estimations and
- the establishment of detailed procedures and the definition of potential further data requirements for dietary risk assessment.

Pesticide Use: Under the pesticide legislation, aluminium and magnesium phosphide have been included in Annex I of 91/414/EC, the inclusion of phosphane is still pending.

MRLs for aluminium and magnesium phosphide are currently re-evaluated and waiting periods the user would have to adhere to are re-considered (waiting period: shortest allowed time interval between end of treatment+ventilation and marketing of the stored product). It can be foreseen that further re-evaluations will be required once phosphane has been included in Annex I of 91/414/EC. Depending on the decision on how biocide MRLs will be regulated in future, further amendments might be needed to reflect also the biocide uses of phosphides.

Pirimiphos-Methyl

Biocide Use: Under the biocide legislation, no use of pirimiphos-methyl has been assessed yet.

Pesticide Use: Under the pesticide legislation pirimiphos-methyl has been included in Annex I of 91/414/EC based on the use in empty cereal storehouses. On national level, in addition to this use the post-harvest treatment of cereals by directly mixing the pirimiphos-methyl into the grain during loading is authorized (admixture use). The maximum application rate for the admixture use is 4 g as/t. Currently an EU MRL of 5 mg/kg is in place for pirimiphos-methyl in cereals, but this MRL is under discussion. Any MRL lower than this would most likely be violated following the admixture use in cereals. Depending on the EU decision on the MRL for pirimiphos-methyl in cereals, the national authorization of the admixture use might be withdrawn.

The ADI value of pirimiphos-methyl has been lowered to 0.004 mg/kg bw/day on the occasion of Annex I inclusion with the consequence that the cereal MRL of 5 mg/kg exceeds this ADI. In a first opinion, EFSA recommended the lowering of this MRL but also highlighted that the existing MRL for cereals could be maintained if a more refined intake calculation proves that this MRL does not pose a consumer health risk. The refinement is still ongoing on EU level.

First step of refinement was not to use the MRL in chronic risk assessment but the median residue from supervised residue trials. In addition to that, some readily available processing factor were applied for wheat flour, whole meal flour and oat flakes.

With this refinement, five diets from those compiled in the EFSA PRIMO model still resulted in an exceedance of the ADI value considering cereal consumption only (see Fig. 1). These were three WHO cluster diets, the Irish adult diet and the Italian children diet. Because the WHO cluster diets are based on food balance sheets rather than on real food intake information, there is not much room for refinement. However, they tend to overestimate the intake considerably and are therefore not fully relevant for consumer risk assessment.

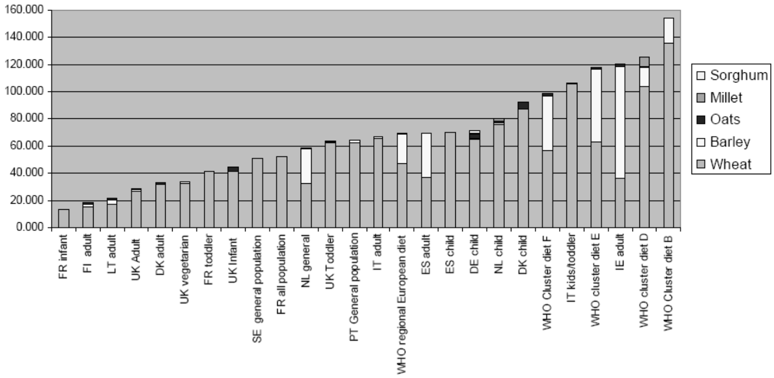

Fig. 1 Refined dietary intake assessment for cereals, using the STMR-p values for wheat and oats and the STMR for barley, sorghum and millet. The exposure is expressed as % of ADI.

Looking into the Irish adult diet in more detail reveals that the main contributor to the overall intake was barley. Further data submitted by Ireland confirm, that the barley intake mainly traces back to beer consumption and that it would be reasonable to use an appropriate processing factor (barley -> beer). With this factor, the chronic risk for Irish consumers based on the intake of pirimiphos-methyl residues via food was acceptable.

Main contributor to the diet of Italian children was wheat, most likely consumed as bread or pasta. More detailed consumption data would be needed for refinement.

Other options for refinement are currently discussed on EU level. One option would be to use a 'percentage of crop treated' factor. This factor could be 0.5 in case of pirimiphos-methyl, based on information according to which 0-44 % of wheat and barley are treated with pirimiphos-methyl in EU member states. However, the European Commission seems to disapprove of this approach. Also the second option, the use of monitoring data in the assessment instead of data from supervised residue trials, will most likely not be followed by the Commission.

Instead or that, EFSA was asked again for a revised risk assessment which was provided recentlyiv). EFSA collected more detailed cereal consumption data and re-calculated processing factors for cereal based products. Still supported uses are barley, millet, oats, sorghum and wheat. With all the new data available, it is now two UK diets (infants and toddlers) which exceed the ADI value. According to all other diets the risk for consumers is now acceptable. Main contributors to the UK diets are wheat bran and wholemeal bread. Concerning wheat bran, it is currently not clear from the data and has to be confirmed by UK, if bran is consumed as such or in the form of bran-based breakfast cereals. In the latter case, a different processing factor would apply and the risk would also be acceptable.

EFSA proposes to maintain the MRL of 5 mg/kg for pirimiphos-methyl in barley, millet, oats and sorghum. If the bran intake in UK turns out to be acceptable, the MRL of 5 mg/kg will also be proposed for wheat. If not, EFSA proposes to lower the wheat MRL to the LOQ.

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13 - Grain and seed storage in France: State of practice and perspectives

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Abstract

ARVALIS – Institut du végétal is a French research and development institute working for farmers on different topics: in the field as well as after harvest with storage and quality preservation of grain. This work is carried out with various partners: public and private research institutes and professional organisations. In France, storage of cereals between harvest and use takes place in elevators and on farms. A survey carried out by the French National Office for Cereal (ONIGC/France Agrimer) showed that elevators use various ways to fight against insects, for example with preventive or remedial use of insecticides.

In this frame and given the current regulatory reduction of chemical products on the market, ARVALIS– Institut du végétal recommends the application of preventive practices through vocational scientific and practical training, articles in specialized papers, and meetings. The approach is first to store clean grain free from insects in cleaned premises. Additionally, the most important parameters to control and manage quality of stored products during storage are grain humidity and temperature. Thanks to this procedure, insects might not infest grain. But in case of insect development in the grain, elevator workers can use one of the three authorized liquid insecticides or control treatment. At the same time, ARVALIS is involved in research. The topics are close to the current preoccupations of elevator operators: sampling (how to get a representative sample of grain for insects search), early detection of insects in stored grain, use of aeration to cool grain temperature to avoid attracting insects to the grain and use of physical processes to kill insects (heat…).

Introduction

ARVALIS is a French institute involved in applied agricultural research. This paper introduces some of ARVALIS activities in the field of grain storage and preservation, and gives some pointers into the understanding of grain storage in France.

ARVALIS – Institut du végétal is an agricultural research and development institute composed of 400 people working in close relation to the food and cereal channel operators.

Principal topics range from the production of different cereal species to the different qualities of cereals required by users. In the field, there are trials of seed assessments, better crop management practice, cropping practices.

ARVALIS works on cereals, maize, pulses, potatoes and forage crops. After harvest, the institute is involved in research on the reception and evaluation of grain quality, grain cleaning and cooling ventilation during storage.

ARVALIS board of directors includes food and cereal channel operators, cultivators also participate in the financial support of the institute.

This is why ARVALIS is so close to the cultivator’s direct preoccupations, to improve competitivity whilst preserving the environment.

The current challenge is to help farmers to adapt their procedures to market and regulation changes, by providing research results, informing, training and advising them in their activities.

Our activities are usually undertaken in partnerships with other institutions, either private or public. Basic research is carried out with the INRA (National Institute of Agronomic Research).

ARVALIS also works with local advisors. They help ARVALIS understand the local demand (in terms of training for example) which is taken into consideration with 19 ARVALIS stations are located throughout France.

France produces approximately 60 million tonnes of cereals each year, cultivated on 9 million hectares.

Almost half of the grain cultivators (47%) store it at on farm, wholly or partially, as feed or to sell on the market, directly or through grain merchants.The grain storage is akin to a chain in which cultivators are the first link. They can sell the grain immediately after harvest or store it on farm in order to sell it later, depending on market prices.

The second link of this chain is composed of around 850 grain merchants.

Grain is stored in cooperative structures or on private grain merchant premises.

Further links could be harbour storage silos, grain merchants or grain processors (millers etc.).

In the current legislative framework, with the recent withdrawal of active substances such as dichlorvos and malathion, all these links have to work together and communicate on their practices.

The relationship between cultivators and grain merchants depend on the contract, the quality of the grain stored and the silo policy. For example, some silo operators visit cultivators to inspect their premises during storage. Some farmers may treat the grain as a curative or a preventive method to guard against insects, all treatments should be noted and indicated to the grain merchant.

Given these elements, the MRL of some active substances could be exceeded and a building up of different storage insecticides could occur.

Traceability of all pesticide usage and more widely all storage techniques used is part of good storage practice.

The message delivered by ARVALIS is clear: store clean grain in clean facilities, regulate humidity and temperature. But it is not as easy to put these credos into application: only 40% of French wheat is cleaned at reception at the silo. There is also a lack of sufficient equipment to cool stored grain, and sometimes a lack of knowledge on silo management.

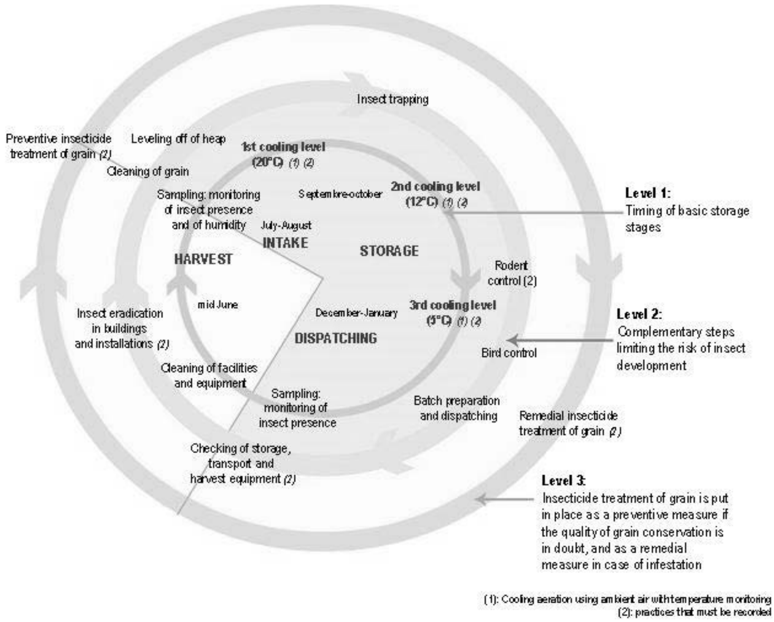

Fig. 1 Good practices to prevent insect development and guarantee grain sanitary quality

There are 3 levels on this chart, each level overlaps onto the others.

Level 1 is composed of the basic storage steps:

- Cleaning facilities and equipment are necessary to ensure a dust free environment.
- When premises are empty, they should be cleaned using brushes and vacuum cleaners.
- Sampling grain at reception makes it possible to detect insects and determine grain humidity. If the humidity of grain is higher than 16%, drying is recommended with aeration or in a grain dryer.
- During storage, the temperature should be lowered using cooling aeration. 3 steps are recommended:
- 20°C immediately after harvest. This should help prevent attracting insects to the grain.
- 12°C in autumn. If insects did penetrate the grain, at such temperatures they would stop feeding and reproducing.
- 5°C in winter. If the grain temperature remained at 12°C for more than 3 weeks, insects would be killed in a few months at this temperature.
- Sampling grain before dispatch ensures the operator that there are no living insect in the grain.

Level 2 is composed of complementary steps to limit the risk of insect development:

- Maintaining harvest and storage equipment: more than just cleaning, all equipment must be cleaned and maintained in good working order.
- Flow rates must also be verified.
- Preventive insecticide treatment on cleaned material, equipment and premises ensures the absence of insects before loading silos with grain.
- Cleaning grain removes dust and straw, clean grain is less easily infested by insects.
- Levelling off the heap allows the cooling aeration to penetrate efficiently throughout the whole pile. When piles are not levelled, aeration is much less efficient, which can allow the necessary conditions for insect development.
- The use of mechanical insect traps during storage may show signs of insect infestation. Early detection makes it possible to undertake curative insecticide treatment.

Level 3 may be applied if there is any suspicion of substandard preservation or in case of a declared insect infestation. The following treatments should only be undertaken with authorized products:

- Preventive insecticide treatment may be used in case of suspicion of bad preservation, or in cases where it isn’t possible to run cooling aeration.
- Remedial insecticide treatment of grain may be used in cases of a declared insect infestation in grain detected by using traps or sample review.

All these steps are part of ARVALIS’ message. These levels are not fully implemented at every storage site in France, but some operators do already follow similar practices.

In this framework and given the current regulatory reduction of chemical products on the market, ARVALIS–Institut du végétal recommends the application of preventive practices through vocational scientific and practical training, articles in specialized papers, and meetings.

Our team is currently involved in research projects on the development or novel methods as well as the evaluation of new equipment for the detection and prevention of insect infestation.

Our topics remain close to the current concerns of grain merchants’ operators : sampling (or how to obtain a representative sample of grain), early detection of insects in stored grain, the use of aeration to cool grain temperature to avoid attracting insects to the grain, grain cleaning and use of physical processes to kill insects.

In conclusion, the future of ARVALIS activities will be the stewardships of current and probably new grain preservation methods. Professional training is a good way to help operators improve their practices.

Arvalis is interested in building new research projects or even discussions with organizations of other countries on grain storage and preservation.

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14 - Efficacy against eggs of Tribolium confusum and Tribolium castaneum after fumigations with sulfuryl fluoride (ProFume®) in flour mills

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Abstract

After the phase out of methyl bromide and dichlorvos (DDVP) the disinfestation of flour mills is in a difficult position in the European Union. Sulfuryl fluoride (ProFume®) is registered in France for the disinfestation of empty premises since 2006. The cost of a fumigation is very high, that's why the aim of this study is to assess the effectiveness of fumigations at low concentrations of sulfuryl fluoride on eggs (the most tolerant stage) of the two mains flour mills pests: *Tribolium confusum* Jacquelin du Val and *Tribolium castaneum* (Herbst). Four mills were fumigated with different concentrations, for an exposure time of 21 to 39 hours with, in five levels of each mill, two 20 litres plastic drums containing flour wheat infested by eggs of *T. castaneum* in the first drum and eggs of *T. confusum* in the second. The two controls, containing eggs of these two species of Tenebrionidae, were placed in the same conditions but without undergoing the fumigation.

After fumigation, the CT products were included between 310 g.h/m3 to 1350 g.h/m3, with temperatures included between 19.6 to 34.1°C. The CT products correspond to 25 to 250% of the CT products advised by the Fumiguide® for a total disinfestation (all stages of all insects species controlled). Low concentrations did not kill all eggs of *Tribolium* spp. in these fumigations. However a variable level of egg control was achieved, depending on the conditions (temperature and CT product). For the eggs of *T. confusum* between 25 to 100% were killed compared with controls. The temperature and above all the CT product were the mains factors which can affect the efficacy on eggs. On the other hand, between 0 to 99.9% of *T. castaneum* eggs were killed, compared with controls, with temperatures below 30°C. But when temperatures exceeded 30°C, the efficacy was enhanced because between 65 to 100% of eggs were killed. For the *T. castaneum* species, the increase of temperature is the most important factor, compared with the CT products reached, which enhances the efficacy of egg's control. Few CT products were higher than the CT products advised by the Fumiguide® but nevertheless they didn't reach the 100% of egg's mortality, at a temperature below 30°C.

As a result, it seems necessary to combine fumigations with heat at 30°C minimum inside the flour mill before and during the treatment in order to reach 100% mortality on the most tolerant stage of *Tribolium castaneum*. Moreover, this practice improves the results of fumigations with low concentrations of sulfuryl fluoride allowing to be close to a total disinfestation.

Introduction

Since the phase out of methyl bromide and the loss of dichlorvos (DDVP), it is very complicated to disinfest with effectiveness the flour mills in the European Union. Sulfuryl fluoride (ProFume®, the DowAgrosciences fumigant) is registered for structure treatments in France since 2006 and this gas began to be used at commercial scale in 2007. However, sulfuryl fluoride is not a very good ovicide with an application rate of 20 g/m3 (dosage generally used with methyl bromide before its withdrawal). It is difficult for the gas to cross the chorion of the insect's eggs. The most tolerant life stage of *Tribolium* spp. with sulfuryl fluoride is the egg stage (Bell et al, 1998), that's why sometimes it is necessary to make flour mill's fumigations with an application rate of about 70 g/m3. This kind of practice can be expensive for millers and, in some cases, they can't do fumigations in their mill. So, the cost of the treatment is quite often a barrier to the use of ProFume® for the disinfestations of flour mills.

However, there is a huge difference between the dosages which ensure to control all stages of all flour mill insect pests, and the dosages which are necessary to kill all stages of these insect species, without a part of eggs, and more precisely a part of eggs of *Tribolium* spp. Moreover, there is a huge difference between the sensibility of *Tribolium castaneum* eggs and *Tribolium confusum* eggs to sulfuryl fluoride fumigations. The eggs of the first species are more tolerant to sulfuryl fluoride than the eggs of the second (Bell et al, 1998).

Sulfuryl fluoride dosages are expressed in Concentration Time Product (CTP or CT), in order to get a good estimation of biological efficacy. The CTs needed to obtain a good disinfestation depend of the temperatures recorded during the gas exposure time in mills, that's why this study tries to get a lot of cases where there were a large diversity of these three mains parameters: sulfuryl fluoride concentrations, exposure times and temperatures.

This study is set up to investigate the impact of flour mills fumigations with sulfuryl fluoride at different dosages on egg's populations of *Tribolium castaneum* and *Tribolium confusum* in full scale.

So, in the case where the results of low dosages of this study are beneficial to disinfestations programs, it leads to:

- open new opportunities to millers from an economic point of view,
- find a good alternative to dichlorvos treatments and to disinfestations by contact insecticides,
- decrease the risk of finding residues in the stored part of the mills close to fumigated areas.

