Singh, N.B., Sinha, R.N., 1977. Carbohydrate, lipid and protein in the developmental stages of *Sitophilus oryzae* and *S. granarius* (Coleoptera: Curculionidae). Annals of the Entomological Society of America 70, 107-111.

Street, M.W., 1971. Nuclear magnetic resonance for detecting hidden insect infestation in stored grains. J. Ga. Entomol. Soc. 6, 249-256.

Yaowaluk, Chanbang, Frank, Arthur, Gerald, Wilde, James, Throne, 2008. Control of *Rhyzopertha dominica* in stored rough rice through a combination of diatomaceous earth and varietal resistance. Insect Science 15, 455-460.

IPM guidelines as fundament for sustainability in plant protection: The case for stored product protection

Bernd Hommel*, Nadine Feuerbach

Julius Kühn-Institut, Federal Research Centre for Cultivated Plants (JKI), Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Königin-Luise-Str. 19, 14195 Berlin, Germany

*Corresponding author: bernd.hommel@julius-kuehn.de

DOI 10.5073/jka.2018.463.226

Extended Abstract

According the EU Framework Directive 2009/128/EC of Sustainable Use of Pesticides (EU, 2009), member states shall implement into practice, amongst others, crop or sector-specific guidelines for integrated pest management (IPM) on a voluntary basis. In this context, article 14 demands that *"member states shall take all necessary measures to promote low pesticide-input pest management, giving wherever possible priority to non-chemical methods"*. Furthermore *"Public authorities and/or organisations representing particular professional users may draw up such guidelines. Member states shall refer to those guidelines that they consider relevant and appropriate in their National Action Plans"*.

For these aims, the EU has defined eight general principles of IPM in Annex III.

These general principles comprise:

- Principle 1: Prevention and/or suppression of stored product pests where ever possible.
- Principle 2: Monitoring of pests with adequate methods and tools.
- Principle 3: Decision-making in collaboration with profesional advisors to apply appropiate plant protection measures.
- Principle 4: Practicable non-chemical measures should be preferred.
- Principle 5: Pest–specific chemical products with the lowest detectable side effects for humans, target-organisms and environment should be preferred.
- Principle 6: Where appropriate, all control measures but mainly the use of chemical products should be restricted to the minimum extent, e.g. by reducing authorized doses, and frequency of application or by partial application.
- Principle 7: Implementation of resistance strategies to maintain the efficacy of the chemical products.
- Principle 8: Documentation of all plant protection measures and evaluation of their success for future decisions.

Barzman et al. (2015) have reviewed in detail application of these eight general principles of IPM from the perspective of what their implementation means for research, advisory services and farmers. There is no doubt that practicable measures of "prevention and suppression" and "monitoring" are of utmost importance to restrict all kinds of direct interventions on a minimum and thus, to keep low risks for human health, the natural environment and groundwater. The sequence of these eight general principles can be considered as a repetitive decision-making tree where misjudgements can be adjusted in the next vegetation period(s). But, Barzman et al. (2015) conclude that there is a need for flexible, locally adapted and practical IPM strategies.

In Germany, the general principles of IPM became binding for farmers and advisors with the entry into force of the revised Plant Protection Act in February 2012. Thereby these general principles are part of the mandatory good plant protection practice. However, due to this practice and several action plans since 2003, high standards of plant protection have already been implemented in Germany for years (Hommel et al., 2013).

Because of the uncontrolled environment, plant protection in arable and horticulture farms is more in focus of critical public debates than stored product protection under controlled environments in stockkeeping or processing companies. These debates and – in many cases - farmers' green attitude have the potential to support development and implementation of innovations to improve plant protection strategies in the context of IPM. In contrast, stored product protection takes place in fully controlled environments (e.g. warehouses, silos, containers, packagings) that are clearly separated from the natural environment. Environmentally-based driving forces to change or improve things are therefore less influential. Only economically-based preconditions, e.g. declined availability of chemical products, storage losses, avoidable discounts in the trade chain, and hygienic reasons are responsible for investments in better trained workers, extension services or storage conditions. It has been shown that protection goals, public goods or dependencies of trading partners are extremely crucial to implement profitably IPM guidelines into practice.

The National Action Plan on Sustainable Use of Plant Protection Products (NAP), issued by the Federal Government in 2013 for 10 years, focuses on all these aspects to strengthen voluntary activities of farmers and all stakeholders to reduce risks to humans, animals and the environment as demanded by the directive 2009/128/EC (https://www.nap-pflanzenschutz.de/en/).

The first IPM guideline for the sector "stored product protection" in Germany was developed in co-operation of different stakeholders (led by the Julius Kühn-Institut, JKI), financially supported by the Federal Ministry of Food and Agriculture (BMEL) and submitted to the BMEL in 2017. After its assessment done by The Scientific Advisory Board of the NAP, it is expected that this guideline will be added to Annex 1 of the NAP in 2018.

The guideline contains a general part with explanations of the eight principles in the context of stored product protection.

This specification of the principles comprises:

Principle 1: Appropriate storage, discharge and conveying, adequate sanitation, sealed chambers or silos, facilities for cleaning, cooling, drying;
Principle 2: Intake control, monitoring, claim advice;
Principle 3: Decision-making for the current problem, solutions to prevent the problem in future, claim advice;
Principle 4: Relocation, cooling, thermic and biological measures;
Principle 5: Choose low-risk products, think about the need for resistance strategies;
Principle 6: Appropriate equipment, dose and frequency of application;
Principle 7: Change of active compounds or alternative measures, monitoring;
Principle 8: Documentation of measures and their success, adjustment of measures for future stored product protection.

