

Control of stored products pests by natural products

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Abstract: The use of natural products has been emerging as one of the prime means to protect crops and their products and the environment from pesticide pollution, which is a global problem. Natural products possess a spectrum of properties including insecticidal activity, repellence to pests, antifeedancy, insect growth regulation, toxicity to mites, and other pests of the agricultural importance. Also they possess antifungal, antiviral and antibacterial properties against pathogens. More significant use of natural products in practice will be possible if they are compatible with the following principles: safe, low toxicity, easy for application, minimal (or nil) problems with insecticide residues on foods, high efficacy at very low concentrations against stored grain insects, adult pests and their progeny, wide spectrum of efficacy against stored grain insect pests and field pests, low adverse effects on grain handling and quality properties, and acceptable in terms of price. Pronounced and multiple synergic modes of action substantially reduce or remove the need for synthetic chemical active ingredients, which reduces application and incidental exposure to these chemicals. Demonstrably safer natural products have advantage in the market where there is a growing aversion to conventional chemical products. In Croatia there is ongoing research on the development of new formulations of natural insecticides based on inert dusts and botanical insecticides and their combinations.

Key words: natural products, efficacy, insecticidal activity, food safety, environmentally friendly

Introduction

Over the last few decades synthetic insecticides have significantly surpassed the use of natural products, especially insecticides derived from different plants. However, due to the more extensive knowledge of their different harmful effects on human health and the environment, the use of safer, less hazardous and toxic substances and processes is becoming an increasing need. During evolution plants have developed defence mechanisms of protection against attacks by various pests. Some mechanisms are based on the existence of a variety of substances with pesticidal properties. It is known that even in ancient times people used certain plant parts (leaves, roots, bark, flowers) as insecticides to protect their food from attack of the pests. In the book "Botanical Pesticides in Agriculture," Prakash & Rao (1997) describe 866 different plant species containing a pesticidal substance. When these substances are extracted from plants, they are called botanical or plant insecticides. In general, they are environmentally friendly because they disintegrate quickly in the environment (typically faster than synthetic insecticides) and are less harmful to their natural enemies.

From a scientific point of view, the plants are rich source of substances with insecticidal, acaricidal, nematocidal, bactericidal, herbicidal, fungicidal, rodenticidal and virucidal effect. Numerous laboratories over the world have been investigating pesticidal ability of extracts obtained from thousands of different plant species (Korunić *et al.*, 2008). These studies discovered that many plant species have extremely effective substance exhibiting pesticidal

characteristics. However, it is extremely long and costly research way from laboratory results to their application in practice because effectiveness of extracted substances is just one of the parameters for introduction of botanical insecticides in commercial production in practice. It is significant that the botanical insecticides should also meet other criteria such as biological criteria (toxicity to mammals, the minimum impact on the environment, etc.), sufficient sources of plant extracts, standardization of the production and quality control of effective substances in the substrate, problems with patent rights, complying with the requirements of registration, etc. (Isman, 1997).

Advantages and disadvantages of plant insecticides

The use of botanical insecticides can have both significant advantages and disadvantages (Korunić & Rozman, 2012). The advantages are reflected in their rapid degradation, quick action, low toxicity to warm-blooded organisms, selectivity and minimal effect on treated plants. Botanical insecticides break down rapidly under the influence of daylight and sunlight, moisture and rainfall. They are less stable and therefore have smaller negative impact on beneficial and non-target organisms. They typically kill insects quickly or prevent their feeding immediately after application. Most botanical insecticides have low toxicity when introduced into the body through the mouth (oral toxicity), and are generally not or are slightly toxic to warm-blooded organisms and bees. Due to their relatively short-term effectiveness, most are much less harmful to beneficial organisms compared with many synthetic insecticides. Many botanical insecticides are not harmful to treated plants (they are not or are slightly phytotoxic) when applied according to instructions. However, like any other group of insecticides, they have some disadvantages. Their rapid degradation, though favourable from the standpoint of environmental protection and human health, is often requiring their frequent use. Although deemed to be considerably less toxic in comparison to synthetic insecticides, certain botanical insecticides such as nicotine and rotenone are toxic to humans and fish. Botanical insecticides are generally more expensive than synthetic insecticides, many are not commercially available for a number of reasons including standardization of their production.