Material and methods

The trials were carried out in four flour mills, with different conditions of temperature, injected gas amounts, speed of wind. The volumes of these premises were between 5000 to 7500 m3. These flour mills are located in France, two of them were selected for fumigation with low dosages in Peyrehorade (5000 m3) and Sallèles d'Aude (6900 m3). The two others were fumigated with the dosages recommended by the Dow Agrosciences Fumiguide® (a software used like a tool to advise and help the fumigators during the fumigation), to control all stages of the most tolerant stored product pest to sulfuryl fluoride: *Tribolium castaneum*, in Gond Pontouvre (7500 m3) and Gerzat (7500 m3). This investigation was undertaken between June 2008 and November 2008.

In laboratory, populations of the two species *Tribolium castaneum* and *Tribolium confusum* were reared in a chamber at 27 ± 1°C and 60% of relative humidity ± 5%. A week before each fumigation, for each species, 100 adult insects were put in a 20 litres plastic drums with one kilograms of wheat flour. After this week, the adults have laid eggs in the flour and there were in the drums a mixed aged eggs included between few hours to seven days. The development of the eggs to the larvae stage, in these conditions, is about 6.8 days for *T. castaneum* (Howe, 1956) and 7.7 days for *T. confusum* (Howe, 1960). The drums were closed but there was a gap in the lid closed with a Whatman® paper in order to have an air exchange but no insects circulation between the inside drum and the outside.

The drums containing the infested flour with adults and eggs were placed at different levels of the mills just before the injection of ProFume® inside the mill. All drums were equipped with a temperature/R.H. sensor/recorder Captsystèmes and a sampling gas pipe was placed on the top of the drum. For each trial, it had to take exact gas concentration and temperature measures for each level of the flour mill with an Automate (Captsystèmes). When the fumigation began, few hours later, the *Tribolium* spp. adults were removed from their drum in order to stop the laying in these control drums because in the fumigated drums, adults were killed by the gas.

The fumigations were carried out by a French professional pest control company: AgroTechmoHygiène (ATH). The dosage for sulfuryl fluoride was determined according to the temperature at the moment and in order to have overall several CTs with low and recommended dosages.

The fumigation results are expressed as Concentration - Time Products (CT) because it is easier to compare CT values (in g.h/m3) in the different mills. Then, the CTs reached in each level of each mill were compared with the registered CT recommended by the Dow AgroSciences Fumiguide®. After fumigation, the flour of each drum was sifted and the dead adults were counted and removed from the drum. Each drum was put in controlled conditions, in the rearing chamber, and after two months, the flour was sifted in order to count the adults resulting from the eggs at the moment of the treatment. These results were compared with the adult populations in the controls and then, a mortality rate of eggs was calculated for each modality.

Results and discussion

The fumigations with low dosages were carried out with an amount of injected gas included between 22.7 to 32.9 kg of ProFume® for 1000 m3 fumigated (Table 1). On the other hand, the two fumigations with recommended dosages have required between 68 to 90.7 kg of ProFume® for 1000 m3 fumigated. The dosages depend of the temperature inside the mill during the fumigation, but these amounts introduced show a trend of the reduction of dosages for sulfuryl fluoride fumigations. The low dosages fumigations needed, in these cases, twice to four time less gas than the fumigations with recommended dosages.

Tab. 1 Amount of injected gas for each fumigation of flour mill

	Injected gas amounts (kg/1000m3)	**Exposure time**
Gerzat	68	22h15
Gond-Pontouvre	90,7	39h
Peyrehorade	22,7	21h
Sallèles d'Aude	32,9	22h30

To enable a comparison of the efficacy of each fumigation on the egg stage of the two species of *Tribolium* spp., the two mains parameters (temperature and CT reached) involved in the efficacy of fumigations were collected in a 3D chart (Figure 1 and 2). These charts collect all the data obtained after the fumigation of all levels of each flour mill. The efficacy of fumigation is expressed as mortality rate of eggs compared with the control.

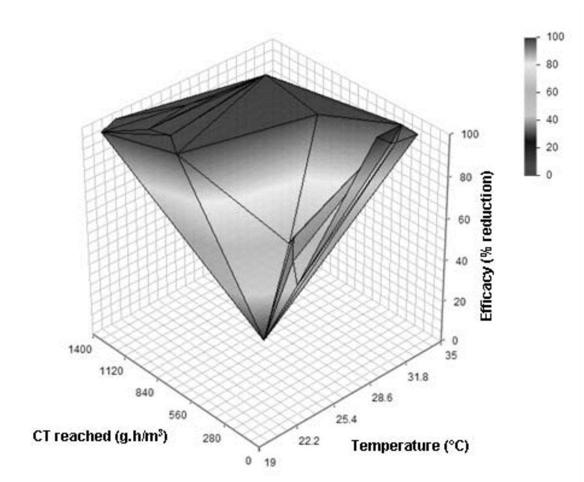

Fig. 1 Mortality rate of *T. confusum* eggs (compared with control) according to CT reached and temperature during the fumigation with sulfuryl fluoride

The results shown on this figure demonstrate that the CT products reached 310 to 1350 g.h/m3 and the temperatures recorded during the fumigations were between 19.6 to 34.1°C. The efficacy, related in percentage of *T. confusum* eggs killed (compared with the control), is more important when there was a high temperature (more than 30°C) in the mill during the fumigation or when the reached CT was important (more than 1000 g.h/m3) (Figure 1). However, in a situation where the reached CT and the recorded temperature were low, the percentage of mortality can decrease to an eggs mortality rate of about 20% compared with control.

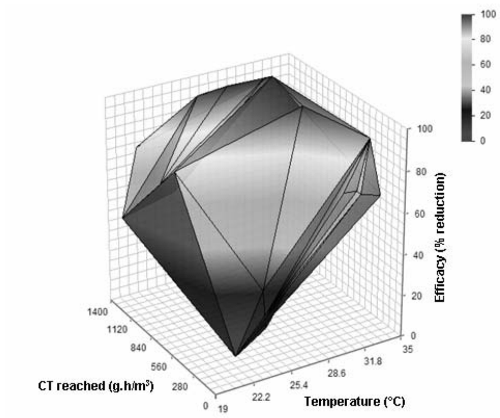

Fig. 2 Mortality rate of *T. castaneum* eggs (compared with control) according to CT reached and temperature during the fumigation with sulfuryl fluoride

First it is obvious on this chart that there is difference of sensibility between the two species of *Tribolium* spp. (Figure 2). The mortality rate of *T. castaneum* eggs is different from the previous figure. Comparing with the previous results, when the temperature during the fumigation is not very high (below 25°C), the efficacy of the treatment is not very good even if the CT reached is high. The temperature needs to be high to get a high effectiveness on eggs of *T. castaneum* when the CT is lower than the recommended CT. With a low temperature (about 23°C) and a low CT reached (about 330 g.h/m3), the efficacy resulting of this combination is bad because there are no differences between the control and this modality concerning the emergence of adults from eggs, but it is a good alternative to dichlorvos as no post embryonic stage survived. So, in this case, the temperature is the main factor which leads to a good ovicide efficacy. An increase of temperature with just few degrees shows direct effects on the efficacy of fumigations (recommended or low dosages) on *Tribolium* spp. eggs. In the two cases, when the average temperature during the fumigation was 30°C or more, between 65 to 100% of eggs were killed depending on conditions.

Conclusion

The main factor of successful fumigations with low dosages is the temperature (particularly to control *T. castaneum* eggs). The fumigations (with recommended or low dosages) below 25°C seem to provide disappointing results, that's why the increase of temperature in order to reach 30°C at minimum allows to:

- reach for sure 100% of egg mortality (with recommended dosages) for *T. castaneum*,
- improve the egg's mortality with low dosages fumigations,
- reduce the gas exposure time,
- reduce the necessary amount of gas.

To conclude, this study confirms other studies (Reichmuth et al., 2003), the dosage can be reduced "intelligently" with good results in disinfestations of stored products pests. The fumigations carried out without controlling all the eggs of the populations of *Tribolium* spp. have allowed to kill all the others stages of these pests (larvae, pupae and adults). Moreover, with low dosages, even if the fumigations don't kill all the eggs of *Tribolium castaneum*, the most tolerant species to sulfuryl fluoride (Bell et al., 2002), the treatment may control all or almost all the stages of others species of insect pests. It is therefore a good alternative to the ban of dichlorvos.

May be the best way consists to combine the fumigations, with low dosages of sulfuryl fluoride, with heat in order to reach 30°C inside the mills before and during the treatment but the economic impact of that combination needs to be assessed.

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15 - Post harvest protection against insects in the bulk grain supply chain the views of economic operators

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Abstract

European (EU-27) grain & oilseeds storers are regularly facing insect management issues. Under worldwide trading standards, the grain industry is committed to maintaining the "zero tolerance" for live insects (WTO-SPS agreements). The grain being harvested each year therefore has to be stored in a manner which ensures that these standards are met. The presence of living insects in stored grains would jeopardize the supply of the grain & oilseeds supply chain, both for food and feed as well as for exports. In this context, our survey covers a quantity of agri-product that is equivalent to 5% of the EU-27 production. Results show that storage operators need several modes of action in order to prevent and cure the build-up of insect infestations in grain while avoiding pest resistance. Ventilation, silo cleaning and fumigation are important aspects in the implementation of an integrated pest management. Because of legislative restrictions, we now rely on one fumigant and on only a limited number of residual storage insecticides. As a result, we show that European operators will face difficulties to combine the available management technique. Therefore we stress the need for legislative development together with an

increase in research and development of new active substances. In addition, flexibility should be given to producers which are willing to submit a product composed with a generic active substance.

Introduction

Each year, EU-27 exports about 9% of its grain crop and although these exports are extremely important to the European economy they represent only about 8% of the total world trade in grain. To maximize competitiveness with this small fraction of world trade, the European grain industry works to ensure products of consistently high quality. Within the supply chain operations, the bulk commodity trading system holds a couple of characteristics. Firstly, storage operates at most of the steps of the cereal & oilseed supply chain. Secondly the collection, trade, transport and processing of commodities is characterized by aggregation of many small consignment into large, uniform bulk shipments. Thirdly, aggregation and mixture takes place at all levels and economies of scale are most important. Finally, compliance with certain quality parameters is crucial. By continuous checks and inspections at the time of export by national authorities, this high quality will be officially granted by issuing a phytosanitary certificate, which is an absolute must with any export originating from the EU. The absence of live insects and other biological contamination have become an important consideration.

In this respect, insect management of stored grain is and was always an important tool for maintaining high quality. The ongoing review process of active substances in the European legislative framework has consequences for grain storage at any operating level. Most of the active compounds used for knockdown treatments (showing rapid effect on insect populations) were phased out in the review process under Directive EC 91/414. Equivalent treatments applied as an alternative are scarce (Deltamethrin, Pirimiphos methyl and Chlorpyrifos methyl) or not always easy to implement (fumigation). Any further loss of active substances will make it nearly impossible to manage infestations. In the light of this technical impasse; Coceral, Euromalt, Unistock, Euroflour and Euromaisiers have carried out a survey to get an accurate understanding of insect management as it is applied by the grain and oilseeds storekeepers.

Above all, the distinction must be made between active substances (ASs) used to knock-down the adult insects and other ASs used as preventive and long-lasting measure to destroy also the larvae and eggs. The survey shows that the use of Delthamethrin and Pirimiphos methyl, widely known as contact insecticides, will possibly increase. As a consequence this can lead to higher chemical residues in the grains and the development of pest resistance could occur even faster. At the same time, the development of pest resistance to widely used compounds could occur even faster than before.

As a consequence, operators will struggle to comply with the nil tolerance for live insect for the following reasons:

- The ASs having a knockdown effect are removed from the market.
- The fumigation, when safe and feasible, is fully efficient only if material is sealed for several days (depending on the temperature, the volume of grain and the silo).
- The 3 ASs that are still authorized have a poor knock down effect. However, theirs efficacy is rather constant on the long run.
- Pyrethroids are highly soluble in fat (eg Deltamethrin). Therefore, the number of storage insecticides for oilseeds is even more limited.

Efficient ventilation and cooling devices are used to obstruct and stabilize at a low level the growth of insect's population. On the other hand, in the major exporting countries the climate is such that cool air is not sufficiently available after the harvest. And higher air flow may be required for timely aeration. Experience shows that this is often considered as economically unfeasible. Therefore, chemical application is needed.

Nevertheless, ventilation, cleaning and fumigation cannot be the sole remedies for prevention of losses in stored grain. Efforts should continue to integrate other methods with these technologies, including insecticides.

The five mentioned European associations therefore stress the need for the legislation to take into account legislative constraints operators are faced with. In particular, both review process of MRLs and of existing substance should grasp the technical constraints of managing grain & oilseeds storage.

Even though especially small and medium sized companies continue to research and develop new active substances, interest in research gets weaker and weaker due to legislative pressure. The major insecticide producers usually focus on the field sciences and consider the next steps of the supply chain as negligible. Consequently, the grain industry, together with the grain traders urge the plant protection industry to focus more research effort on storage insecticides and alternative technologies in order to obtain effective and less hazardous formulations.

Trade & Services: COCERAL: the European grain & oilseeds traders, UNISTOCK: the European port silos operators , EUROFLOUR: the European wheat flour exporters.

First process industry: EUROMALT: the European malting industry , EUROMAISIERS: the European maize milling industry

16 - Cross-contamination of oilseeds by insecticide residues during storage

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Abstract

Pesticide residues are found in oilseeds (rapeseed and sunflower) and crude oils: they are mainly organophosphate insecticides (pirimiphos-methyl, malathion) used in empty storage facilities and for application to stored cereal grains. Even if pests are found in stored oilseeds, French regulation does not allow use of these insecticides on stored oilseeds. These residues arise from cross-contamination from storage bins and facilities, and not from illegal use. This uptake of insecticide residues from their storage environment by oilseeds can lead to levels that exceed regulatory limits. A two-year investigation in grain storage companies allowed us to follow the course of 27 sunflower batches (storage season 2006-2007) and 21 rapeseed batches (storage season 2007-2008), from reception at the storage facilities to outloading. Samples from each of these batches, made at outloading, were analysed by ITERG, looking for insecticide residues. Traceability of oilseeds established by storers allowed us to identify cross-contamination sources. Substances discovered were mostly pirimiphos-methyl, and malathion, dihlorovos (in sunflower), plus chlorpyriphos-methyl and deltaméthrine (one case). Pirimiphos-methyl was most commonly detected, and caused most cases of non-accordance with regulatory levels in rapeseed. Main cross-contamination hazard resulted from treatment of cereals at their receipt during the same period of rapeseed receipt, especially when these cereals treatments were frequent on that elevator. For sunflower, main cross-contamination hazard resulted from treatment of cereals at outloading, just before sunflower seeds were outloaded, especially when these cereals treatments were frequent on that elevator. Other situations led to cross-contaminations, but generally of lower levels: oilseeds stored in bin that contained previously treated cereals, empty bins and handling equipment treated before receipt of oilseeds.

Introduction

Post-harvest insecticide residues can be sometimes found on oilseeds, at low levels. But, no insecticide is allowed to be applied directly on oilseeds during storage. Consequently, maximum residue levels (MRLs) allowed by European regulation are very low (mostly at the lower limit of analytical determination): 0,05 mg/kg for pirimiphos-methyl, 0,05 mg/kg for chlorpyriphos-methyl and 0,1 mg/kg for deltamethrin on rapeseed. No MRL existed for malathion during this study, so it shouldn’t be found beyond the analytical limit of quantification (10 µg/kg); but since September 2008 the MRL for malathion in oilseeds is 0,02 mg/kg (Commission regulation n°839/2008 of 31 July 2008).

These insecticide treatments are authorised on stored cereals and corn as grain protectants, and on empty storage and handling equipment as control agents for residual insect populations in empty granaries. Pirimiphos-methyl and still malathion were the substances most employed during this study (storage season 2007-2008). Dichlorvos and malathion were forbidden and could be used only until 1st December 2008. As MRL for dichlorvos has lowered to 0,01 mg/kg in cereals in November 2006, this substance, which was largely used until the previous storage season 2006-2007, could not be used by storage companies anymore. MRL of malathion hadn’t been lowered in cereals, so it could be still be used.

We can hypothesise that cross-contamination phenomena can exist, between these various kinds of seeds, cereals and oilseeds, sharing the same grain handling and storage system. This phenomena has already been demonstrated in Canada on rapeseed (Watter and Nowicki 1982 ; White 1983 ; White and Nowicki 1985), when empty bins are treated with organophosphorous insecticides (bromophos, malathion, fenitrothion). Canadian storers were warned that treating before storing rapeseed could lead to residues above the maximum allowable limits.

Uptake of pirimiphos-methyl by a single-layer of rapeseed or wheat on galvanized-steel surfaces was demonstrated in a laboratory study (Dauguet and al 2007). It was shown that, for small bins (less than 50 tons), it could lead to residues quantities above regulatory limits.

In order to improve our knowledge about this post-harvest insecticide cross-contamination, especially in big elevators, an investigation was carried out with the collaboration of several French grain storage companies on sunflower seeds during the storage season 2006-2007 (Dauguet OCL 2007). An investigation, similar to the previous one on sunflower seeds, concerns rapeseed harvested in 2007. Dichlorvos was not used anymore during the storage season 2007-2008, so grain protection strategies changed. Rapeseed is harvested in june-july, like cereals (wheat and barley).

Materials and methods

The process adopted for these surveys on oilseeds was:

- Identifying, with storage operators, oilseed lots that could be "traced" (recording of each step from receipt to outloading).
- Making a mean sample from each batch representative of oilseed arriving at the storage facilities ("first sample") and preserving it. These samples are preserved if we suspect that contamination occurred before receipt by the grain company.
- Making a mean sample representative of outloaded oilseed, "final sample", when the traced lot is commercialized (from one to eight months after harvesting). All these "final samples" were analysed. The sampling method used was based on a standard method (moving seeds, for contaminant with heterogeneous distribution determination, PR EN ISO 24333:2006): 25 elementary samples for 500 tons evenly distributed during the outloading (one elementary sample each 20 tons).
- Filling a questionnaire called "traceability" which recorded each step from receipt to outloading.