In addition, a more detailed table of measures is given for grain and bulk storage in the IPM guideline. Other stored products will be added later. The table shows the sequence of measures to be considered for individual pest problems. There is a clear priority to preventive and non-chemical measures. All measures are evaluated according to their practicability. To this end, the criteria effective, economically viable and proven are considered individually.

The IPM guideline for the sector "stored product protection" will be evaluated regularly and an adoption of advances in IPM is possible. In Germany's NAP, the aim is that 50 % of stock keepers shall apply the guideline 5 years after its publication, i.e. in 2023. To achieve this ambitious goal, a network will start in 2018 under the acronym VSnet for IPM demonstration in on-farm and off-farm commercial grain storage facilities.

Barzman, M., P. Bàrberi, N.E. Birch, P. Boonekamp, S. Dachbrodt-Saaydeh, B. Graf, B. Hommel, J.E. Jensen, J. Kiss, P. Kudsk, J.R. Lamichhane, A. Messéan, A.-C. Moonen, A. Ratnadass, P. Ricci, J.-L. Sarah, M. Sattin, 2015: Eight principles of Integrated Pest Management - Agronomy for Sustainable Development **35**: 1199-1215. DOI: 10.1007/s13593-015-0327-9.

EU, 2009: Directive 2009/128/EC of the European parliament and of the council of 21 October 2009 establishing a framework for community action to achieve the sustainable use of pesticides - Official Journal of the European Union L309 **52**: 71-86. DOI: 10.3000/17252555.L_2009.309.eng.

Hommel, B., S. Dachbrodt-Saaydeh, B. Freier, 2013: Experiences with Implementation and Adoption of Integrated Plant Protection (IPP) in Germany. In: R. Peshin, D. Pimentel (eds.), Integrated Pest Management Experiences with Implementation, Global Overview **4**: 429-465. DOI: 10.1007/978-94-007-7802-3.

Capability and limitation of anoxic treatments in museum collections protection

Bill Landsberger [1]*, Harro Frauendorf[1], Cornel Adler[2], Rudy Plarre[3]

[1]Rathgen-Forschungslabor, Staatliche Museen zu Berlin - Preußischer Kulturbesitz
[2]Julius-Kühn-Institut, Bundesforschungsinstitut für Kulturpflanzen Berlin
[3]Bundesanstalt für Materialforschung und -prüfung Berlin
*Corresponding author: b.landsberger@smb.spk-berlin.de
DOI 10.5073/jka.2018.463.227

Without precaution, insects may cause serious damage to museum collections. Quarantine of potentially infested objects can be logistically challenging. Anoxia under controlled nitrogen atmosphere is a most compatible but also time-consuming method to eradicate insect pests in all kinds of different materials. Treatment results are usually effected by duration, temperature, humidity and residual oxygen content. During a two-year research project, 34 relevant pest insect species of all developmental stages were tested in several different materials (wood, paper, wool) to monitor treatment success and to determine optimum treatment parameters. Duration of treatment ranged from one to three weeks at temperatures of 20 - 27 °C. As expected, results showed significant differences in mortality among tested species. Highest tolerance of hypoxic conditions was found in older larvae of *Hylotrupes bajulus*. However, this species is an unlikely museum pest. Anobiids and other wood boring beetles are more often an issue related to cultural heritage. Tested imbedding materials in general had no mortality lowering influence. A combination of three weeks exposure time at up to 0.5 % residual oxygen and at 24 °C and 50 % RH is recommended for infested artefacts.

Susceptibility of phosphine-resistant cigarette beetles to various insecticides

Naoto Fukazawa*

Leaf Tobacco Research Center, Japan Tobacco Inc., 1900, Idei, Oyama, Tochigi 323-0808, Japan
*Corresponding author: naoto.fukazawa@jt.com
DOI 10.5073/jka.2018.463.228

Abstract

Management of phosphine resistance in the cigarette beetle *Lasioderma serricorne* (F.) has become a topic of great interest to the tobacco industry in recent years. Effective use of contact insecticides with modes of action different from that of phosphine can be a key element in preventing or delaying the evolution of phosphine resistance. This study was conducted to ascertain whether five insecticides selected from three mode-of-action classes (fenitrothion, pirimiphos-methyl, permethrin, bifenthrin, and spinosad) can be incorporated into a phosphine-resistance management strategy. Specifically, we examined the contact efficacy of the insecticides to a phosphine-susceptible strain and six resistant strains (38–184-fold in resistance ratio based on LC_{50}). Susceptibility to organophosphates (fenitrothion, pirimiphos-methyl) and spinosad was not significantly different between phosphine-susceptible and phosphine-resistant strains (within 2.3-fold resistance ratio). The absence of the cross-resistance between these insecticides and phosphine makes them ideal for resistance-management programmes. However, high resistance to synthetic pyrethroids (>145-fold for permethrin and >1697-fold for bifenthrin) was found in three of six phosphine-resistant strains. Based on these results, synthetic pyrethroids cannot be recommended as insecticides of primary choice.

Keywords: *Lasioderma serricorne*, resistance management, contact insecticides, pyrethroid resistance

1. Introduction

The cigarette beetle, *Lasioderma serricorne* (F.) is the most important pest of stored tobacco. Fumigation by phosphine, the most important method for disinfestation of stored tobacco, has been used for post-harvest management of insect pests since the 1970s. Phosphine resistance in *L. serricorne*, although first recorded in India and the United States in the 1990s (Zettler, 1990;