The main criteria for the use of plants with insecticidal properties

When choosing the appropriate plant species which is found to have insecticidal substances, strict attention should be paid to preservation of ecosystems. The plant should be widely spread in large numbers in nature. Leaves, flowers and fruits, which means parts of plants that are regularly renewed should be used mostly, and the root of the annuals if root is needed. If using parts of perennial plants special care should be taken in order not to exterminate the species (avoid using root of perennial plants). Selected plants should occupy small area for cultivation, and be undemanding in terms of tillage, water and nutrients. The selected plant is preferred to be used in other areas such as health care, pharmaceutical industry, food industry, etc. Also, it is preferable that the plant does not have high economic value. Active substance of the selected plant should be effective at lower concentrations.

Ongoing research in Croatia

Croatia has an ongoing three-year research under the project entitled "Development of new natural insecticide formulations based on inert dusts and botanicals to replace synthetic, conventional insecticides" financed by the Croatian Science Foundation (Rozman *et al.*, 2015). This research will try to discover and develop natural formulations of insecticides in

the control of various pests using compounds of Croatian origin, and put them into use in agriculture and related industries in Croatia. New formulations of Croatian natural insecticides are the real basis for possible development of different insecticides that will fulfil the requirements for safe use and effectiveness in pest control. Besides applications in the protection of stored products, new formulation with minor modifications may be used in other areas of pest control e.g. public health and communal hygiene, plants protection in vegetation, veterinary medicine and food industry. Development of formulations will be based on the new technology of mixing and most acceptable combination of substances with different modes of action on insects, such as, physical (inert dusts) and chemical (plant extracts) mode of action. Because of the common physical and chemical (toxic) effects the efficiency against the insects is increased as compared to the same substance when applied alone. There is a great probability that a complex mode of action significantly slows the emergence of insect resistance. Since all the substances in the formulations will be of natural origin and belong to the group of "food grade" and/or "organic" substances, there should not be any concern about the harmful insecticide residues in processed commodities, on surfaces and in the area. Natural substances in the formulations of insecticides have very low, negligible toxicity and low danger to warm-blooded organisms; therefore we believe that the registration process of these insecticides will be faster. It is planned to produce these insecticides in Croatia because all components in the formulations are of Croatian origin. They should become one of the basis of integrated protection measures. In this project, the research team consists of experts from Croatian Geological Survey, Diatom Research and Consulting Inc. from Canada and the Faculty of Agriculture in Osijek as the coordinator.

The project activity

Our research and project work is planned to be done in three phases in the period of three years. In the first phase of the field trials deposits of inert dusts and diatomite in Croatia are examined and physically and chemically analysed in the laboratory. All field test samples in this phase are subjected to a number of laboratory tests of selection, with respect to the effectiveness of the test insects *Sitophilus oryzae* (Linnaeus), *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (Fabricius) in comparison with the standard diatomaceous earth already having application worldwide, and in order to make selection of promising Croatian samples for further research. Simultaneously, we explore and test Croatian aromatic and food plants with a potential insecticidal activity as components of new future insecticide formulations: laurel (*Laurus nobilis* L.), lavender (*Lavandula x intermedia*), lemon balm (*Melissa officinalis* L.), mint (*Mentha piperita* L.), basil (*Ocimum basilicum* L.), marjoram (*Origanum marjorana* L.), oregano (*Origanum vulgare* L.), woodland sage (*Salvia nemorosa* L.), sage (*Salvia officinalis* L.), clary sage (*Salvia sclarea* L.), savory (*Satureja hortensis* L.), wild thyme (*Thymus serpyllum* L.), garden thyme (*Thymus vulgaris* L.), sunflower (*Helianthus annuus* L.), rapeseed (*Brassica napus* L.). Test trials of the selected plants in combination with the selected samples of effective Croatian inert dusts are carried out. This first phase of the research is characterized by an intensive field and research work on the selection of potential Croatian resources in terms of inert dusts and plants that will be a component of new formulations of insecticides, as well as the selection of methods and ways of mixing tested plant components and inert dusts.