Determination of insecticide residues in all "final samples": the analytical laboratory ITERG (Pessac, 33, France) conducted these determinations : Soxhlet extraction of oil with hexane (NF EN ISO 659), pre-purification with acetonitril and freezing, purification with solid phase extraction C18 and Florisil cartridges, analysis by gaseous chromatography with NPD detection (organophosphorous) and ECD (pyrethrinoid).

Results

Twenty-eight samples of sunflower seeds and twenty-two samples of rapeseed were analyzed. (Table 1, Table 2).

The insecticides used on cereals and for storage facilities treatment were detected on rapeseed : pirimiphos-methyl, malathion, chlorpyriphos-methyl and deltamethrin (only 1 case). The most commonly detected substance was pirimiphos-methyl, quantified in 55% of samples. This substance also caused most cases of non-accordance with MRL, in 32 % of the samples.

On the whole, final samples were quite contaminated as half of them contained more than 34 µg/kg of insecticide residues (sum of residues median), and 10% of them contained more than 581 µg/kg (sum of residues 9th decile).

Compared with the results obtained in the previous investigation on sunflower harvested in 2006 (Table 1), pirimiphos-methyl is much more often found in rapeseed, especially above MRL, and with higher levels (mean for rapeseed 130 µg/kg, mean for sunflower seeds 19 µg/kg). Dichlorvos is not found anymore in rapeseed because of the new regulation.

Tab. 1 analytical results (expressed in µg/kg) on the 28 final samples of sunflower seeds (storage campaign 2006-2007)

	LQ	**MRL**	**Mean**	**Median**	**Standard deviation**	**9th decile**	**Maxi**	**% samples ≥ LD**	**% samples ≥ LQ**	**% samples MRL**
Dichlorvos	10	10	21	0	79	27	422	32%	29%	21%
Pirimiphos-methyl	10	50	19	5	55	29	295	61%	39%	4%
Chlorpyriphos-methyl	10	50	0	0			10	4%	4%	0%
Malathion	10	-	8	0	25	17	125	18%	18%	18%
Sum of residues			48	12	102	120	427			

LQ: limit of quantification, LD: limit of detection, MRL: maximum residues limits in sunflower seeds. Sum of residues: a value of 5 µg/kg is given when a substance is detected but below the limit of quantification, and zero value if under the limit of detection.

<u>Traceability analysis</u>

Four cases leading to cross-contamination were identified:

- K1: treatment of cereals at outloading, just before outloading of oilseeds
- K2: outloading of cereals, treated at their receipt, just before outloading of oilseeds
- K3: storage of treated cereals in the same bin just before storage of oilseeds
- K4: treatment of empty bin and of handling equipment before receiving oilseeds
- K5: receipt of oilseeds at the same time that cereals treated at receipt (concerns only rapeseed)

Tab. 2 analytical results (expressed in µg/kg) on the 22 final samples of rapeseed (storage campaign 2007-2008)

	LQ	MRL	Mean	Median	Standard deviation	9th decile	Maxi	% samples ≥ LQ	% samples > MRL
Pirimiphos-methyl	10	50	130	22	266	335	1117	55%	32%
Malathion	10	-	19	0	69	16	322	18%	18%
Chlorpyriphos-methyl	10	50	3	0	9	0	31	9%	0%
Deltamethrin	10	100	1	0	3	0	13	5%	0%
Sum of residues			152	34	290	581	1161		

LQ: limit of quantification ; MRL: maximum residues limits in rapeseed. Sum of residues: 0 µg/kg if under the limit of quantification.

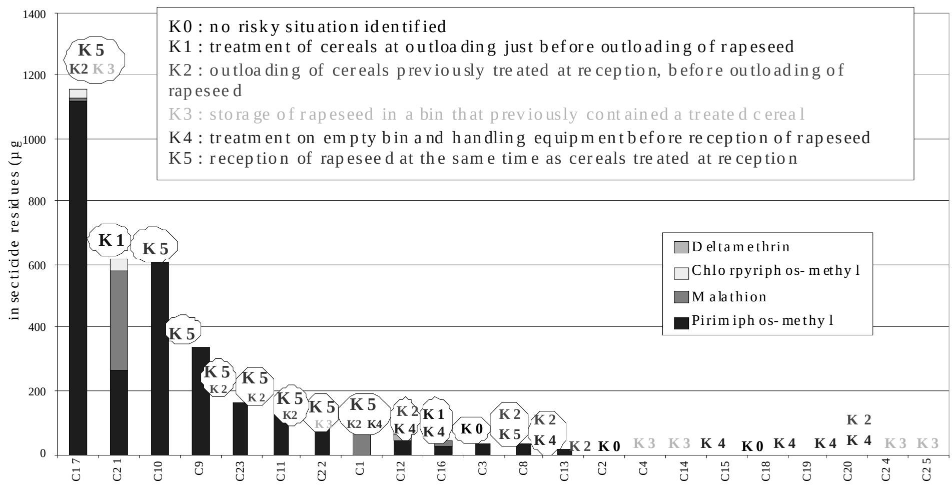

Fig. 1 Distribution of the five cases for each rapeseed lot

It appears that the biggest cross-contamination on rapeseed occurred with the situation K5. This one is characteristic of rapeseed, which is harvested during the same period than cereals (wheat, barley) in june-july. Most samples with pirimiphos-methyl above MRL are in the situation K5. Looking at each sample, we can observe that highest contaminations occur when treatments on cereals at receipt are systematic. Treatments of cereals at receipt increased during this campaign because dichlorvos was banned. Indeed dichlorvos could be used when there was pest infestation just before commercialization. Now storage operators seem to prefer strategy of security against pest, with preventive treatments: in this investigation 29% treat cereals at receipt systematically, 52% treat occasionally, and 19% never treat at receipt. There is only one case with deltamethrin residues (13 µg/kg), in one silo where cereals are systematically treated with this substance at their receipt. In the other silos, deltamethrin is used occasionally. It seems that contaminations with deltamethrin are slight for the time being, either because it is used since a few time, either because quantities applied are low.

K5 can also be linked to problem on insecticide application equipment: weak escape in the treatment system, treatment not stopped after cereals going on treating the empty circuit (accumulation of substance), mistake possible with treatment directly on rapeseed received just after cereals. These problems could not be checked in our investigation.

The situation K1 is less frequent than the situation K5, but can also lead to cross-contaminations (C21, C3). It was this situation, in the previous investigation on sunflower, that led to the highest contaminations when treatment of cereals was systematic at outloading. It can also occur on rapeseed. In the case C21, malathion and chlorpyriphos-methyl were not used during the storage campaign 2007-2008, but during previous campaigns. This silo is made of concrete; so we can guess that this material can keep residues more than a year.

The case K2 can also lead to slighter cross-contaminations. The cases K3 and K4 do cause problems, except if there are associated to other risky situations.

Conclusion

Our study in real situations showed that cross-contaminations of oilseeds by post-harvest insecticide residues exist, and can sometimes lead to residues above the regulatory limits.

The highest risk of contamination for rapeseed appears when cereals are systematically treated at receipt, at the same time than rapeseed receipt, using the same conveyer circuits. The other identified cases can also lead to slighter contamination. But, silo operators have to concentrate on accumulation of several risky cases, which can worsen the contamination.

Other sources of insecticide residues can occur in storage facilities, but we couldn't check them in this investigation. This include leak of insecticide by the application equipment.

We noticed differences in cross-contaminations between sunflower and rapeseed, especially because of the harvest period. But also this new investigation was carried out in the new regulatory context in which dichlorvos and malathion are forbidden for cereal treatment. Thus storage operators have new grain protection strategies, with more preventive strategies to protect cereals against pests.

So in order to reduce these cross-contaminations, we can advise to avoid sharing same receipt circuits when cereals are systematically treated, and to avoid accumulation of risky situations. It is also very important to verify the insecticide treatment equipment. This investigation allowed us to make the storage companies aware of this issue, and to help them to understand how cross-contaminations can occur in their silos and how to avoid them, knowing that each silo is different of the others.

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17 - Fumigants in Stored Product Protection

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Abstract

Since man began to store huge amounts of harvested cereal grains and other products in large bulks the application of fumigants was the method of choice for thorough disinfestations. Only these molecules are suitable to meet all the stages of pests even hidden within the products and kill them without moving the stored produce. Some boundary conditions are linked to effective use of fumigants for pest control:

- The product of premise must be sealed to a high degree of gas tightness – for instance by use of tarpaulins, glue, sticky tapes, poly urethane foam, silica glue or other appropriate materials – to keep the concentration of the gas for some length of tome sufficiently high.
- The temperature must be sufficiently high to allow penetration of the poison into the insect body and reaction at the target site within the insect.
- The concentration must be sufficiently high for a considerable length of time to control all stages or the target stage of the pest at a mortality rate of at least 99.9% (to avoid selection for resistance).

Only a few fumigants remain as registered compounds for this purpose:

- metal phosphide products for the release of phosphine gas
- carbon dioxide as inert atmosphere for replacement of oxygen; also under high pessure
- nitrogen [as inert atmosphere without need for registration as plant protection product]
- [hydrogen cyanide as gas for use as biocide]

The specific features of the fumigants including the efficacy against pests and fields of applications will be discussed.

<u>Today‘s Situation</u>: The economical importance and the impact of stored product pests, especially insects, has been highlighted and described quite often (Reichmuth et al. 2007). The elements of Integrated Management of these organisms (Reichmuth 1994b) comprise besides biological, physical and technical approaches a variety of chemicals and especially fumigants. These are especially required to control insect pests in products that are stored in bulk like in silo bins, granaries or deep ship holds during transit (Leesch et al. 1994). Also container fumigation is nowadays an important issue of pest control. The following fumigants are regulated in Germany (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, 2009) according to the Plant Protection Law:

1 Phosphine
2 Sulfuryl Fluoride
3 Carbon dioxide [including registration for High Pressure + CO2] and as biocide
4 Hydrogen Cyanide.

According to new definitions, a registration for nitrogen as inert fumigant does not seem to be necessary any more. Fumigants registered in various other countries around the world for pest control in general:

5 Carbonyl Sulfide (Australia)
6 Ethyl Formate (+CO2) (Australia)
7 Ethane Dinitrile (Australia)
8 Propylene Oxide (United States of America, [USA])
9 Methyl Iodide (USA, Japan) Against microbes
10 M(ethyl)-I(so)-T(hio)-C(yanate) (France, USA) Against microbes
11 Chloropicrin (USA)

The following table gives a raw description of advantages and disadvantages of the different fumigants:

Tab. 1 Survey on some advantages and disadvantages of fumigants for stored product protection

	Advantages	**Disadvantages**
Phosphine, PH3	The alternative for commodity disinfestation Fairly economic With prospects even for perishables	Exposure time of several days Corrosion of copper and electronics Risk of resistant strains
Sulfuryl fluoride, SO2F2	Quick lethally acting Very good penetration characteristic Excellent for empty space treatment No long lasting residues of sulfuryl fluoride	Less effective against eggs of insects than against other stages F- residues in fumigated products conflict with existing MRLs. Global Warming Potential (GWP) fairly high compared with the GWP of carbon dioxide
Carbon dioxide, CO2 gas mixtures with low residual oxygen content, modified (MA) or controlled	No significant residues in treated products Obtainable also from natural sources Suitable for organic products Fairly quickly acting at elevated temperatures	Fairly long exposure period of several weeks at 20°C High degree of gas tightness of treated objects required

	Advantages	Disadvantages
atmosheres (CA)	above 30°C	
Carbon dioxide, CO_2, in combination with high pressure of about 20 bar	Very quick acting method in hours Suitable for organic products Suitable for bulk products	Expensive pressure tight metal chambers necessary Good logistics necessary
Nitrogen, as inert gas with very little residual oxygen content, produced from cylinders, pressure swing absorption (PSA) machines or semi permeable membrane machines with pressurized air	Residue free disinfestations of all stages of arthropods No registration required Worker safety high Easy production in the field	Long lethal exposure periods of several weeks required High degree of gas tightness necessary to avoid gas losses and back diffusion of oxygen Costly treatment

In previous publications the fumigants phosphine (Bell and Watson 1999, Hasan et al. 2007, Reichmuth 1990, 1994a,c, 1998, 1999, 2007, Klementz and Reichmuth 2004, Reichmuth et al. 2006, 2008, Shazali and Reichmuth1999, WHO 1988), methyl bromide (Bell et al. 1996, Bond 1984, Monro 1969, MacDonald and Reichmuth 1996, Reichmuth 1998) hydrogen cyanide (Reichmuth 1990, 1998), nitrogen (Adler et al. 2000, Reichmuth 2000) and carbon dioxide (Adler et al. 2000, Corinth and Reichmuth 1991, Reichmuth 2000, Hashem and Reichmuth 1992/1993, Mitsura et al. 1973, Reichmuth 2000, 2002, 2007a, Reichmuth and Wohlgemuth 1994, Stahl et al. 1985) are discussed at length.

This paper therefore focuses on some theoretical considerations, concerning all fumigants and especially sulfuryl fluoride.

Figure 1 describes the dependency of the lethal ct product - required for effective fumigation of all stages of the red flour beetle Tribolium castaneum other than eggs with SF at 25°C. The purple line represents a parameter curve to obtain a ct product of 113 gh/m³ with various concentrations of sulfuryl fluoride and exposure times in the laboratory. The dotted line indicates the corresponding times and concentrations of sulfuryl fluoride for a ct product of 300 gh/m³, being necessary from experience to provide lethal control under practical conditions when uneven concentration, temperature and insects hidden in cracks and crevices limit the direct transfer of laboratory data into practice.

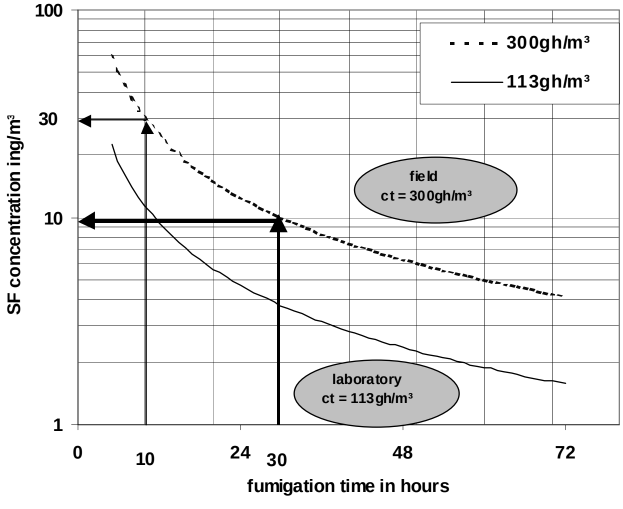

Fig. 1 Model for the control of adults, larvae and pupae of the red flour beetle *Tribolium castaneum* at 25°C with sulfuryl fluoride; possible dosages (t and c) to obtain a lethal ct product of 113 gh/m³ (lower line) or a higher lethal ct product of 300gh/m³ (dotted upper line) to compensate for some leakage, limited gas distribution and temperature gradients; the arrows demonstrate two cases of dosage selection with either 10 g/m³ for 30 hours or 30 g/m³ for 10 hours, both resulting in the same lethal ct product of 300 gh/m³.

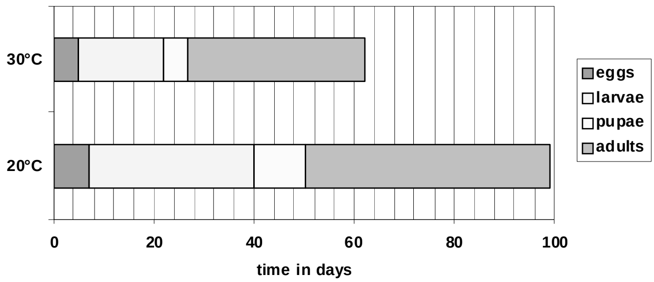

Fig. 2 Model for the control of the red flour beetle *Tribolium castaneum* at 25°C with sulfuryl fluoride; different developmental times of the three pre immature developmental stages of the beetle and different life times of adult beetles at 20°C and 30°C, respectively

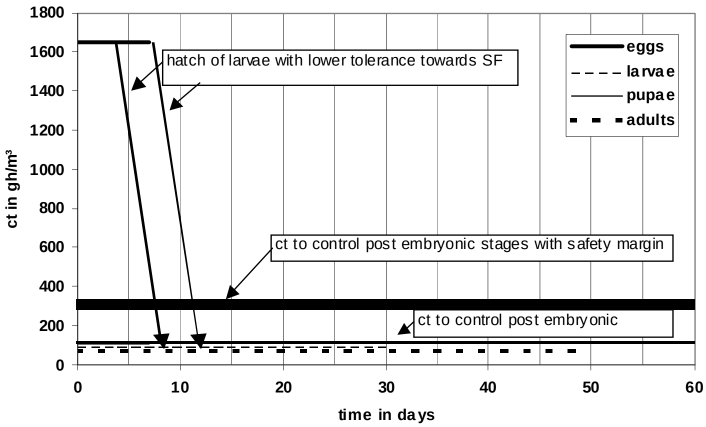

Fig. 3 Model for the control of the red flour beetle *Tribolium castaneum* at 25°C with sulfuryl fluoride; egg hatch starts after about four days to continue for further four days to result in larvae with low tolerance towards SF; the ct product of about 300 gh/m³ during the first fumigation controls all post embryonic stages (larvae, pupae, adults); a second fumigation about two weeks after the first with about the same ct product of 300 gh/m³ would wipe out all those larvae that had hatched from eggs surviving the first fumigation.

As shown in figure 3, pronouncedly different ct products are required to control either the egg stage or all the other stages including the adults. Following fumigation with about 300 gh/m³, only the more tolerant eggs would remain as survivors. After a waiting period of about 12 days, a second consecutive fumigation again with 300 gh/m³ should be sufficient to kill all the larvae. Since the adult beetles had already been controlled by the first fumigation, no more eggs could have been laid between the two treatments. These twin fumigations should achieve full control with altogether 600gh/m³. The obviously necessary length of time (pulse) between two consecutive fumigations with 300 gh/m³ to achieve full control of all present stages including eggs, seems to be in the range of at least 14 days.

Discussion – efficacy of SF

Baltaci et al. (2006) have presented laboratory data for the temperature dependency of the ct products of SF to obtain 50%, 95% and 99% mortality (LD50, LD95 and LD99), respectively, for control of *Oryzaephilus mercator*.

