Insecticide resistance of storage insect pests in Europe

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Preventive non-target applications of residual sprays may enhance risk of pest resistance.

Stored product pests are a group of harmful organisms that include small arthropods (insects, mites) that damage and contaminate food and other products stored in storage facilities. They have negative economical and medical impacts on the agricultural and food industries and on commodity and food distribution chains. The high potential for damage caused by storage pests requires systematic and effective physical and chemical control.

However, data from around the world highlights the worrying fact that the limiting factor in the chemical control of warehouse pests may be their increasing physiological resistance to insecticides. In practice resistance can manifest itself by the insecticide preparations ceasing to be as effective as when they were initially placed on the market, even though they are applied exactly as labelled and technologically correct.

Significance and impacts of pest resistance

Pest resistance in farm and warehouse food industry practices has various impacts on production and storage economics of crops and commodities. Here are some of these impacts.

The initial impact is the increased risk of losses and the reduced quality of commodities: if pests are resistant to the insecticides used, their effectiveness is not sufficient. This means that farmers face higher losses and lower quality of their stored crop commodities, which affects their profits.

Another impact is the increased cost of pest control: resistant pests often require the use of higher doses or increased application frequency (if legally allowed) of insecticides or other control measures. This means that farmers must spend more money to protect their crops and they may have to invest in more expensive technologies that appear on the market to cope with resistance.

It is important to realise that resistance is not only an economic problem, but also involves ecological aspects, such as various negative environmental impacts. The use of higher doses of pesticides or more frequent applications can have an adverse effect on non-target organisms and ecosystems. Given these impacts, it is important to implement measures to prevent the emergence and spread of resistance in pests.

How to slow down the emergence of pest resistance?

There are strategies and programmes (Integrated Resistance Management) used in agriculture and plant protection to manage the emergence of pest resistance to pesticides. The emergence of resistance in storage pests cannot be completely prevented but resistance can be slowed or even reduced by appropriate practices and programmes. However, any such programme requires monitoring of the resistance status of treated species and pest populations. A specific pest resistance management programme must then be selected in response to the findings. This usually includes the selection of pesticides and active substances for which resistance has not been detected, their correct use includes dosage and application, as well as adherence to application timing and limitation of overuse. The aim is to minimise the specific selection pressure that can lead to resistance to a particular active substance. The use of different pesticides or pesticide groups on a cycle or rotation basis is also important. This prevents the development of pest resistance to one

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Residual insecticide sprays (so called grain protectants) are mostly based on pyrethroids. They are commonly applied on grain during its transport on conveyer belts.

particular substance. Pesticides with different mechanisms of action are rotated to reduce the likelihood of resistance developing.

Pesticide combination: The use of a combination of two or more pesticides with different mechanisms of action or different modes of action on pests. This increases the effectiveness of control and reduces the risk of resistance. Subsequent systematic monitoring of resistance in a given facility (warehouse/farm) or geographical area allows rapid responses and adjustments to resistance management strategies.

Resistance of storage pests to insecticides

Globally, resistance of storage pests to insecticides is considered to be a major problem. The specific resistance profile of pests may depend on several factors, including geographic location, pest species and local agricultural practices. It is always best to consult with local agricultural or pest management experts for the most accurate and up-to-date information. Resistance of stored product beetles and moths to approximately 30 active ingredients is currently recorded.

Several storage pest species have developed resistance to several generations of insecticides. For example, organochlorine insecticides (such as DDT), which are no longer used extensively anywhere in the world, can still be persistent. Resistance to carbamate, organophosphate, and pyrethroid insecticides has developed in multiple pest species (Champ, 1976). Globally, there is accumulating documentation of resistance to phosphine as the major fumigant (Nayak et al., 2020).

Although Europe is one of the economically richest regions of the world and an important importer as well as exporter of commodities including grain cereals, there is surprisingly little data on resistance of storage pests from Europe (Boyer et al., 2012). From the EU as a whole, available information on resistance is historically limited and fragmented, available from only a few countries or geographical areas (Agrafioti et al., 2019). Furthermore, the limited amount of data about the resistance of storage pests is most commonly published in scientific and professional publications, making it difficult to access for practical use.

EU project novIGRain: New insecticide and mapping of resistance in storage pests

In most EU countries, only a few effective synthetic insecticides are still used for treating post-harvest pests infesting stored grain. These substances fall into three groups of products: organophosphates (eg pirimiphos methyl, formerly chlorpyrifos, which is now banned), pyrethroids (eg deltamethrin, cypermethrin), and ➔

Left: Populations of grain weevil seem to be less frequently resistant than populations of other primary pests infesting stored grain. Right: Primary pest lesser gran borer was found resistant to fumigants and sprays.

Resistance towards preparations releasing phosphine gas is becoming a global issue.

phosphines (usually generated from various phosphide based compounds). This range of products is relatively limited in terms of possible measures to reduce resistance, such as effective rotation or combination of pesticides.

In order to expand the available effective substances, an international project named novIGRain - Horizon 2020 was initiated, supported by funding from the European Union (EU). Its main aim is to develop a new larvicide spray formulation based on S-methoprene and a specialised precise application device for insecticides in the form of ULV (ultra-low volume) spray. These new products are intended to provide the agro-food industry with a broader information and decision-making system for proper, efficient, and safe application.

Part of this decision-making system includes incorporating certain aspects of pest resistance. For this reason, the project also encompasses the creation of an informational module (eg maps) that summarises previously published data on storage pest resistance from various authors across Europe. This informational module will be further expanded with original results of resistance screening obtained during the project. Resistance screening for gas fumigants based on phosphine and insecticidal sprays based on deltamethrin (pyrethroid) or pirimiphos-methyl (organophosphate) was conducted on six target species.

The preliminary results (Aulicky et al., 2022) indicate that the aspect of resistance may be particularly important in the decision-making process, especially in the case of phosphine fumigant. Resistance to this fumigant has been demonstrated in some populations of all six target species of storage pests. Resistance to deltamethrin and pirimiphos-methyl insecticides was found in some populations of four target pest species.

The collected data so far suggests that the highest number of resistant populations has been recorded in the lesser grain borer (*Rhyzopertha dominica*), the confused flour beetle (*Tribolium confusum*), and the rice weevil (*Sitophilus oryzae*); conversely, the lowest number was observed in the sawtoothed grain beetle (*Oryzaephilus surinamensis*) and the granary weevil (*Sitophilus granarius*)." ■

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