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PROSPECTS AND LIMITS OF BOTANICAL INSECTICIDES IN ORGANIC FARMING

IZGLEDI (OČEKIVANJA) I OGRANIČENJA BOTANIČKIH INSEKTICIDA U EKOLOŠKOJ POLJOPRIVREDI

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ABSTRACT

Organic agriculture has experienced rapid worldwide growth with the highest growth occurring in the United States, where organic sales grew by $12,2 billion. Recently, organic production of export cash crops of coffee, cocoa, and cotton has increased rapidly. In developed countries, organic fruit and vegetable production has expended to serve local and export markets. The increasing expansion of organic farming has considerable consequences for plant protection. In spite of preventative measures, an outbreak of pests can substantially reduce quality and yield. For this reason the application of plant protection products is an important element of direct regulation measures.

Natural insecticides are generally less stable than synthetic materials and decompose quickly in the environment, meaning that they are also less potent and have shorter residual periods than their synthetic counterparts. Therefore, satisfactory arthropod pest management can only be achieved when insecticide use is integrated with other strategies. These include timing of applications to minimize harmful effects on beneficial organisms. One of the major barriers to commercialization of new, selective insecticides made of natural substances is that there generally must be a large marketing base in conventional plant protection to cover the high costs associated with obtaining marketing approval. If the quality and efficacy of natural products like teas, extracts and fermentation products could be enhanced by commercial research and development programs, better solutions for some typical problems of plant protection in organic farming could be found.

Key words: biological control agents, conservation biological control, organic insecticides

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SAŽETAK

Ekološka poljoprivreda je u naglom porastu, posebno u SAD gdje je prodaja ekološki proizvedene hrane porasla na 12,2 milijarde dolara. U posljednje vrijeme uvećana je ekološka proizvodnja kave, kakaa i pamuka za izvoz. U zemljama u razvoju, ekološka proizvodnja voća i povrća za domaće tržište i izvoz također raste. Takav porast ekološke proizvodnje u poljoprivredi odražava se na zaštitu bilja. Usprkos preventivnih mjera širenje štetnika može umanjiti kakvoću i visinu uroda. Stoga je primjena biljnih zaštitnih sredstava važan element direktnih mjera zaštite.

Prirodni insekticidi su općenito manje stabilni od sintetičkih i brže se razgrađuju u okolišu, dakle manje su efikasnosti i kraćeg rezidualnog djelovanja. Prema tome zadovoljavajuća kontrola štetnika može biti postignuta samo ako je insekticid dopunjen drugim mjerama zaštite. Ovo uključuje pravilno vrijeme primjene kako bi negativni učinak na korisne organizme bio što manji. Najveća zapreka komercijalizaciji novog selektivnog insekticida od prirodnih sirovina je nedostatak snažne trgovačke baze konvencionalne zaštite bilja koja bi bila u stanju pokriti visoke troškove oko dobivanja trgovinske dozvole. U koliko kakvoća i efikasnost prirodnih proizvoda, kao što su čajevi, ekstrakti i proizvodi fermentacije mogu biti poboljšani komercijalnim razvojem i istraživanjima, mogla bi se iznaći bolja rješenja za neke tipične probleme ekološkog uzgoja bilja.

Ključne riječi: biološke kontrolne tvari, održiva biološka kontrola, organski insektici.

INTRODUCTION

Organic agriculture has experienced rapid worldwide with the highest growth occurring in the United States, where organic sales grew by $12,2 billion. Recently, organic production of export cash crops of coffee, cocoa, and cotton has increased rapidly in recent years. In developed countries, organic fruit and vegetable production has expended to serve local and export markets

(Zehnder et al. 2007). The increasing expansion of organic farming has considerable consequences for plant protection. In spite of preventative measures, an outbreak of pests can substantially reduce quality and yield. For this reason the application of plant protection products is an important element of direct regulation measures. Despite the growth of organic agriculture, there has been a lack of research-based information to address the need for a greater understanding of the mechanisms operating in organic farming systems, including plant pest interactions. Wyss et al. Have proposed a conceptual model for the development of an arthropod pest management program for organic crop production. In this model, indirect, preventative measures are of highest priority to be considered early in the adoption process, followed by more direct and curative measures only when needed (Figure 1). Insecticides of biological and mineral origin used as a "last option" for the control of pests when all methods used in preceding phases have failed. These strategies include also the application of pheromones for mating disruption, and repellent agents as physical barriers. This paper reviews the arthropod pest management by botanical insecticides in organic farming.

Table 1. Diagrammatic representation of arthropod pest management strategies for organic crops. Priority is given to preventative strategies, which are considered first, followed by more direct measures if preventative strategies are not sufficient. Data from Wyss at al. 2005.