From the presented data it is obvious that there is a pronounced temperature effect on the lethal dose. Increase of temperature by 5°C leads to reduction of the LD99 of about 10%. For demonstration purpose, the difference of the ct product between control mortality of 95% and 99% is given. The necessary ct product for control of 99% of the merchant grain beetle even at 15°C is still far lower than the registered 1500 gh/m³ (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit 2009). Again, there is clear indication that significant increase of the dosage is required to control only 4% more and ensure a higher rate of control of all the present stages.

These facts have to be taken in consideration when discussing the selection of the appropriate dosage for application of SF as fumigant for insect pest control.

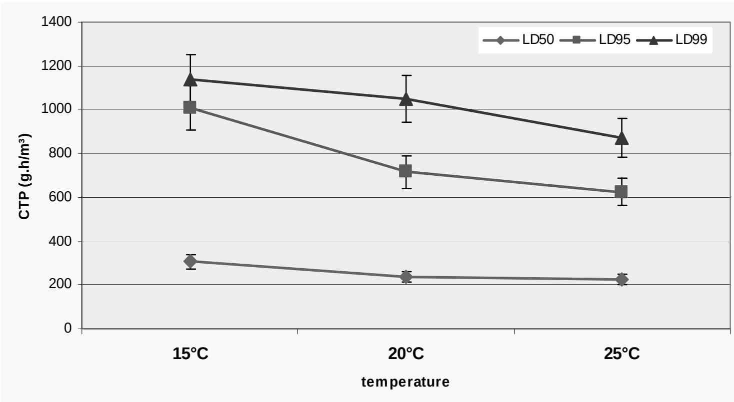

Fig. 4 Dependency of the ct product for control of the merchant grain beetle Oryzaephilus mercator of the temperature between 15°C and 25°C; the indicated standard deviation covers a range of 5%.

Why using Fumigants for Pest Control?

In the light of reduced acceptability of toxic pesticides for use in pest control, the point has to be stressed, that these fumigants are a very important and nearly the only final tool in Integrated Pest Management to be able to control pests in certain situations of storage. Despite increased efforts to avoid pest infestation in the first place by various mechanical and other methods, insect infestation of large bulks of stored harvested products have to be thoroughly disinfested. Otherwise, large amounts of stored food or feed stuff will be lost. The question is allowed to be asked: What if we would not have access to these chemicals? What did man do before he used them? Long term storage without this tool seems to be very difficult. To some extent, construction of gas tight storages (Newman 1989) combined with right concepts of aeration (Reed and Arthur 2000, Navarro and Noyes 2002), and cooling (Armitage and Burrell 1978, Meier 1994) might be a promising approach. The knowledge of this complicated strategy is around but difficult to apply. A high degree of expert knowledge and understanding of the physics limits access to this technique. Costs may be another constraint. There are some examples in history (Cyprus bins), that show the possibilities and limits of this approach. Hermetic storage with aspects of reducing oxygen in the storage environment goes along with this concept (Adler et al 2000). Scientific data in abundance on the effects and use of inert atmospheres with low residual oxygen content (Bailey 1955, 1956,1957, Bailey and Banks 1975, Banks 1981, Banks et al 1990, Oxley and Wickenden 1963, Stahl et al. 1985, Adler et al. 2000, Corinth et Reichmuth 1991, Reichmuth and Wohlgemuth 1994, Reichmuth 2000, 2002, 2007a, Calderon and Barkai-Golan 1990, Navarro et al. 1994, Navarro et al. 1993, Bell) is inviting the application of this alternative. Constraints are the long lethal exposure times, the necessities concerning the structure and linked to gas tightness the costs. Toxic fumigants of these days bring along the high degree of efficacy in a fairly short time without leaving toxic residues in the treated commodities. Therefore, these few chemicals are especially suitable, useful and indispensable for effective and thorough pest control

- in large infested structures and space and
- in bulky infested commodities including large stacks of bags and boxes.

View from the roof of the main building of the Research Centre towards the Fumigation station of the department for Stored Product Protection (green churchlike-shaped building) and Skyline of Berlin

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18 - Ozonation – What is the potential? Application of ozone as an alternative to traditional fumigants

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Abstract

Ozonation, the process in which stored products are exposed to a mixture of ozone gas and air in order to terminate unwanted biologic activity is presented as potential method to control pest infestation.

Following a historical resumée of the scientific research on ozonation, the s shown that in at least some cases Ozonation seems to be very effective against infestation. A brief summary on some of the studies relating to the effects on the crops treated with Ozone is given. It is shown that the reported effects in most cases are not causing any harm to the crops.

How are laboratory test results transferred to full scale storage facilities? A number of considerations are discussed; and results from field trials are discussed. It is shown that the amount of Ozone generated is critical, and that the distribution in larger facilities is also critical.

What are the advantages of Ozonation? The potential advantages of the use of Ozone are discussed in relation to the following: effectiveness as a 100% killer, immunity, environment, safety and economical issues.

A brief look to the future of Ozonation is attempted.

Introduction

<u>Research on ozone as a fumigant</u>

- More than 100 scientific articles have been published on the subject.
- Several scientific studies have demonstrated that low ozone contents in air - like 50 ppm - are sufficient to kill insects, mites, molds, bacteria and other organisms.

Ozone as a strong oxidizer is traditionally used for sterilization of water. It eliminates flavour and color and can also purify air.

Results of initial tests on effects of ozone mixtures (50 ppm ozone in air) on *Aspergillus flavus* and maize germination showed:

- 66 % reduction in survival of surface conidia
- Complete inhibition of Hyphal growth and sporulation
- 97% reduction of aflatoxin production
- No reduction of maize germination
  (Ref.: Linda Mason et al, Perdue University)

Tab. 1 Studies at Perdue University on some of the key features of crops that are not affected by Ozone

Grain	Quality Tests
Rice	Adhesiveness test
Popcorn	Popping-volume test
Soybean	Grain composition Amino acid & fatty acid profiles
Corn	Grain composition Amino acid & fatty acid profiles Dry and Wet Milling
Soft and Hard Wheat	Grain composition Amino acid and fatty acid profiles Milling Bread making properties

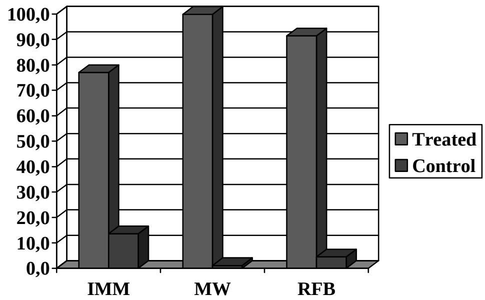

Fig. 1 Lethal effect of 25 ppm ozone in air for 5 days on the red flour beetle *Tribolium castaneum*, the Indian meal moth *Plodia interpunctella* and the meal worm *Tenebrio molitor* (Ref.: Journal of Stored Products Research Volume 37, Issue 4, October 2001, Pages 371-382)

Tab. 2 Effect of 5 ppm ozone in air on micro fungi (Ref.: Mason L Perdue University)

Fungi		**Ozone 5 ppm**	**Control**
Aspergillus flavus	Conidiation (Conidia/plate)	0	1.0x109
	Aflatoxin (ug/plate)	32	1000
Fusarium verticillioides	Conidiation (Conidia/plate)	0	1.0x108

Ozonation works in the laboratory. How can it be applied in silos in practice and and satisfy the industrial needs to disinfest large quantities of grain in big silos with a sufficiently high degree of efficiency. The challenge consists in building ozone generating machines that are able to supply sufficient amount of gas to treat large quantities of grain in industrial complexes with up to 500.000 metric tons and single silos with up to 30.000 metric tons.

Ozonation of stored corn in a 300 ton pilot bin

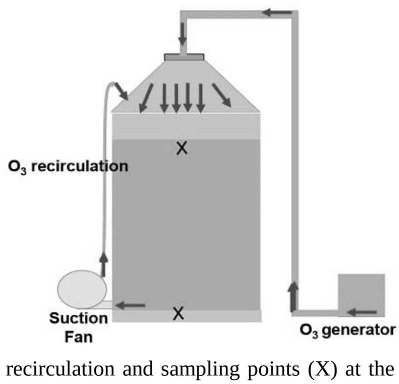

Fig. 2 Ozonation treatment with recirculation and sampling points (X) at the top and bottom of the grain mass (Ref.: Kells, S et al. Journal of Stored Products Research 2001, 7, 371-382)

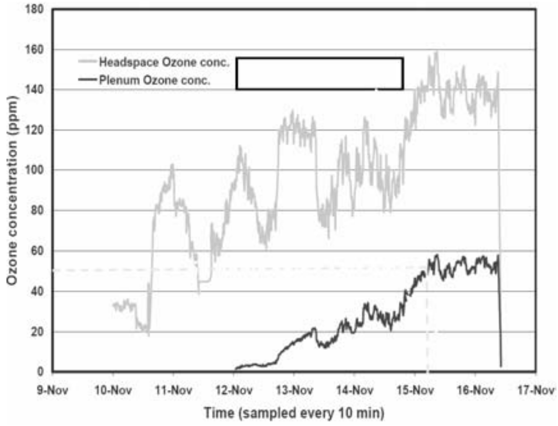

Fig. 3 Ozone contents in air during a field application of maize in the US (ref. Dirk Meier, Perdue University)

Figures 4-6 show some pictures of transportable ozone generators for field application.

Fig. 4-6 Ozone generating machines for field application

<u>The ozonation process in practice</u>

- Applying the existing aeration system
- Sealing off the silo
- When is the ozonation finished?
- Safety procedures

Fig. 7 picture of two ozone generators in action at a treatment of a large elevator Treating an entire structure is difficult; an alternative is to focus on the outlet silo semi continuous treatment.

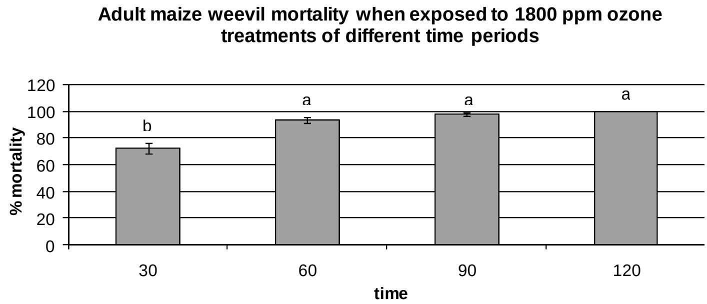

Fig. 8 Mortality of maize weevils when exposed to 1800 ppm ozone in air for different exposure times; 100% mortality after 120 min exposure

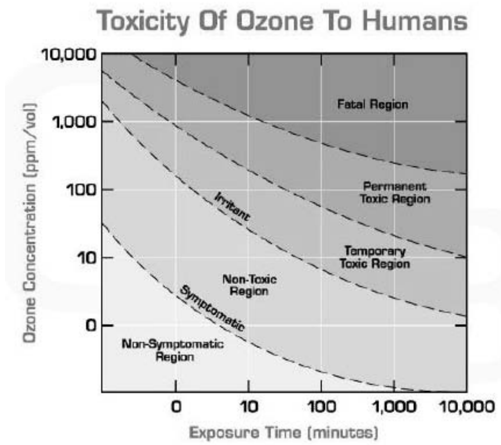

Fig. 9 Toxic side effects of ozone on humans (Langewerf 1963; cited in Dimitriou 1990)

<u>Environmental advantages</u>

- Ozone is a non toxic and non pollutant agent.
- Ozone is most likely less damaging to the crop than other fumigants.
- Ozone can substitute phosphine in certain circumstances and also methyl bromide and other chemicals.
- No transport of toxic gases necessary since the ozone is generated on-site.
- Only electric power is required to generate ozone; this fact is enabling remote areas in developing countries to obtain easy access to an efficient fumigation.

<u>Safety advantages</u>

- Ozone is at low contents in air much less toxic to humans than other fumigants like for instance phoshine etc. can cause lethal accidents when misused.
- Although ozone is toxic, the ozonation process uses so low contents in air that there is no need to use an "expert company" to operate the machine.
- During the ozonation period it is a lot safer to be close to the silo site compared to conventional fumigation. Even an accidental short entrance into the silo is not considered to be dangerous.

<u>Economic advantages</u>

- Ozonation is cheaper than conventional fumigation methods. Depending on the size and shape of the silo, it is estimated that Ozonation is 30 – 50% cheaper.
- Reduced requirement for fan operation.
- When Ozonation is used supplementary to grain chilling, the need to cool is significantly reduced.

Technological advantages

- Ozonation is most likely more efficient than the use of traditional fumigants.
- If the ozonation is performed with the right timing and the right concentration profile, studies have showed that harmful biological organisms will be completely killed.
- And controlled.
- Ozone seems to be a more "broadband" fumigant than other chemicals since it seems to attack cell walls in the organisms in a fundamental way (some refer to this as cell lysing).
- Some consider it most certain that most organisms will not be able to develop immunity towards ozone due to less or none mutations.

Ozone is not recognized for use on stored crops in the eu!

Regulatory status in USA

- FDA and EPA define it as "pure air" – GRAS (Generally Regarded As Safe). This has encouraged practical use.
- It is currently used in many organic applications.
- Major industries are currently implementing applications for:Pathogen reduction in storage of grapes, potatoes and onions.
- The author expects to supply 4 machines capable of treating up to 2000 tons of cereals within 12 months in USA.

19 - The Crop Protection Industry´s View on the Regulatory Situation for SPP Chemical

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Abstract

The regulatory situation regarding products for the protection of stored products in the EU has become increasingly complex in recent years. Since 1991, products for the control of the major storage pests – insects and rodents – were regulated by the Plant Protection Directive 91/414/EEC, one of the world´s most stringent legislations for pesticides. In the course of the EU review program for existing active substances, the number of available plant protection active substances was reduced from around 1000 in 1993 to about 250 to date. Many SPP pesticides were lost in this process already.

A second challenge for industry came with the Biocidal Products Directive 98/8/EC (BPD) in March 1998. Due to insufficient clarification of borderlines and lack of harmonisation, many products are now under the scope of both directives. Additional bureaucratic hurdles are now raised by the new European chemicals legislation REACH, requiring registration for all chemicals, including coformulants.

For many companies, especially SMEs, the costs of several million € for studies, dossier compilation and authorisation fees are not viable for the relatively small storage protection product segment.

For the remaining products, use restrictions due to the high importance of human and environmental safety are increasing, resulting in less availability of products for amateur use. At the same time, the political climate tends against the use of chemicals in general.

Awareness must urgently be raised, both on the political public level, as to the necessity and benefits of chemical storage protection.

Introduction

The Regulatory Environment: Farmers in Europe as producers of food or feed commodities are subject to a whole network of stringent regulations. The "Basic Regulation" on food and feed safety requires zero tolerances to contamination by insect pests, rodents or microorganisms. Therefore, chemical pest control is often inevitable to ensure the requ ired quality of the produce.

The use of chemical pest control agents, in turn, is subject to one of the world´s most stringent legislations. Products must be authorised according to their intended uses. Depending on the area and site of application, one product may, under European law, be subject to several overlapping bodies of legislation at a time. For example, rodent baits or insecticides when used in post-harvest treatment or storage of crops or in processing factories are subject to the Plant Protection Directive 91/414/EEC. When used against the same target organisms in stables, barns or household areas, the same products must be authorised according to the Biocidal Products Directive 98/8/EC. Furthermore, if residues are likely to occur following application, maximum residue levels (MRLs) must be set for each crop/active substance combination.

Consequences of the Regulatory Burden: In order to comply with legal requirements, industry is facing extremely high investments in terms of time and costs. On average, the development of a new active substance takes about eleven years until EU approval. The costs of data generation for regulatory purposes alone amount to about 135 Mio Euro. As a consequence, even the leading agrochemical companies can afford to develop only one or two active substances per year as a maximum.

Due to the lengthy and costly evaluation process, the products need to be highly profitable in order to recover the costs within a relatively short timeframe before patent protection runs out. Therefore, the most profitable markets are preferred for the development of new products, with smaller segments, like storage protection, being explored at a later time or not at all.

The EU review process for existing active substances, started in 1993 and officially terminated in March 2009, has already now led to decreasing availability of plant protection products for minor uses, including storage protection. Of about 940 active substances on the market in at least one Member State before 1993, 26 % (about 250 substances) have been included in the EU positive list. Only 7% of the active substances actually failed because the evaluation showed unacceptable safety concerns for human health or the environment. The vast majority of substances (67%) have been phased out not for lack of safety but because dossiers were either not submitted, incomplete or withdrawn by industry(1). Many of those active substances were used in niche markets not generating enough value to justify the high regulatory costs.

Moreover, for those products falling under the scope of both Plant Protection Directive 91/414/EEC and Biocidal Products Directive 98/8/EC, the regulatory requirements are similar but not identical under both legislations. Dossiers must be generated in different formats and fees paid to different authorities. Especially smaller companies often lack manpower and financial resources to face this double challenge.

Future prospects: A further cut-down in availability of products for storage protection is anticipated as a consequence of the future regulation on the placing on the market of plant protection products (2). It stipulates the assessment of active substances according to their potential hazardous properties, meaning that critical effects caused by the pure active substance at high concentrations may lead to non-inclusion or substitution, even if the products can be applied safely.

According to the new provisions, active substances fulfilling the criteria to be classified as carcinogenic, mutagenic, toxic to reproduction (CMR, categories 1 or 2 according to Dangerous Substances Directive 67/548/EEC) or deemed to be endocrine disruptors, or which fulfil the criteria laid down in the REACH Regulation 1907/2006 for certain long-term environmental effects(POP, PBT, vPvB) shall not be included in the positive list in the future. Active substances deemed to possess neurotoxic or immunotoxic properties will be identified as candidates for substitution and authorised only as long as no “safer” alternative exists.

The new provisions are likely to come into effect by mid 2011. Active substances authorised under the present legislation by that date can be placed on the market until the end of their respective inclusion date. However, re-evaluation after that period will be performed applying the new criteria, and this is likely to affect a number of products presently in use in storage protection, due to their modes of action against the target organisms.

For instance, insecticides acting by their influence on growth and development of the target species are suspected to act as endocrine disruptors. Active substances of this type may not be authorised any more in the future. Other insecticides targeting the nervous system will have to be listed as candidates for substitution due to their neurotoxicity, and phased out as soon as a less critical alternative becomes available. Research activities will have to focus on active substances with new modes of action not interfering with any of these critical endpoints. Today, only one out of 100.000 chemicals screened will be authorised as an active substance. Most probably, this proportion will shift to a much higher number of unsuccessful candidates.