The second phase of the research is mostly characterized by further development of formulations of insecticides. The emphasis is on the selection and further research into the best formulations safe for warm-blooded organisms, and their effectiveness on the insects. It will also test the effectiveness of selected formulations on the basis of prolonged action (at least 10 months) on treated wheat and corn which should provide long-term protection of

stored pests. Simultaneously, possible residues of the tested formulations on treated wheat and corn will be analysed, and chemical analyses of the selected formulations of insecticides will be carried out.

The third phase of the research includes tests and bioassays of the stability of new formulations under normal storage conditions and testing in the field. At this stage it is planned to carry out toxicological analysis of new formulations of possible acute, oral, dermal and inhalant toxicity. It is also planned to carry out preliminary studies into the formulations applied on other pests that cause problems in public health and communal hygiene, protection of plants in vegetation period, animal health and food industry. At this stage of research we should get a definitive answer to the question whether Croatia has developed new formulations of insecticides from its own resources, and whether we have a new Croatian product.

The current status of research

Currently, research on the project is in the first phase. For the time being, there are several potential Croatian samples of inert dusts and diatomite (Liška *et al.*, 2015). Also obtained are potentially good results in testing of lavender (*Lavandula x intermedia*) whose essential oil and flower and leaf powder mixed with diatomaceous earth can be used to develop new formulations of natural insecticides applicable to the protection of stored products (Lucić *et al.*, 2015).

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References

- Isman, M. B. 1997: Neem and Other Botanical Insecticides: Barriers to Commercialization. *Phytoparasitica* 25(4): 339-344.
- Korunić, Z. & Rozman, V. 2012: Botanical Insecticides (in Croatian). In: Proceedings of the 24th Scientific and Educational Seminar DDD and ZUPP 2012 Disinfection, Disinfestation and Deratization and Protection of Stored Agricultural Products, 20-23 March 2012, Split, Croatia (ed. Korunić, J.): 269-280. Korunić d.o.o., Zagreb.
- Korunić, Z., Rozman, V. & Kalinović, I. 2008: The potential use of natural essential oils in the fumigation of stored agricultural products. In: Proceedings of the 8th International Conference on Controlled Atmosphere and Fumigation in Stored Product – CAF2008, 22-26 September 2008, Chengdu, China (eds. Daolin, G., Navarro, S., Jian, Y., Cheng, T., Zuxun, J., Yue, L., Yang, L. and Haipeng, W.): 511-519. Sichuan Publishing Group, Sichuan Publishing House of Science & Technology.
- Liška, A., Rozman, V., Korunić, Z., Halamić, J., Galović, I., Lucić, P. & Baličević, R. 2015: The potential of Croatian diatomaceous earths as grain protectant against three stored-product insects. Book of Abstracts of the 10th Conference of IOBC-WPRS Working Group Integrated Protection of Stored Products, 28 June – 1 July 2015, Zagreb, Croatia: *In press*.

- Lucić, P., Liška, A., Rozman, V., Baličević, R. & Đumlić, M. 2015: The potential use of lavender (*Lavandula x intermedia*) in protection of stored wheat against storage insects (in Croatian). In: Proceedings & Abstracts 8th international scientific/professional conference Agriculture in Nature and Environment Protection, 1-3 June 2015, Vukovar, Croatia (eds. Baban, M. and Rašić, S.): 160-165. Glas Slavonije d.d., Osijek.
- Prakash, A. & Rao, J. 1997: Botanical Pesticides in Agriculture. CRC Lewis Publishers, Boca Raton, Florida, USA.
- Rozman, V., Korunić, Z., Halamić, J., Liška, A., Baličević, R., Galović, I. & Lucić, P. 2015: Development of new natural insecticide formulations based on inert dusts and botanicals to replace synthetic, conventional insecticides – presentation of the research project of Croatian Science Foundation (in Croatian). In: Proceedings of the 27th Scientific and Educational Seminar DDD and ZUPP 2015 Disinfection, Disinfestation and Deratization and Protection of Stored Agricultural Products, 24-27 March 2015, Mošćenička Draga, Croatia (ed. Korunić, J.): 197-201. Korunić d.o.o., Zagreb.