1st phase:	Cultural practices compatible with natural processes, such as crop rotation, soil management, non-transgenic host plant resistance, farm/field location.
2nd phase:	Vegetation management to enhance natural enemy impact and exert direct direct effects on pest population
3rd phase:	Inundative and inoculative releases of biological control agents
4th phase:	Aproved insecticides of biological and mineral origin, and use of mating disruption

REVIEW OF BOTANICAL INSECTICIDE USE IN ORGANIC FARMING

The criteria for the evaluation of whether insecticides can be used in organic agriculture are provided by the IFOAM Basic Standards for Production and Processing (IFOAM, 2005) which form the basis of all national regulations (e.g., CONSLEG 1991, USDA NOP). The most important criterion is the non-synthetic origin of these agents. One allowed exception is the use of synthetic pheromones which may be used for mating disruption in organic agriculture due to the fact that they are contained in dispensers and therefore do not come into contact with crops.

It is important to note that the criteria for approved substances differ between the national organic standard organizations with respect to impacts on the environment and on human and animal health (Zehnder et al. 2007). The most important botanical insecticides used in organic farming are listed in Table 1.

Table 2: Most important botanical insecticides and their application in organic farming (Zehnder et al. 2007)

Azadirachtin	
Source:	Neem tree (*Azadirachta indica, A. Juss*); pantropic distribution
Active substances:	Azadirachtin A and B and other compounds.
Mechanism of action	Mitotic poison, damages the hormone system. Food poison / anti-feedant / feeding deterrent, impairs metamorphosis and reproduction. Reduces insect activity and vitality; impairs intra-species communication.
Mode of application:	Kernel extract products are used against chewing and sucking insect pests.
Side effects:	Not harmful to honey bees, parasitic wasps or lacewings.
Pyrethrin	
Source:	Pyrethrum daisy (*Tanacetum cinerariaefolium = Chrysanthemum cinerariaefolium, C. cinerariifolium*); Africa (Kenya / Tanzania), Asia, South America.
Active substances:	Pyrethrin I and II, jasmolin I and II, cinerin I and II.
Mechanism of action:	Neurotoxin, contact poison and repellent.
Mode of application:	Extract of flowers used as a spray or dust to control sucking and chewing insects and storage pests
Side effects:	Pyrethrins are harmful to beneficials such as predatory mites and parasitoids. Toxic to honeybees and fish as well as to aquatic animals eaten by fish.

Quassia	
Source:	Bitter wood (*Quassia amara* L.); Caribbean region, Central America, Brazil
Active substances:	Quassin, Neoquasssin
Mode of action:	Food and contact poison, antifeedant
Mode of application:	Quassia wood extract applied as a spray to control sawflies (*Hoplocampa* spp.) in orchards and for aphid control.
Side effects:	Does not harm lacewings (*Chrysoperla carnea*) or honeybees. Selectively toxic to mosquito larvae.
Rapeseed Oil	
Source:	Rapeseed (*Brassica napus*) and field mustard oil (*Brassica rapa*)
Active substances:	Fatty acids like oleic acids, linoleic acid, and linolenic acid.
Mode of action:	Fatty acids are contact insecticides that enter the insect's body, where they block membrane permeability, thus leading to asphyxiation.
Mode of application:	Rapeseed oil is used in arable farming, fruit-growing, and vineyards. It is toxic to spider mites, gall mites, mealy bugs and scales and partly toxic to aphids and winter moths.
Side effects:	Rapeseed oil products (e.g. Telmion) produce side effects in the adult Hymenoptera egg parasitoid *Trichogramma cacoeciae*, but they are only slightly persistent. Rapeseed oil does not harm predatory mites.
Rotenone	
Source:	Derived from the root of various tropical and subtropical plants of the genus *Derris*, *Lonchocarpus* and *Terphrosia* from Southeast Asia, Central America and South America.
Active substances:	Rotenoids
Mode of action:	Contact and food poison. Rotenone is a cellular respiratory enzyme inhibitor. It acts as a stomach poison in insects.
Mode of application:	The dried and powdered roots can be dusted on directly or used to make root extracts for spray application. Used in organic fruit, wine and vegetable-growing to control various insect pests. Is less effective in controlling leafhoppers in eggplant or thrips in citrus fruit and dessert grape. Can also be used to control storage pests.
Side effects:	Compared to other botanical insecticides, rotenone is the most toxic to humans and other mammals. The oral LD50 of rotenone ranges from 132 to 1500 mg/kg in rats. A link between rotenone and Parkinson's disease has been suspected for several years. Rotenone is highly toxic to fish and can also be harmful to lacewings and predatory mites. Rotenone is not harmful to bees.

LIMITATIONS FOR BOTANICAL INSECTICIDES

Natural insecticides are generally less stable than synthetic materials and degrade quickly in the environment, meaning that they are also less potent and have shorter residual periods than their synthetic counterparts. Therefore, satisfactory arthropod pest management can only be achieved when insecticide use is integrated with other strategies. These include timing of applications to minimize harmful effects on beneficial organisms. One of the major barriers to the commercialization of new, selective insecticides made of natural substances is that there generally must be a large marketing base in conventional plant protection to cover the high costs associated with obtaining marketing approval. If the quality and efficacy of natural products like teas, extracts and fermentation products could be enhanced by commercial research and development programs, better solutions for some typical problems of plant protection in organic farming could be found.

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