With rodenticides, the situation looks critical already. For plant protection products, only six active substances are presently listed on Annex I of Directive 91/414/EEC: three phosphides, two anticoagulants and carbon dioxide. For biocidal products, 15 rodenticides were notified, most of them belonging to the class of anticoagulants. Discussions are ongoing on EU expert level on the reproductive toxicity of this substance group. Furthermore, persistence is also an issue with some anticoagulants.

Under the new plant protection legislation, both endpoints are cut-off criteria which may lead to non-inclusion of the active substances concerned, even though the end-use products are formulated and applied in a way so as to avoid exposure of humans and the environment. The Biocidal Products Directive (BPD) also stipulates that substances with CMR properties shall not be authorised, however the criteria are not clearly specified. Presently, two anticoagulant rodenticides are on the positive list of for a reduced time period of seven years instead of the usual ten.

Development of new rodenticides is particularly difficult, since it is unlikely that a selective mode of action for the control of rodents exists that would not affect other vertebrates. Due to the limited prospects of success, there is practically no research in this field. As a consequence, the availability of chemical control agents against rodents will decrease even more in the future.

Conclusions

The discussion on chemical products for the control of harmful organisms has been shifting from a factual to an emotional debate in the past years. Consumers are concerned about chemicals in the environment and what they perceive to be the potential dangers from these omnipresent but invisible substances. A wide variety of fresh foods year-round and clean drinking water are taken as a matter of course, while the necessity and benefits of plant protection and biocidal products are ignored by the general public.

Similarly, regulatory decisions are becoming more and more political instead of science-based. Both the revision of the Plant Protection as well as that of the Biocidal Products Directive are targeted to eliminating substances perceived to be of concern and promoting non-chemical alternatives, by applying the precautionary principle. The fact that there are no “zero risk” situations in life and that the benefits of chemical pesticides (comprising plant protection products and biocides) outweigh their risks if they are applied correctly must therefore be made clear to decision-makers as well as to the public.

As the bi-annual reports of the German government on the progress of implementation of the BPD and on the substitution of high-risk products (3) clearly point out, non-chemical alternatives are scarce and have so far proven insufficient in terms of efficacy and costs. On the other hand, an increasing bureaucracy blocks the development of innovative chemical products without adding to consumer or environmental safety.

The report on the impacts of the Biocidal Products Directive (4) points out that small and mid-sized companies are most affected by the requirements of the legislation. Similar conclusions had been drawn for the Plant Protection Directive in 2001 (5). Many of the niche products supplied by those smaller companies have already disappeared from the market, resulting in gaps especially for minor uses. The research-based industry will not be able to deliver new solutions for all calamities in the future. How this situation will be dealt with in case of emergencies remains open.

Literature

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Study on Impact of the implementation of Directive 98/8/EC concerning the placing on the market of biocidal products, http://circa.europa.eu/Public/irc/env/bio_reports/library?l=/study_implementation/report_101007pdf/_EN_1.0_&a=d

Report from the Commission to the European Parliament and the Council: Evaluation of the active substances of plant protection products (doc. COM (2001) 444), 25 July 2001

20- Actual registrations for post harvest disinfestations and perspectives in France

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Abstract

During the last few years, many pesticides were banned. For SPP, in France, this situation is particularly critical since they were key compounds. For grain, DDVP was used to meet the requirement of zero insect when the grain was sold, for mills, methyl bromide and DDVP were the base of the disinfestation.

France is reluctant to employ gases like phosphine for grain, but as long as contact insecticides will be permitted, they will be used. Ethyl formate, applied as a liquid, but acting as a gas, could be an interesting compromise. Research shows good results but sorption, and then distribution in the grain, is the main problem to overcome. Mills are in a bad position since DDVP has no alternative and, as a result, curative disinfestation is not an option, heat or fumigation.

Introduction

Heat is not yet used in France for many reasons and fumigation with sulfuryl fluoride is not so easy to apply properly and expensive. The need for a chemical alternative is urgent, and unlikely like DDVP. A fumigant could be add to SF, with a complimentary nature, the old and controversial formonitril, more known as HCN.

- The concept of Integrated Pest Management (IMP) comprises control of pest insects when infestation has occurred.
- The insect population has to be reduced or totally killed.
- There exist physical ways to perform pest control like application of cold or heat.
- Still, chemical compounds are an integral part of IPM. The presentation focuses on these chemicals.

The application of insecticides requires in any case a registration for the envisaged purpose. Therefore, it is important to know about the registrations in each member state.

<u>Agro-food industry sector: structures</u>

Chemical disinfestation includes:

1) Application of long lasting insecticide on surfaces.
2) Fogging when flying insects are seen.
3) Once a year, a curative total disinfestation by fumigation.

<u>For structures, the following registrations are in place</u>

Fogging:

- Pyrethrum 12 mg/m³ + Piperonyl butoxid (PBO).
- This compound is not an alternative to the phased out DDVP!.
- The loss of DDVP is a serious concern for two main reasons.
    1) The high vapour pressure of 10-2 mm Hg and correlated efficacy compared with 10-10 mm Hg for pyrethroids.
    2) The good efficiency against all insects, even *Tribolium* spp.

Dichlorvos (DDVP) has been phased out:

- The grain industry is very affected by the ban of DDVP.

The way they used to work with DDVP was:

- Grain ventilation.
- Sometimes use of long lasting insecticide.
- When the grain moved out of the silo, DDVP was systematically applied or only when a live insect was detected.

Long lasting contact insecticides:

- Chlorpyriphos-methyl 0.5 g/m².
- Pyrimiphos-methyl 0.2 g/m².
- Deltamethrin 0.125 (+ PBO; 10 times application).

Fumigation:

- Sulfuryle fluoride CTP max 1500 gh/m³.

About border lines between Plant Protection Products (PPP) and Biocidal Products (BP), the target pest should be part of the decision: a *Tribolium* beetle is a storage pest to be treated with authorised PPP pest even if it appears in a bakery or pasta factory! These beetles with their biology and possibilities to be avoided and controlled are studied by storage specialists. Responsible scientists and administrators for the biocidal products normally are involved in control of cockroaches, flies and fleas, the typical pests with impact for human hygiene and not with *Tribolium* spp., typical stored product pest insects. For the industry it is a heavy burden to have to apply for two registrations with different national authorities and different data packages. Harmonisation seems to be the way for the future.

Agro-food industry sector: stored products

For stored products, like dried fruits, nuts, beverages, herbs, etc. registrations are

- phosphine generators,
- aluminum phosphide and magnesium phosphide,
- the Canadien Cytec company tried to register ECO2fume but abandoned this idea last year.

Agro-food sector: legumes and oil seeds sector

Registrations are:

- Beans have a deltamethrin registration.
- For all other products, generators of phosphine, aluminium phosphide (AlP) and magnesium phosphide (Mg3P2) for the grain sector.

Grain sector includes three categories:

- Cereals (wheat, barley, oat, triticale).
- Maize.
- Rice (paddy, brown or cargo and white rice).

Contact insectides registered in France:

- Active ingredient g/t.
- Chlorpyriphos-methyl 2.5 cereals.
- Cypermethrin 1.67 (+PBO; 3 times) cereals.
- Pyrimiphos-methyl 4.
- Deltamethrin 0.5 (+PBO; 10 times).
- Pyrethrum 3 (+PBO) 4 to 8 litres of ready to use formulation for 100 t.

Insecticide efficacy (s = susceptible):

- Organo-P – Pyrethroids.
- *Sitophilus* spp. - S - Not very S.
- *Rhyzopertha dominica* – tolerant Very S.
- *Tribolium* – S - Not very S.
- Others – S – S.

Fig. 1 Small system for spraying the grain

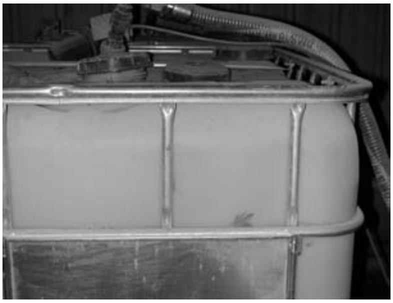

Fig. 2 Insecticide Tank, 1000 litres

Fig. 3 Insecticide application system

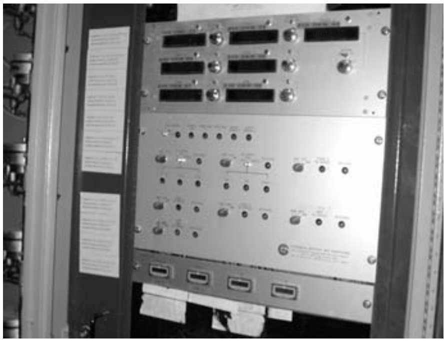

Fig. 4 Local control panel – remote control from the desk

Perspectives for Phosphine (PH3)

Fumigation of grain in silo bins: During storage, application of the phosphine generating compounds on top of the grain and use of a recirculation system; together with a recirculation system even gas distribution can be achieved; much less safety problems for the workers due to this approach; the rests of the phosphine generating phosphides do not remain in the grain; fumigation can takes place at any time without moving the grain.

As phosphine fumigation is a fairly "new" technique for grain in France, the new way of phosphine release avoids

- that the fumigator has to go on the top of the silo to introduce the generating phosphide product,
- the time taken by the chemical reaction to release the gas,
- the necessary reaction of the remaining undecomposed phosphide with liquid water.

Research on new compounds, especially for disinfestation of grain

GLO2, CSIRO patended a mixture of Ethyl Formate and 5% Allyl Iso Thio Cyanate. This compound could also be of interest for the French grain sector: It is a fumigant that can be applied as a liquid, like a contact insecticide. The appropriate dosage has still to be defined. The Australian climatic conditions are too different to use the Australian dosages directly also for France concerning the different temperature and moisture content. Dosage has to be higher, more than 80 g/m³ and flammability is close to this concentration. Very big tendency for sorption: in some hours the whole amount is sorbed on grain. Vapormate is not an option in French conditions with not very gas tight grain bins.

Research on new compounds

In France, research is dealing with

- Ethane dinitrile (EDN) for museum fungi as an alternative to ethylen oxide: is very effective if the relative humidity is high.
- Methyl iodide (MJ) as preliminary work on grain as a model. Seems to be more effective than methyl bromide.

Research on new ways

For structures, since sulfuryl fluoride (SF) has a very good efficiency towards all stages except eggs, that require much higher ct products than the other stages. SF has a good penetration property. To compensate for the weak effects towards eggs, SF could be combined with formonitril, HCN. HCN kills eggs of *Tribolium castaneum* at a CTP of 5 gh/m³, but does not penetrate more than 4 cm of flour.

21 - Best Practice takes the place of Insecticides in dried Tobacco Handling

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Abstract

Tobacco remains one of the most valuable, dried, processed, almost-food commodities in the world. As a result manufacturing and storage, including transport, are important elements where serious infestations can occur. By agreement throughout the tobacco industry, and often as a result of national legislation, the “magic bullet” commonly used in the dried food industry against insect infestations – fumigation – is not available after the first processing stages. [Cereal processing is similar – grain and flour can be fumigated, but biscuits and cakes cannot.]

The still unfinished “cut rag” dried chopped tobacco leaves – a very infestible commodity – is widely shipped around the world and frequently subjected to heavy infestation pressures, yet is already beyond the simplest curative method of fumigation.

This paper describes the development, over several years, of effective insect detection systems, allowing hygiene and physical options to chemical control to be tested. The end result was a practical manual of logical systems and options - a fully independently audited system - which has implications for storage, transport and handling of all dried foods, where currently pesticides are used and relied upon.

Introduction

Tobacco remains one of the most valuable, dried, processed, almost-food commodities in the world. As a result manufacturing and storage, including transport, are important elements where serious infestations can occur. By agreement throughout the tobacco industry, and often as a result of national legislation, the “magic bullet” commonly used in the dried food industry against insect infestations – fumigation – is not available after the first processing stages. [Cereal processing is similar – grain and flour can be fumigated, but biscuits and cakes cannot.]

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<u>Comments and Questions during the Symposium</u>: Mainly concentrated on the correctness of maintaining good standardised practices, in hygiene, in trapping/monitoring of beetles, and in fumigation activities. All agreed that getting the senior staff, including the CEO, “on-board” was most likely to lead to success, and many were interested in the codification of the best practices into an extensive practical manual, which also allowed non-technical auditors to look for non-compliances. The manual is called the HIMILO Handbook (Hygiene and Infestation Management In Leaf Operations), published by the Indian Leaf Tobacco Division (ILTD) of the Indian Tobacco Company (ITC) in 2004.

There was also general agreement that even straightforward application of conventional practices can achieve impressive results in minimising storage infestation problems, despite the threats to some commonly used pesticides.

<u>Creating Beetle-free Tobacco Exports with minimum pesticide usage</u>: Creating a beetle-free export tobacco shipment supply line with minimum pesticide usage = “best practice”?

- Year 1 (1997).
- $360,000 in re-fumigation charges.
- First visit to region to understand the flow of product from farmer to export port.

Tobacco flow chart (see final page).

Farmers' tobacco storage

- Beetles start here.
- Action possible? No!
- Too many farmers over a very wide geographic area.
- No effective extension/advisory service.

Auction platform and warehouses

- More Beetles here.
- Action possible? No!
- Auction is too fast and no-one takes responsibility for infestation.
- No individual one wants to pay - it's an "industry" problem.

Aggregating warehouses

- The real start of professional warehousing.
- Self-closing doors with beetle-proof meshes introduced.
- Floors repaired to permit fumigations.
- Hygiene dramatically upgraded, with competitions introduced between cleaning crews.
- Pheromone traps to a standardised layout and usage (SOPs).

Own GLTs

- Structural improvements in a rolling programme, to agreed standards.
- Areas within GLT "sectioned-off" with hanging deltamethrin-sprayed cloth drapes.
- Press-section - special cleaning and fogging ('press section' = packing).

RDS at GLT

- Pheromone trapping to monthly SOP.
- Leaving doors open a serious offence.
- Daily and weekly counts monitored by supervisor.
- If beetle counts exceed agreed maxima, entire store stock fumigated to agreed standard – fumigation training started – for all staff.

Export rail/containers lorry

- Loading (in open air) only up to mid-day.
- Containers all checked/sprayed prior to acceptance.
- All fumigation measured and monitored by senior staff. New PH3 electronic monitors, Plus micro-perforated poly-liners for tobacco cases allowing gas entry.

Tobacco beetles – a big quality problem in tropical dried tobaccos. Dried semi-processed tobacco shipped from S. Africa to Luanda, but held in Port Customs for 4 months. How many dead on container floor? And how many alive inside the tobacco cases.

Standardised beetle monitoring with pheromone traps

Tobacco beetles. @ 35 – 40oC they increase in numbers x 60 per month. How many on this sticky trap? 4 months in container in Luanda sunshine!

- Tobacco beetles fly.
- Adults chew but don't feed.
- They spread the infestation.
- Larvae chew and feed.
- Trap position painted on warehouse floor.
- Record card held with trap.
- Trap changed monthly.
- Stand-alone Serrico-Trap stand, with position painted on warehouse floor in case it needs to be moved for unloading or loading.
- Strict adherence to monthly SOP.

- Monthly total beetle counts used to trigger fumigations of entire warehouse section stock.
- Pheromone-based Serrico-Trap, used according to strict monthly SOP.

Beetle-proofing

Fully mesh-proofed inspections shed alongside rail loading platform The shed is Serrico trapped continuously to ensure it is beetle-free prior to, and after, each Tobacco inspection by the customer(s). Completely beetle-proofed RDS inspection shed with north light glazed roof. Mangalagiri Warehouse, fitted with beetle-proofed aeration meshes to allow opening swivel windows for dried tobaccos. Note also the proofed outer doors, closed manually, over the internal thief-proof metal doors. Making hard-wood hinged beetle-proofed doors.

Fumigation standardisation – Floors Sheeting, Sandsnakes, Case poly-liners, Gas measuring/recording

- Gas readings with Uniphos PH_3 tubes.
- Bedfont PH_3 readings from stack (now replaced by Uniphos electronic meters).
- Careful gas sampling of cases for final graph of fumigation.
- Successful but disruptive green leaf pre-fumigation.
- Multi-stack coverage with joined sheeting.
- Very neat corners and safety barrier tape.
- Dosage 1.5 gPH_3/M^3 for 8 days.
- Metal trays for tablet placement.
- Post-Fumigation protection using cotton cloth shrouds and extra sandsnakes.
- Cotton cloth sheeting left on AFTER fumigation.
- Every shipment was fumigated at the export port in sealed containers, for 100% assurance during Year 4 (2001).
- ZERO re-fumigation charges imposed by receiving customers across Europe.

22 - Status and recent development in stored product protection in Denmark

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Abstract

Situated in the northern temperate region, Denmark has relatively few problems with stored product pests. In grain stores the major pest is the granary weevil *Sitophilus granarius*. No recent surveys have been conducted, but it is considered to be widespread throughout the country. Other insect species are occasionally found in grain stores as well. Pests only rarely develop high densities in grains stores, partly due to the fact that grain is cooled to a target temperature of 5°C as soon as possible after harvest. The main problem occurs when live insects are found in grain that has been loaded into a ship prior to export, in which case fumigation is necessary. However, this situation can easily change soon, as the last insecticide for direct treatment of grain, malathion, is no longer available in Denmark. The only options now are fumigation with hydrogen phosphide or treatment with inert dust. In addition, possible future climate change with higher temperatures and higher humidity will probably lead to increased problems due to pests. The pests found in other stored products in the processing chain are similar to the rest of Europe, as temperature and humidity conditions are less correlated with out door conditions.

Introduction

Grain stores: Situated in the northern temperate region with cool, humid winters, Denmark has relatively few problems with pests in stored grain. The major pest is the granary weevil *Sitophilus granarius*. No recent surveys have been conducted, but it is considered to be widespread throughout the country. Other insect species are occasionally found in grain stores as well; *Oryzaephilus surinamensis, Cryptolestes ferrugineus, Tribolium confusum*.

Pests only rarely develop high densities in grains stores, partly due to the fact that grain is aerated to a target temperature of 5°C as soon as possible after harvest. Good hygienic practice conducted in the stores is also important for the low pest densities. The main problem occurs when live insects are found in grain that has been loaded into a ship prior to export, in which case fumigation is necessary. However, this situation can easily change soon, as the last insecticide for direct treatment of grain, malathion, is no longer available in Denmark. The only options now are fumigation with hydrogen phosphide or treatment with inert dust. Possible future climate change with higher temperatures and higher humidity may lead to increased problems due to pests in stored grain.

Flour mills: The pests found in other stored products in the processing chain are similar to the rest of Europe, as temperature and humidity conditions are less correlated with out door conditions. In flour mills the main pests are *Ephestia kuehniella* and *Tribolium confusum*. Pest problems are managed by a combination of sanitation and application of residual pesticides and pyrethrin fogs. Heat treatment and application of inert dusts are not used very much.

Wholesale and retail stores: In this sector the pests are the same as in other EU countries. However, during recent years Plodia interpunctella has become more common in private households. The consequences of this on human health are unknown, but it could represent a problem due to adverse effects of fragments from *Lepidoptera* (allergies resulting from presence of wing scales and fragments in the immediate environment and human food).

A description of the pest situation in stored products in several EU countries can be found in the proceedings from several meetings of COST Action 842, WG IV: Bio-control of arthropod pests in stored products, available at http://cost842.csl.gov.uk/

23 - Stored Product Protection Perspectives in Spain

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Abstract

There is an important food industry in Spain that represents the main industry sector, accounting 16.2% of net product sales and 14.6% of industrial employment. Consumption of many types of cereals, dried fruits and nuts, legumes and spices in Spain is very high as they are a component of our traditional food. A number of these food products could be stored after the harvest season for more than 3 months, and be processed little by little during the year. The storage of imported commodities is similar except for those products with high demand that are commonly processed in a period of 1-month or less. Both silos and warehouses are used for the storage of raw material and final food products. A number of pest species can affect both commodities and processing facilities, among them several Coleoptera, Lepidoptera, Psocid and Mite species. Chemical control based on residual insecticides and fumigants is the most common pest control method used. In Spain, there are a limited number of active compounds that are allowed to use for stored pest control. As a consequence pesticide resistant insect strains are already present in some areas. Treatments are concentrated in summer when temperatures are optimal for insect development. Among pesticides, phosphine has replaced in most cases the use of methyl bromide after its phase out. There is an increasing use of prevention, hygiene, monitoring of pests and alternative control methods. HACCP protocols and IPM are followed by a number of companies. Other methodologies in use are Modified Atmospheres for both fumigation or packaging and, CO2 at high pressure for treating spices and herbs. Biological control is not used and still not known as an alternative control method by the agro-food industry.

Keywords: Stored Products, Pest control, Chemical Control, IPM.

Introduction

Value of market including imports and exports: There is an important food industry in Spain that represents the main industry sector, accounting 16.2% of net product sales and 14.6% of industrial employment (Ministerio de Medio Ambiente y Medio Rural y Marino, 2009a). Consumption of many types of cereals, dried fruits and nuts, legumes and spices in Spain is very high as they are a component of our traditional food.

In Spain there are about 220 mills and 15,000 bakeries. The number of mills has gradually decreased during the last 10 years due to a reorganization of the sector and the merge of companies trying to re-duce competitiveness. Milling capacity of the Spanish industry is approximately 27,000 tons of wheat per day. However, flour production is about 2,7 millions of tons per year, thus only 40% of the total milling capacity. This low productive capacity is caused by sales and exports cuts during the last years. The consumption of bread per capita (58 kg approximately) has also decreased during the last 20 years. There is also an important dried fruit industry in Spain. The main commodities produced are almonds, hazelnuts, chestnuts, figs and carobs (Table 1). Spain is the second largest almond exporter (45,000t/year) and the fourth largest hazelnut exporter (4,600t/year) in the world. Both commodities represent a trade value of more than 200 million euro. There is a high quantity of imports of dried fruits and nuts such as almonds (35,000t/year) and hazelnuts (5,000t/year). In Spain there are more than 100 private exporter companies, 95% of those with international standard quality certification (ISO 9000).

Tab. 1 Dried fruits and nuts produced in the world, Europe and Spain.

	Production (t/year)			% Spain vs.	
	World	**EU**	**Spain**	**World**	**EU**
Carobs	186,817	141,700	72,000	38.5	50.8
Almonds	2,065,489	385,686	201,100	9.7	52.1
Hazelnuts	776,890	160,641	17,600	2.3	11.0
Chestnuts	1,223,385	125,990	10,000	0.8	7.9
Dates	6,422,325	5,250	5,250	0.1	100
Figs	1,062,473	103,400	38,000	3.6	36.8
Walnuts	1,694,889	159,089	10,000	0.6	6.3

Source: FAOSTAT ProdSTAT (2007)

Processing and retail trade of spices and aromatic and medicinal herbs have a long tradition in Spain. Nowadays, more than 400 different species of spices and herbs and more than 350 essential oils and extracts from these herbs are used. Spanish imports rank the 5th European country and the 12th in the world. According to the WHO, medicinal plants alone represent 138 million € in Spain.

Storage of raw and processed materials: For cereals, both silos and warehouses are used for the storage of raw material. Flour is not stored after its production. A majority of mills use to send the flour to their customers within the first week. However, in some cases part of flour production could be stored for a maximum period of 3 months. For legumes and dried fruits, warehouses, silos and big bags are used for the storage of raw material. Most companies and cooperatives use refrigerated chambers (5 to 12ºC) for the storage of both commodities during the warm seasons to prevent increases in insect pests. The largest part of legumes, nuts and dried fruits are stored after the harvest season for more than 3 months. They are processed little by little during the year. The storage of imported commodities is similar except for those products with high demand that are commonly processed in a period of 1-month or less. Aromatic herbs and spices are stored in bags, big bags and boxes in warehouses and refrigerated chambers. Raw materials are stored for long periods of more than 3 months.

Pest problems found: Thirty species of arthropods representing six orders and 15 families are the most important pest of stored products in Spain (Riudavets et al., 2002). Orders with the greatest number of species are Coleoptera and Lepidoptera. Among pests, the rice weevil, *Sitophilus oryzae* (L.) and the lesser grain borer, *Rhyzopertha dominica* (F.) are the most abundant species in stored cereals. The cigarette beetle, *Lasioderma serricorne* (F.), the drugstore beetle, *Stegobium paniceum* (L.), the flour beetle, *Tribolium castaneum* (Herbst) and *T. confusum* Jacquelin du Val, the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), the Indian meal moth, *Plodia interpunctella* (Hübner) and the flour moth *Ephestia* sp. are the most numerous and widely distributed species in wheat flour, dried fruits, spices and medicinal herbs. The bean weevil, *Acanthoscelides obtectus* (Say) and other Bruchidae species are abundant in legumes. Several species of mites are present in wheat semolina and final food products, but always related with high humidity conditions. Psocids, an increasing problem worldwide, are collected in high number in grain, semolina and other cereal by-products, but also in herbs and spices. In addition, four species of parasitoid Hymenoptera are found in food facilities, among them the pteromalids *Anisopteromalus calandrae* (Howard) and *Lariophagus distinguendus* (Foerster), the Ichneumonidae *Venturia canescens* (Gravenhorst) and the *Braconidae Habrobracon* hebetor (Say).The predatory mite Blattisocius tarsalis (Berlese) is also present in silos of grain and legumes.

Pesticides used: Chemical control based on insecticides and fumigants is the most common pest control method used. Although some chemical pesticides could be considered for controlling pests, Spain recognizes only a limited number of active compounds for controlling pests affecting stored products (Table 2). As a result, food facilities and commodities must be repeatedly treated with the same insecticides. Treatments are concentrated in summer when temperatures are optimal for insect development. Some companies also apply chemical treatments on a calendar based schedule. This implies a potential risk of insect resistance, making pest control more difficult or even ineffective.

Chlorpyriphos-methyl, Pirimiphos-methyl, Deltamethrin and Natural Pyrethrins are registered for commodity treatment, i.e. cereals and legumes. Pirimiphos-methyl and Natural Pyrethrins are registered for space treatments against crawling and flying insects. Phosphine (PH3) (Magnesium Phosphide and Aluminium Phosphide) is a fumigant registered for the control of pests in a number of stored food products. Even so, PH3 cannot be considered as an alternative to MB. In comparison with MB, PH3 needs much longer treatment times to effectively control pest (i.e. S. oryzae, 12 days for non-resistant insects at 20-30ºC, EPPO 1998). Sulfuryl Fluoride (SO2F2) is registered as a biocide for flying and crawling insects. It is classified as toxic and dangerous for the Environment. It is used exclusively for the treatment of sealed premises, isolated from houses or inhabited buildings. Dosage and application has to be according to the FUMIGUIDE software and type of premise, temperature, exposition time and pest species, with a maximum dosage of 1500 g·h/m3 (31,25 g/m3 48h). Furthermore, it is not permitted to use insecticides as part of treatments applied to final products.

Tab. 2 Pesticides registered in Spain

Active compound	Formulation	Dosage	Commodity / Structures	Pest
Methyl Clorpiriphos	22.4% (EC)	10 cc/T	Barley, Wheat, Maize	*Ephestia, Oryzaephilus, Rhizoperta, Tribolium*
Deltamethrin	0.6%(UL)	40-80 cc/T	Cereals, Legumes	SP pest
	0.2% (DP)	250-500 g/T		
Methyl Pirimiphos	2% (DP)	1.25kg/100m3	Space treatment	SP pest
		400g/T	Cereals	
	50% (EC)	100mL/100m2	Space treatment	
Pirethrin	0.8% (DP)	0.5-0.75kg/T	Cereals	Weevils , Months
	5% (EC)	6.5%	Space treatment	SP pests
		1L 4% /T	Cereals, Legumes	Weevils, Months
	6% (EC)	5.5%	Space treatment	SP pests
		1L 3.3% /T	Cereals, Legumes	Weevils, Months
Pirethrin + BPO	0.2% + 2%	1kg/T	Cereals, Legumes	SP pest, Weevils, Months
	5% + 50%	6.5%	Space treatment	SP pest, Flies
		1L 4% /T	Cereals, Legumes	Weevils, Months
Aluminum Phosphide	57% (0.6g/Pellet)	15-25 Pellet/T	Peanuts, Cacao, Spices, Cereals, Legumes, Equipment, Bags, Tobacco	SP pests
	57% (3g/Tablet)	3-5 Tablets/T		
	57% (34g/Bags)	1 Bag/2-3m3		
Magnesium phosphide	56% (117g/Plate)	1 Plate/6-10m3	Cacao, Spices, Dried fruits, Cereals, Wheat flour, Legumes, SP, Seeds, Tobacco, Bags	SP pests
	66% (3g/Tablet)	3-5 Tablets/T		

Source: Ministerio de Medio Ambiente y Medio Rural y Marino, (2009b)

Pesticides must be exclusively applied by authorized pest control companies and qualified pest control technicians. There are three levels of authorization depending on the toxicity of the product and the people involved in treatment: basic, qualified and special. Basic and qualified levels are addressed for people applying pesticides classified as non-very toxic. For those who have passed the tests of basic or qualified levels that determine the field of accredited training, is considered a special level for highly toxic products. Training is not only addressed to professionals' users but to distributors and advisers. The training program covers: IPM strategies and techniques, use, equipment maintenance and application techniques, legislation on pesticides, risk and hazard of pesticides, emergency measures for human and environment safety and registration of PPP.

Other control measures or IPM used: Although the main control method is still based on chemicals, there is increasing use of prevention, hygiene, monitoring of pests and alternative control methods. HACCP protocols are followed for most of the companies. However, IPM is a term under discussion since HACCP is covering most of the tools issued from the IPM concept. According to the HACCP protocols chemical control is usually the main tool for prevention and control of insects in contradiction with the IPM concept.

Among prevention techniques to avoid insect and mite development, aeration and refrigeration of grain in silos and warehouses and the storage of several commodities such as legumes, dried fruits and spices in cold chambers are increasingly used.

Heat treatments are used sporadically for the treatment of pallets and other packaging materials. When quarantine and pre-shipment treatments are applied, MB is still generally used. Heat treatments for space disinfestations and structural treatments in mills and other food facilities are not in practice in Spain, in comparison to other EU countries and the USA where it is increasingly applied. Poor insulation, thin walls and the presence of windows in most of the facilities might be a barrier to the implementation of this technology.

Cryogenic cleaning with pellets of CO_2 to remove food residues that act as a refuge for pest in machines and hiding places is an alternative used in some food facilities. Diatomaceous earths are registered as a food additive. However, their use is not widespread.

Biological control is not used and still not known as an alternative control method by the agro-food industry. However, natural enemies, parasitoids and predators, are abundant and present throughout the whole year in the food factories in Spain. They are not only present in organic food factories but in factories applying chemical control. This is probably due to the presence of refuges where chemical insecticides cannot reach.

More recently, companies are considering the use of some plant extracts containing bioactive compounds as repellents or to prevent insect development. Substances must be considered as safe (GRAS) and are normally blended with the final product or integrated in the packaging materials as a barrier to prevent cross contaminations.

Controlled or Modified Atmospheres are increasingly in use for either fumigation of commodities or packaging of final food products. Modified atmosphere treatments are safe and environmentally friendly ways of controlling pests that affect a large number of raw and manufactured food products. Application of high CO_2 modified atmospheres have tended to focus on the control of pests affecting raw or semi-processed food products in silos and warehouses as an alternative to using conventional chemical fumigants and insecticides. However, this technology is also being applied to final products during the packaging process, to prevent the development of pests that are found after the manufacturing process. Modified atmospheres are used with consumer packages that involve the use of modified flow pack machinery, when storing intermediate food products into large big bags or when preparing final products for pallet storage. Modified atmospheres are equally flushed into either small (1 kg) plastic packages or large (1000 kg) big bags. Different types of plastic film are available and these offer different barrier properties for gases and make it possible to maintain a given gas mixture throughout the treatment. CO_2 at high pressure for treatment of spices and herbs and vacuum packaging for rice and dried fruits are two technologies now established in a number of processing companies.

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24 - Reaction of Polish industry to reduction of pesticides suitable for stored product protection

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Abstract

Methyl bromide (MB) had been widely used for fumigation of durable commodities, perishable products, structures and transport vehicles. This good gaseous pesticide may not be replaced by one alternative, but various methods and means have to be used. Contact insecticides may be used as MB alternatives on stored grain and in storage structures and food production plants. These insecticides are applied directly to grain during handling on grain conveyors and elevators, or sprayed onto the surface of bag stacks, walls and floors of empty structures and transport vehicles. Spaces of structures are sometimes treated by “fogging” to control of flying insects. However, the number of available contact insecticides was recently limited by the Directive 91/414/EEC and the others will be restricted in the EU by a new Thematic Strategy on Pesticides. Thus, the following measures are currently used in Poland: (a) phosphine, (b) a few contact insecticides, (c) heat, (d) high pressure and CO_2, and (e) Integrated Pest Management (IPM). The most important mean is phosphine (PH_3) from solid phosphides. The following techniques for application of solid phosphides were adopted: (a) Speedbox, (b) dispenser technique, (c) phosphine recirculation system (J-System). Speedboxes seems to be popular in Poland as handling and maintenance of them is

simple, and the gas concentration required for killing the pests is reached in shorter time. J-System has been installed in a silo of the ZZZ Company in Zamosc, Poland, and it is already used in fumigation treatments of stored grain. The high pressure chambers that hold 20-30 bars of pressure and 100% carbon dioxide are now being used in Bialystok and Lublin for medicinal herb treatments.

Introduction

Methyl bromide (MB) had been widely used for fumigation of durable commodities, perishable products, structures and transport vehicles. This good gaseous pesticide may not be replaced by one alternative, but various methods and means have to be used. Contact insecticides (Table 1) may be used as MB alternatives on stored grain and in storage structures and food production plants.

In Poland, in 1995/1996 two products were registered for smoke generating treatment, 11 products for spraying, and 5 products for fogging (Table 1). In 2000/2001, the situation was still similar with two products for smoke generating treatment, 10 products for spraying, and 4 products for fogging (Table 2). However, in 2004/2005 an abrupt decline in the number of available products was observed with no more products for smoke generating treatment, 5 products for spraying and one product for fogging (Table 3).

Tab. 1 Insecticides for stored product pest control in empty enclosures in Poland, 1995/1996

Treatment	Product name	Active substance
Smoke	Actellic 20 FU	pirimifos-methyl
	Coopex 13 FU	permethrin
Spray	Actellic 500 EC	pirimifos-methyl
	Alfasect 05 SC	alfa-cypermethrin
	Ambusz 25 EC	permethrin
	Coopex 25 WP	permethrin
	Kordon 10 WP	cypermetrin
	K-Othrine 2,5 WP	deltamethrin
	K-Othrine 25 SC	deltamethrin
	Nuvan 7	dichlorfos
	Permasect 10 WP	permethrin
	Permasect 250 EC	permethrin
	Pybuthrin 6/60	pyrethrin + piperonylobutoxyd
Fog	Actellic 500 EC	pirimifos-methyl
	Ambusz 25 EC	permethrin
	Nuvan 7	dichlorfos
	Permasect 250 EC	permethrin
	Pybuthrin 6/60	pyrethrin + piperonylobutoxyd
Dust	-	-

Tab. 2 Insecticides for stored product pest control in empty enclosures in Poland, 2000/2001

Treatment	Product name	Active substance
Smoke	Actellic 20 FU	pirimifos-methyl
	Coopex 13 FU	permethrin
Spray	Actellic 500 EC	pirimifos-methyl
	Alfasect 05 SC	alfa-cypermethrin
	Ambusz 25 EC	permethrin
	Coopex 25 WP	permethrin
	K-Othrine 2,5 WP	deltamethrin
	K-Othrine 25 SC	deltamethrin
	Nuvan 7 070 OL	dichlorfos
	Permasect 10 WP	permethrin
	Permasect 250 EC	permethrin
	Pro-Store 420 EC	malathion + bifenthrin
Fog	Actellic 500 EC	pirimifos-methyl
	Ambusz 25 EC	permethrin
	Nuvan 7 070 OL	dichlorfos
	Permasect 250 EC	permethrin
Dust	-	-

The number of available contact insecticides was recently limited by the Directive 91/414/EEC and the others will be restricted in the EU by a new Thematic Strategy on Pesticides.

Tab. 3 Insecticides for stored product pest control in empty enclosures in Poland, 2000/2001

Treatment	Product name	Active substance
Smoke	Actellic 20 FU	pirimifos-methyl
Spray	Actellic 500 EC	pirimifos-methyl
	Alfasect 05 SC	alfa-cypermethrin
	K-Othrine 2,5 WP	deltamethrin
	K-Othrine 25 SC	deltamethrin
	Pro-Store 420 EC	malathion + bifenthrin
Fog	Actellic 500 EC	pirimifos-methyl
Dust	-	-

The following measures are currently used in Poland:

(a) a few contact insecticides (Table 4),
(b) phosphine,
(c) heat treatment,
(d) high pressure and CO2,
(e) Integrated Pest Management (IPM).

The contact insecticides are applied directly to grain during handling on grain conveyors and elevators, or applied onto the surface of bag stacks, walls and floors of empty structures and transport vehicles.

Tab. 4 Contact insecticides for stored product pest control in Poland, 2009

Treatment	Product name	Active substance
empty enclosures		
Smoke	Actellic 20 FU	pirimifos-methyl
Spray	Actellic 500 EC	pirimifos-methyl
	K-Othrine 2,5 WP	deltamethrin
Fog	-	-
Dust	K-Obiol 02 DP	deltamethrin
Stored grain and seeds		
Smoke	-	-
Spray	Actellic 500 EC	pirimifos-methyl
Fog	-	-
Dust	K-Obiol 02 DP	deltamethrin

Phosphine is available in solid preparations of Al or Mg phosphide. Insect resistance ia a serious concern. Improved application techniques are necessary (Fig 1).

Phosphine generating products are:

- Delicia-Gastoxin 56 GE
- Magnaphos Pellets 66 GE
- Magnaphos Tablets 66 GE
- Magtoxin 66 GE
- Quickphos Bags 56 GE
- Quickphos Belts 56 GE
- Quickphos Blankets 56 GE
- Quickphos Pellets 56 GE
- Quickphos Tablets 56 GE

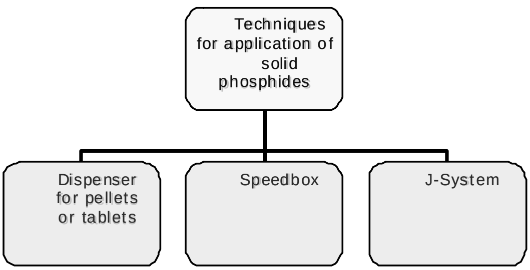

Fig. 1 Techniques for application of solid phosphides.

Application of tablet and pellets (Fig. 2) is more economic and safer.

Fig. 2 Dispenser for pellets or tablets

Speed boxes (Fig. 3) seem to be popular in Poland as handling and maintenance of them is simple, and the gas concentration required for killing the pests is reached in shorter time. Plates with magnesium phosphide are used in Speed boxes.

Fig. 3 Speed box for plates with magnesium phosphide

The Phosphine recirculation system (J-System) (Fig. 4) has been installed in a silo of the Grain Company in Zamość, and it is already used in fumigation treatments of stored grain.

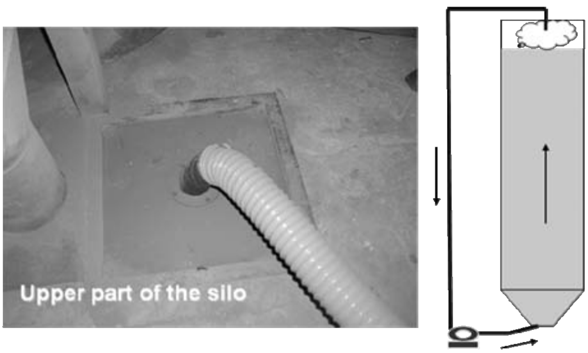

Fig. 4 Phosphine recirculation system (J-System)

Phosphine resistance test kits (Fig. 5) are applied testing the behaviour and the activity of insect pests in a defined atmosphere containing phosphine (3,000 ppm). If tested flour beetles are still alive after 8 minutes at a concentration of 3.000 ppm, then they are considered resistant. Urgent elimination of this insect strain is required.

Fig. 5 Phosphine resistance test kit.

Heat treatment:

- The need for rapid large scale treatment still exists.
- Thermal remediation
- Full scale
- Spot treatment
- Silo treatments

Spot treatments are zone oriented, they are as small as possible because size is money (Fig. 6).

Fig. 6 Spot heat treatment

Heat treatments are accompanied by pest monitoring to answer the questions „Where are the insects?" and „How often is heat required?".

<u>High pressure + CO2</u>: The high pressure chambers (Fig. 7) that hold 20 bars of pressure and 100% CO_2 are now being used in Białystok and Lublin for medicinal herb treatments.

Fig. 7 high pressure chambers

Integrated Pest Management (IPM): Integrated Pest Management is a process that combines as many control measures as possible to reduce the pest population in the way which is efficient, economical and safe to the environment and humans. IPM is implemented into the food industry as a requirement of systems HACCP, AIB, and IFS/BRC.

Fig. 8 Funnel trap for stored-product moths in a mill

Relavant key-words for Integrated Pest Management are:

- Monitoring of pest(s) (Fig. 8);
- Identification of pest(s);
- Threshold level and pest control decision (comparison of the infestation level to the threshold level);
- Pest control – use the combination of different methods;
- Follow-up evaluation and corrective actions.
- IPM uses the combination of two or more methods: sanitary,mechanical, biological, physical or chemical.
- Pest-proof buildings
- Proper storage techniques
- Sanitation
- Hygiene measures
- Action levels

Last but not least, the cooperation between the plant co-ordinator, the plant employees and the pest control company is necessary for the successful implementation of IPM.

25 - Plant protection products and biocides

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Abstract

Today we have two directives and some amendments that regulate use of pesticides in most European countries. Directive 91/414 regulates placing of plant protection products (PPP) on the market whereas Directive 98/8 regulates placing of biocidal products (BP) on the market. Evaluation process for the registration is in most parts similar because it takes into account same parameters (efficacy, toxicity, ecotoxicity). Due to the same active ingredients that are used overlapping arise within the group of insecticides, acaricides, rodenticides and avicides.

Introduction

Storehouses with/for agricultural products are treated with the same a.i. as storehouses with/for stored food or feed. These products are registered according to different directives and in many countries under responsibility of different ministries (agriculture and health).

The application of the different regulations is particularly difficult, because the same pest rodent, insect, mite… cause damage on agricultural products as well as on food or feed (also under responsibility of different ministries in some situations) and "move" among different legal areas like biocidal law, plant protection law and public health regulations.

According to the mentioned it will be important to take an initiative to integrate biocidal, plant protection and public health regulations to strengthen pest control.

Plant protection products and biocides: Plant protection products and biocides are placed on the market according two directives and amendments in most European countries. Directive (91/414/EEC) concerning plant protection products was published on 19 August 1991 (OJ L 230). It came into force on 26 July 1993.

The main elements of the Directive are as follows:

(a) To harmonise the overall arrangements for authorisation of plant protection products within the European Community (EC) by harmonising the process for considering the safety of active substances by establishing agreed criteria whereas product authorisation remains the responsibility of each Member State.
(b) The establishment of a positive list of active substances (Annex I), that have been found without unacceptable risk to people or the environment.
(c) Member States can only authorise the marketing and use of plant protection products after an active substance is listed in Annex I. Exception are transitional arrangements.

The Directive consists of six Annexes. Set out are common rules and guidance on data requirements, data evaluation, risk assessment; the transition from a national to the EC authorisation system, the protection of commercial information (data protection); and public access to information on pesticides.

- Annex I - the 'positive' list of active substances that are authorised for use in plant protection products within the Community.
- Annex II - a comprehensive list of the tests and studies required for an active substance to support its inclusion in Annex I.
- Annex III - a comprehensive list of the tests and studies required on the plant protection product active substance either to support an application for product authorisation following inclusion of the active substance in Annex I or required for at least one representative product to support the inclusion of an active substance in Annex I.
- Annex IV and Annex V - provide for additional specific phrases for special risks and safety precautions for plant protection products.
- Annex VI - lays out the "Uniform Principles" which are the harmonised criteria for evaluating products at a national level. Application of the Uniform Principles ensures that authorisations issued in all Member States are assessed to the same standards.

The Directive also allows mutual recognition. This allows Member State to authorise the product without the submission of further data if the product was authorised in the original Member State in accordance with Uniform Principles. Comparability in terms of climate, soil, cultural methods, and that the Member State that has already authorised the product has implemented the Annex I decision, must be demonstrated. If the product is different, for example in use or formulation, then further data on safety and/or efficacy will be required before an authorisation can be granted.

Here are plant protection products discussed only in the scope of stores and plant products: Directive 98/8/EC of the European Parliament and of the Council on the placing on the market of biocidal products was adopted in 1998. The Biocidal Product Directive aims to harmonise the European market for biocidal products and their active substances.

This Directive concerns:

- The authorisation and the placing on the market for use of biocidal products within the Member States;
- The mutual recognition of authorisations within the Community;
- The establishment at Community level of a positive list of active substances which may be used in biocidal products. Active substances have to be assessed and the decision on their inclusion into Annex I of the Directive shall be taken at Community level. Inclusion to Annex I may be denied if there are less harmful, suitable substitutes available for the same purpose. The biocidal products should be authorised in accordance with the rules and procedures set in Annex VI of the Directive.

There are:

- Annex I - List of active substances with requirements agreed at community level for inclusion in biocidal products
- Annex IA - List of active substances with requirements agreed at community level for inclusion in low-risk biocidal products
- Annex IB - List of basic substances with requirements agreed at community level
- Annex II - Common core data set for biocidal products
- Annex III - Additional data set for active substances
- Annex IV - Data set for active substances
- Annex V - Biocidal product-types and their descriptions are presented in an exhaustive list of 23 biocidal product types.
- Annex VI - Common principles for the evaluation of dossiers for biocidal products

The available knowledge and control of biocidal products has been significantly improved across the EU, and particularly in those Member States that did not have any existing systems, or where only a part of all 23 groups of biocides was covered. As a direct result of identifying and starting to evaluate the biocides that were on the EU market, a number of obsolete products have been removed.

Equal but different: Due to similarities and possible overlapping there is a guidance document agreed between the Commission services and the competent authorities of Member States for the biocidal products Directive 98/8/EC and for the plant protection products Directive 91/414/EEC. Explanations are presented in “Manual of decisions for implementation of directive 98/8/EC concerning the placing on the market of biocidal products”. The Manual is updated from time to time with new information whereas last modification was in July 2008.

As a general rule a relevant product is regulated either by the BPD or by the PPPD, though there may be some significant exceptions. In these exceptions exactly the same physical product would fall within the scope of Directives 98/8/EC and 91/414/EEC for the purpose of these Directives. This means that for this product dual authorisation will be needed. Good example is a i. deltamethrin registered under both Directives for control of same insect species (e.g. Tribolium spp. and Plodia interpunctella are pests treated with PPP or BP in different stores on different commodities). The authorisation procedure to be followed prior to placing a given product on the market will be governed in most cases either by the BPD or by the PPPD.

Products in the unprocessed state or having undergone only simple preparation such as milling, drying or pressing, derived from plants are treated with PPP. Products like pheromones or any other attractants and repellents that need to be applied before or during the pest attack shall be considered as PPPs if they are used against pests that can damage plant or plant products. On the other hand if pest is detrimental in other field e.g. detrimental to humans or to products other than plants or plant products then the product used is considered as a BP.

Proposal for general and specific borderline: Products for the treatment of empty structures and articles are considered PPPs on condition that the purpose of the use is to destroy exclusively and specifically organisms harmful to plant products and that after the treatment only plants products will be stored in the treated structure.

In the cases where products are used for a general hygiene purpose or when it is not clear which kind of products will be stored after the treatment it is agreed to consider these products as biocidal products.

On the basis of the above consideration the following borderline is agreed:

- Biocidal Products: All products used for a general biocidal purpose. These would include general hygiene disinfectants in empty structures when it is not clear which kind of products will be stored after the treatment.

The following are considered to be examples of biocidal products:

- Products to destroy dust mites from textiles, as opposed to products used against mites that cause harm to plants.
- Fumigants used in storage rooms for food like cheese and meat.
- Products for the control of termites when used as bait or as a soil-drench treatment.
- Products for the control of birds for hygiene purposes.
- Products for the preservation of wood, from and including the saw-mill stage, or wood products by the control of wood-destroying or wood-disfiguring organisms.
- Rodenticides are considered as biocidal products if used for the control of mice, rats or other rodents in farms, cities, industrial premises etc, and inside plant growing areas not to protect plant or plant products.
- Rodenticides are considered as plant protection products if applied in plant growing areas (agricultural field, greenhouse, forest) to protect plants or plant products temporarily stored in the plant growing areas in the open without using storage facilities.

If a product is used in both situations, than it falls within the scope of both, Directive 98/8/EC and Directive 91/414/EEC for the purpose of these Directives and it will need dual authorisation for the relevant use.

Explanations on border lines: Question: A company uses a product to treat empty storage areas for plant products such as grain and flour. This product is within the scope of the Plant Protection Products Directive. The same or other products are used against cockroaches in storage areas where flour is stored to be used in bread production.

Answer (agreed in June 2003): According to the Guidance Document on the borderline between biocides and plant protection products, products in the unprocessed state or having undergone only simple preparation such as milling, drying or pressing, derived from plants. If the target organism is detrimental to plant or plant products then the product used is considered as a PPP either if applied directly on plants or plants products or applied indirectly on empty structures to control pests of plant or plants products exclusively. Products used for a general biocidal purpose are biocides. These would include general hygiene disinfectants in empty structures when it is not clear which kind of products will be stored after the treatment. Flour produced at a mill from grain is a plant product having undergone a simple preparation such as milling etc. However, additional steps, such as transport to another food production site, go beyond simple processing. Therefore, products used to treat storage areas in mills or other installations of ‘simple processing’ are plant protection products, whereas products used to treat storage areas in installations of more advanced food processing are biocides. If such a product is an insecticide it is placed in Product Type 18, if it is a repellent than it is Product Type 19.

Question: A fumigant is used for treatment of mills and pasta factories (both processing and storage areas) which are located directly adjacent to the mills. The factory and the mill will be fumigated at the same time. Is the fumigant to be authorised as PPP or biocide?

Answer (agreed in June 2003): The fumigants used anywhere in the mill would have to be authorised as PPP. This, however, does not seem to hold for the pasta factory. Here the processing step is more advanced and fumigants used in the pasta factory are then biocides. Therefore, strictly speaking, the same fumigant has to be authorised both as a PPP and as a biocide. However, if indeed the pasta factories are situated directly adjacent to the mills and are treated at the same time with the same product, Member States could in a pragmatic approach also decide to authorise the product for both uses as PPP.

Conclusion

There are equivalences as well as differences between regulations regarding plant protection products and biocides. The same pest species, rodent, insect, mite… is detrimental to plant products as well as on food or feed. Due to this narrow border line between these two groups and in unclear situations the need is for clear explanations like in “Guidance manual”.

The application of the different regulations is particularly difficult due to responsibility of different ministries in some countries and that pests “move” among different legal areas like biocidal law, plant protection law and public health regulations.

According to the mentioned it will be important to take an initiative to integrate biocidal, plant protection and public health regulations to strengthen pest control and make providing easier.

Literature

Council Directive of 15 July 1991 concerning the placing of plant protection products on the market (91/414/EEC)

Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market

Manual of decisions for implementation of Directive 98/8/EC concerning the placing on the market of biocidal products - 2008

26 - Latest developments in the registration of SPP chemicals in Germany and Europe

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Abstract

Regulation of the European Parliament and of the Council (EC) No 396/2005 of 23 February 2005 on maximum residue levels of pesticides in and on food and feed of plant and animal origin and amending Council Directive 91/414/EEC. The review process of active substances under Directive 91/414/EEC led to a rapid decline in the number of available existing active substances on EU level. New active substances to protect stored products are missing. Consequently the number of available storage insecticides is reduced even more. The aim of Regulation 396/2005 is to harmonise the maximum residue levels (MRLs) on EU level to eliminate barriers to trade and to increase the transparency of the market. A reduction of MRLs and as a result the reduction of the number of available active substances is possible. Subsequently the number of gaps and resistance problems will increase. In the consequence all persons involved, including farmers, industry, government and administration, research and trade are requested to spare no effort to reach a long-term and effective store protection, which is save to users and consumers as well as the environment. The influence of the new Regulation on placing plant protection products on the market will depend on its arrangements on EU and national level.

Introduction

Referring to actual estimations about 20 to 25 % of the crops are damaged by stored product pests worldwide. The main management techniques in the protection of stored products are:

- hygiene,
- air circulation/ventilation and
- chemical treatment.

Due to different conditions during storage and infestation pressure, precautionary measures are often insufficient to protect the stored products. The infested stored products have to be treated, not only to ensure the necessary quality (nil tolerance) and quantity, but also because of health precautions. In many cases no alternatives to chemical treatment exist. At EU level two legislative regulations have an important impact on the availability of plant protection products:

- Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market.
- Regulation of the European Parliament and of the Council (EC) No 396/2005 of 23 February 2005 on maximum residue levels of pesticides in and on food and feed of plant and animal origin and amending Council Directive 91/414/EEC.
- EU evaluation program for active substances under Council Directive 91/414/EEC.

Current situation regarding the evaluation of existing active substances. Table 1 shows the current situation regarding the evaluation of existing active substances.

Tab. 1 Current situation regarding the evaluation of existing active substances

Stage	No. active substances	Inclusion in Annex I	Non-inclusion or withdrawal	Not yet decided
Stage 1	90	55	35	0
Stage 2	148	32	116	0
Stage 3	387	62	319	6
Stage 4	316	62	252*	2
Total	941	211	722**	8

*It was decided that 25 active substances from the original stage 4 do not fall under the scope of Directive 91/414/EEC. They were withdrawn from Reg. 2229/2004. **64 non-inclusions of active substances due to voluntary withdrawal (3rd stage: 49; 4th stage: 15). Authorised PPP can remain on the market. Possibly re-submission according to Reg. 33/2008.

The EU review of the 941 existing active substances was divided into 4 stages. Concerning stages 1 and 2 all decisions have been taken, i. e. 87 old substances are included in Annex I of Directive 91/414. Concerning stages 3 and 4 there are 124 substances which are included in Annex I.

This means in total:

- 211 existing active substances are included in Annex I,
- 722 are not included and
- 8 existing active substances have not yet been decided on.

Regarding the percentages:

- 26 % of the existing active substances are included in Annex I of Directive 91/414/EEC.
- 67 % have been withdrawn from the market. The reasons are
- no dossier submitted,
- dossier incomplete,
- withdrawn by the applicant.
- 7 % are not included following the Peer Review because of no proof of safe application.

Consequently the review process of active substances under Council Directive 91/414/EEC led to a rapid decline in the number of available existing active substances at EU level. Table 2 shows the current situation regarding the evaluation of new active substances.

Tab. 2 Current situation regarding the evaluation of new active substances

	No. active substances	Inclusion in Annex I	Non-inclusion or dossier withdrawn	Not yet decided
Chemical active substances	129	74	8	47
Microorganisms	19	8	1	10
Total	148	82	9	57

In total 148 new active substances have to be evaluated, 129 chemical active substances and 19 microorganisms. 82 of these are already included in Annex I of Directive 91/414, 9 substances are not included. 57 have not yet been decided on.

Future work

The plans for the years 2009 - 2010 are:

- Peer Review for new active substances: > 53 active substances
- „Green tracks" (Peer Review following Annex I
- inclusion, Regulation (EC) No. 1095/2007): 68 active substances
- Re-submissions (Regulation (EC) No. 33/2008): 71 active substances
- Annex I renewals: 9 active substances
- Submission of confirmatory data: 26 active substances

Therefore 227 active substances in total have to be examined during the years 2009 and 2010. Situation regarding the evaluation of active substances for storage protection.

Insecticides and Acaricides: Table 3 shows the current situation regarding the evaluation program for active substances at EU level and authorisation status in Germany for insecticides and acaricides.

Tab. 3 Situation regarding the evaluation program for active substances (EU) and authorisation (Germany) – insecticides/acaricides

Substance	RMS	Status under Regulation 91/414/EEC	Status under the German Plant Protection Act	Problem area
Aluminium phosphide	DE	Included expiry: 31/08/2019	+	consumer, operator, worker and bystander exposure
Bifenthrin	FR	Pending (non-inclusion proposed)	+ (outdoor)	consumer, operator, worker and bystander exposure; contamination groundwater, protection of aquatic organisms, earth-worms and non-target arthropods
Carbon dioxide	UK	Included expiry: 31/08/2019	+	no areas of concern
Chlorpyrifos-methyl	ES	Included expiry: 30/06/2016	-	risks to birds, mammals, aquatic organisms, bees and non-target arthropods
Cypermethrin	BE	Included expiry: 28/02/2016	+ (outdoor)	operator exposure; protection of aquatic organisms, bees and non-target arthropods
Deltamethrin	SE	included expiry: 31/10/2013	-	operator and consumer

Substance	RMS	Status under Regulation 91/414/EEC	Status under the German Plant Protection Act	Problem area
				exposure
Dichlorvos	IT	not included withdrawal of authorisation: 06/12/2007 period of grace: 6/12/2008 (2007/387/EC)	-	operator, worker, bystander exposure
Endosulfan	ES	not included withdrawal of authorisation: 02/06/2006 period of grace: 30/06/2007 (2005/864/EC)	-	environmental fate and behaviour, operator exposure (indoor)
Fenitrothion	UK	not included withdrawal of authorisation: 25/11/2007 period of grace: 25/11/2008 (2007/379/EC)	-	risks to operator, worker, and consumer unclear
Kieselguhr	EL	Included expiry: 31/08/2019	+	
Lambda-Cyhalothrin	SE	Included expiry: 31/12/2011	+	operator and consumer exposure, protection of aquatic organisms, bees and non-target arthropods
Magnesium phosphide	DE	included expiry: 31/08/2019	+	consumer, operator, worker and bystander exposure
Malathion	FI/ UK	not included withdrawal of authorisation: 06/12/2007 period of grace: 06/12/2008 (2007/389/EC) re-submission!	-	risks to operator, worker, bystander and consumer unclear
Methyl bromide	UK	not included withdrawal of authorisation: 18/03/2009 period of grace: 18/03/2010 (2008/753/EC)	-	insufficient data; bystander and consumer exposure; acute, short and long term risks to birds and mammals; toxicity to non-target arthropods and earthworms; ozone depletion (Montreal Protocol)
Nitrogen	-	not included (2004/129/EC)	-	insufficient data or not notified
Permethrin	IE	not included (2000/817/EC)	-	insufficient data or not notified
Phoxim	FI	not included (2007/442/EC)	-	insufficient data or not notified
Phosphane	DE	pending (dossier complete)	+	
Pirimiphos-methyl	UK	Included expiry: 30/09/2017	+	operator exposure, MRLs
Pyrethrins	IT	Included expiry: 31/08/2019	+	piperonyl butoxide (synergist)
Sulfuryl fluoride	UK	pending (dossier complete)	+	

Rodenticides: Table 4 shows the current situation regarding the evaluation program for active substances at EU level and authorisation status in Germany for rodenticides.

Tab. 4 Situation regarding the evaluation program for active substances (EU) and authorisation (Germany) - rodenticides

Substance	RMS	Status under Regulation 91/414/EEC	Status under the German Plant Protection Act	Problem area
Brodifacoum	-	not included (2007/442/EC)	+ essential use; expiry: 31/12/2010)	insufficient data or not notified
Bromadiolone	SE	not included (voluntary) withdrawal of authorisation: 31/12/2010; period of grace: 31/12/2011 (2008/941/EC) re-submission?	+	
Calciferol	-	not included (2004/129/EC)	-	insufficient data or not notified
Chloralose	-	not included (2007/442/EC)	-	insufficient data or not notified
Chlorphaci-none	PT	not included (2007/442/EC)	+ (outdoor) essential use; expiry: 31/12/2010)	insufficient data or not notified
Coumatetralyl	-	not included (2004/129/EC)	-	insufficient data or not notified
Difenacoum	FI	Included; expiry: 30/12/2019 only uses in the form of pre-prepared baits placed in specially constructed, tamper resistant and secured bait boxes are authorised, the nominal concentration of the	+	further information on methods for the determination of residues in body fluid and on the specification is needed

Substance	RMS	Status under Regulation 91/414/EEC	Status under the German Plant Protection Act	Problem area
		active substance in the products shall not exceed 50 mg/kg		
Difethialone	PL	not included (2004/129/EC)	-	insufficient data or not notified
Diphacinone	-	not included (2004/129/EC)	-	insufficient data or not notified
Flocoumafen	PL	not included (2004/129/EC)	-	insufficient data or not notified
Hydrogen cyanide	-	not included (2004/129/EC)	-	insufficient data or not notified
Phosphane	DE	pending (dossier complete)	+	
Warfarin	IE	Included expiry: 30/09/2013	+ (outdoor)	only uses in the form of prepared bait if appropriate, placed in specially constructed hoppers; protection of operators, birds and non-target mammals
Zinc phosphide	DE	not included (voluntary) withdrawal of authorisation: 31/12/2010 period of grace: 31/12/2011 (2008/941/EC) re-submission?	+	

Regulation (EC) No 396/2005: The aim of Regulation 396/2005 is to harmonise the maximum residue levels (MRLs) at EU level to eliminate barriers to trade and to increase the transparency of the market. A reduction of MRLs and as a result the reduction of the number of available active substances is possible and subsequently an increase in the number of use gaps and resistance problems as well as misuse.

Authorisation situation for storage protection in Germany - Insecticides and Acaricides: Table 5 shows the authorisation situation for storage protection in Germany regarding insecticides and acaricides.

Tab. 5 Authorisation situation for storage protection in Germany – insecticides/ acaricides

Active substance	Number of authorised plant protection products*	Applications
Aluminium phosphide	5	rooms, silo units, sacks; stored cereals, cereal products, starch, expeller, dried fruit, dried vegetables, pulses, cocoa, tea, coffee, spices
Carbon dioxide	2	stored cereals, cereal products, fatty seeds, tobacco, tea, spices, medicinal plants, dried fruit
Kieselguhr	1	rooms; stored cereals (conveyor belt)
lambda-Cyhalothrin	1	hardwood/softwood (consignments)
Magnesium phosphide	3	rooms; stored cereals, cereal products, dried fruit, dried vegetables, tobacco, cocoa, tea, coffee, spices, oil seed, nut fruits, medicinal plants, hay
Phosphane	1	stored cereals, fatty seeds, dried fruit, coffee, cocoa
Pirimiphos-methyl	1	rooms; stored cereals (conveyor belt)
Pyrethrins	1	rooms
Sulfuryl fluoride	1	rooms; dried fruit, nut fruits, hardwood/softwood (consignments)

*not including transfers of authorisation

Rodenticides: Table 6 shows the authorisation situation for storage protection in Germany regarding rodenticides.

Tab. 6 Authorisation situation for storage protection in Germany - rodenticides

Active substance	Number of authorised plant protection products*	Applications
Brodifacoum	2	common rat, domestic mouse
Bromadiolone**	2	common rat, domestic mouse
Difenacoum	2	black rat, common rat, domestic mouse
Zinc phosphide**	1	domestic mouse

*not including transfers of authorisation; ** re-submission?

Selected examples

Dichlorvos: Control of storage pests (moths and beetles) in the presence of stored goods and taking a relatively short exposure time into consideration. Non-inclusion in Annex I of Directive 91/414/EEC and withdrawal of authorisations by 6 December 2007 (deadline for selling stocks 6 December 2008). Evidence that estimated operator, worker and bystander exposure is acceptable could not be provided.

Pirimiphos-methyl: Significance for safe cereal protection for post-harvest treatment, concerning both the decontamination of empty rooms and pest control in cereals and equipment. Inclusion in Annex I of Directive 91/414/EEC. Only applications using automatic systems in empty rooms are permissible unless the Member States pay special attention to operator safety and observing maximum residue limits for other authorisations. Alternatives are highly toxic fumigation products (PH3) which can often not be used due to constructional reasons. During the process of evaluation at Community level, toxicological threshold values (ADI, AOEL) were reduced, but can still be complied with. However, consumer protection is being discussed at EU level (exhausting the ADI). It is therefore uncertain whether the maximum residue limits will apply in the long term.

Sulfurylfluoride: The procedure for inclusion in Annex I of Directive 91/414/EEC is not yet completed. In the context of the harmonisation of maximum residue limits according to Regulation (EC) No. 396/2005, fluoride was considered as a metabolite which occurs during application. The admissible maximum limit for cereals was set at the level of the analytical limit of determination of 2.0 mg/kg. Because the product was not listed in Annex I of Regulation (EC) No. 396/2005, no maximum limit was determined for dried fruit. It must be clarified legally whether the standard value of 0.01 mg/kg is valid. Consequently, it is not assured that the maximum limits for applications in rooms in the presence of cereals and dried fruit which are valid as from 1 September 2008 can be complied with. Authorisations were amended by restrictions so that the co-treatment of cereals was excluded.

Summary and perspectives: The limited range of active substances/plant protection products for storage protection is alarming (gaps, resistance, misuse). Preventative measures are becoming more and more important, but are still not adequate. The different kinds of storage goods, pests, local conditions, etc. require different active substances, formulations and application techniques. Many non-chemical measures are not yet ready to be put into practice or are problematic as far as food legislation is concerned. Regulations should not compete with one another but should complement one another (plant protection products, biocides). All those persons involved, including farmers, industry, government and administration, research and trade, are requested to spare no effort to find solutions for adequate storage protection which is safe both for operators and consumers as well as for the environment. Effects of the revision of Directive 91/414/EEC (for example cut-off criteria, zonal authorisation, mutual recognition) on the availability of storage protection products are open. The influence of the revision on placing plant protection products on the market will depend on its arrangements at EU and national level.

27- The new Regulation on placing plant protection products on the market – possible impacts on stored products protection

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Abstract

On 13th January 2009, the European Parliament accepted in second reading a compromise text on a new Regulation on placing plant protection products on the market. The proposal still needs to be formally adopted by the Council before publication and entry into force. The new Regulation provides for important improvements in the framework of assessment and approval of active substances. Although the scope of the new Regulation will not change, and also the borderline to biocides legislation will stay the same, some provisions in the new Regulation might also have an impact on stored products protection. The new Regulation provides for clear criteria for approval of active substances: substances which are considered as persistent organic pollutant (POP), as persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumuluative (vPvB) under the REACH Regulation or which are classified as mutagenic (cat. 1 or 2) will not be approved under the new system. The same applies to substances which are classified as carcinogenic or toxic to reproduction (cat. 1 or 2) or which are considered as endocrine disruptors, unless the exposition of humans is negligible under realistic proposed conditions of use. However, active substances classified as carcinogenic cat. 2 with threshold, toxic to reproduction (cat. 1 or 2) or which are considered as endocrine disruptors can be approved under restricted conditions if they are necessary to control a serious danger to plant health.

It can be expected that the approval criteria will speed up decision–making and increase the legal certainty for notifiers, but will also lead to a decrease in the number of active substances available. The number of products available to users is, however, not expected to decrease to a significant extent, because the measure described above is counterbalanced by some other measures increasing availability of products to users, like the improved framework for minor uses or the enhanced mutual recognition within the zonal system. Under this system, the EU is divided into in three evaluation zones (North, Center, South). For some uses (e. g. empty storage premises, post-harvest treatments) the whole EU is considered as one zone.

The zonal system provides for obligatory mutual recognition of authorisations within one zone and for voluntary mutual recognition between different zones. The procedure of mutual recognition has been streamlined and strict timelines apply. Member States, when recognising an authorisation, may modify the risk mitigation measures in order to adapt the authorisation to their own purposes; if this is not sufficient and an unacceptable risk persists, the recognition can be refused.

Other provisions of the new regulation, like comparative assessment and substitution, shall have no detrimental influence on the availability of products, if they are implemented on a scientifically and technically sound basis.

Improtant objectives of the proposal:

- To protect human and animal health and the environment
- To safeguard the competitiveness of agriculture
- To improve the functioning of the common market
- To speed up decision making

Key issues:

- Zonal system and obligatory mutual recognition
- Criteria for approval
- Comparative assessment and substitution principle
- Minor uses
- Scope (safeners & synergists, co-formulants)
- IPM
- Monitoring and controls
- Human testing
- Low risk/basic substances
- Information about use

Zonal Mutual Recognition:

Art 40 (also: 41, 36)

- 3 zones in general, one zone for greenhouse, post-harvest, storage rooms and seed treatment)
- Initial evaluation shall take into account the whole zone
- All Member States of a zone can participate in evaluation
- Different time periods for initial (12+6 months) and recognised authorisation (120 days)
- Obligatory Mutual Recognition within a zone
- Voluntary Mutual Recognition between zones, for candidates for substitution, for provisional authorisations, for derogations under art. 4(7)
- Mutual recognition no longer needs consent of authorisation holder in case of a prevailing public interest
- Adapting risk mitigation measures is possible in order to address the specific situation in a MS
- Possibility to refuse Mutual recognition in case of a serious risk for health or the environment

Criteria for approval:

Annex II.3

- CMR cat. 1&2, POP, PBT, vPvB, endocrine disruption
- Exemption for CR cat. 1&2 and ED if only negligible exposure to humans
- Endocrine Disruptors:
- COM to present specific scientific criteria within 4 years
- Transitional regime: CR cat. 3 shall and R cat. 3 + toxic to endocrine organs may be considered as endocrine disruptors

Art. 4(7)

- Derogation in order to control a serious danger to plant health
- Endocrine disruptors and CR cat. 2 can be approved for 5 years
- MS to report on possible phasing out
- No residues
- Burden of proof on notifier

Substitution and Comparative Assessment:

Art. 50, Annex II.4, Annex IV

- Candidates for substitution identified at EU level
- Comparative Assessment at MS level
- Criteria: high ADI/ARfD/AOEL, PB/PT/BT, non-manageable concerns (critical effect + exposure pattern), high in non-active isomers, falls under point 3.6.3-3.6.5 together with negligible exposure
- Approval period: 7 years

Conditions:

- significantly lower risk
- no significant economic or practical disadvantages
- sufficient chemical diversity to minimise occurrence of resistance
- sufficient experience
- minor uses are taken into account

Transition:

- One authorisation without comparative assess-ment of 5 years in order to gain experience
- Compliance deadline 3 years after assessment

Minor uses:

Art. 51

- Definition in the text
- MS may take measures to facilitate or encourage applications
- Off-label extensions
- Mutual recognition of extensions possible
- “Minor uses fund” within two years after entry into force

For more information please consult our new website:
http://ec.europa.eu/food/plant/protection/evaluation/index_en.htm

Please keep in mind: Regulation = directly applicable in MS,
Legislative framework, many technical issues to be tackled during the implementation phase (31 tasks for implementation given to COM),
Scope unchanged (also with respect to biocides),
Zonal system and comparative assessment must be seen as complementary concerning MS workload.

Epilog

The International Symposium on stored product protection (SPP) drew plenty of interest in many European states and could demonstrate the shortages and deficiencies of this branch of pest control. The permanently diminishing number of accessible chemicals for use as SPP products reveal alarmingly that the structures for research and development in the member states are critically neglected. On the other side it was shown that the impact of stored product pests lies not only on shortage of food and feed but also on human health. The EU plays an important role in this context and does not yet consider SPP as a special area that needs specific consideration when banning substances without thorough communication between the various involved national ministries on the consequences for the European market. Still there seems to be the prejudice that there is an endless reservoir for new chemicals to fill gaps after one product has been phased out. Internationally, the replacement of methyl bromide has drawn together more than 150 member states under the umbrella of the UNEP to detect and develop feasible alternative prior to fully phasing out methyl bromide. This unfortunately does not happen in Europe with the consequence that for instance dichlorvos (DDVP) was taken off the market without having a feasible alternative for its use in Europe. It is strongly recommended to create a task force with national governmental technical specialists that oversees the various fields of application of such a product, communicates with the EU and proposes technical solutions for the further modified use without risks that might have led to the envisaged ban. This task force could use the network of EPPO or other existing networks but the Europeasn MS must employ scientists to deal with these questions and cooperate under each other and with European industry to develop spp into the future responding to the public expectation of supply with economically affordable feed and food of high quality without critical chemical residues or microbiological contaminants.

In so far the symposium achieved the goal to describe the possibilities of reducing the foreseeable shortages and risks for spp and proposed solutions to overcome them.

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