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Review paper

IMPACT OF INSECTICIDES ON BENEFICIAL ORGANISMS

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Abstract

In the process of increasing crop production, the use of insecticides is much greater than in the past. These chemicals have largely emerged since the introduction of synthetic insecticides in 1940, when organochlorine insecticides were the first used to control pests. Insecticides are now an integral part of our modern life and are used to protect agricultural production, storage products, as well as to destroy pests that transmit dangerous infectious diseases. It would be ideal if the applied insecticides are toxic only to the target organisms, biodegradable and environmentally friendly to some extent. But, the most of them are non-specific and, in addition to pests, destroy organisms that are harmless or beneficial to the ecosystem (predators, pollinators) or affect their proper growth and development.

Key words: *pests, insecticides, predators, pollinators, earthworms, biological control*

INTRODUCTION

Knowing the fact that the world's population is expected to grow to nearly 10 billion by 2050 (Gill & Garg, 2014), increasing food production is a major goal for all countries. According to the Food and Agriculture Organization (FAO) of the United Nations the world food production needs to increase by 70% to keep up with the demand of a growing population (Gill & Garg, 2014). In the process of increasing crop production, pesticides and fertilizers are now used in greater quantities than in the past. These chemicals have largely emerged since the introduction of synthetic insecticides in the 1940s, when organochlorine insecticides were first used to control pests (Gill & Garg, 2014).

Pesticides are an integral part of our modern life and are used to protect agricultural production, stored products, flowers, as well as to destroy pests that transmit infectious diseases. Approximately, 2 million tons of pesticides are utilized annually worldwide, where China is the major contributing country, followed by the USA and Argentina, which is increasing rapidly. However, by the year 2020, the global pesticide usage has been estimated to increase up to 3.5 million tons (Sharma et al., 2019). Nowadays manufacturers and researchers are creating new pesticide formulations that are specific only to the target organisms, biodegradable and environmentally friendly to some extent. Although pesticides are beneficial for crop production of view, extensive use of pesticides can possess serious consequences because of their persistence. The continuous use of persistent and non-degradable pesticides pollutes various components of water, air and soil and indirectly affects the living organisms.

In this review paper, the impact of insecticides on beneficial organisms and possible ways to reduce the use of insecticides in the plant protection from pests will be presented.

EFFECT OF PESTICIDES ON BENEFICIAL ORGANISMS

The effect of pesticides on non-target organisms has been a source of worldwide attention and concern for decades. Adverse effects of applied pesticides on non-target arthropods have been widely reported (Ware, 1980). Unfortunately, the natural enemies of insects, for example, predators and parasitoids, are the most susceptible to insecticides and are severely affected (Gill & Garg, 2014).

Usually, if natural enemies are absent, additional insecticide sprays are required to control the target pest. Along with natural enemies, the population of soil organisms is also drastically disturbed due to indiscriminate application of pesticides in agricultural systems.

Effects of pesticides on earthworms

Earthworms represent the largest proportion of terrestrial invertebrates (>80%) (Yasmin and D'Souza, 2010) and play a significant role in improving soil fertility by decomposing organic matter into humus. They also play a major role in improving and maintaining soil structure by making channels in the soil that improve its water-air regime. They are also considered an important indicator of soil quality in agricultural ecosystems (Paoletti, 1999). However, their diversity, density and biomass are strongly influenced by the use of pesticides. Various studies confirm the harmful impact of carbamate and organophosphate insecticides on earthworms by reducing their population (Edwards, 1987). For example, carbamate insecticides are highly toxic to earthworms, and some organophosphates (chlorpyrifos and azinphos methyl) have been shown to reduce earthworm populations (Reinecke & Reinecke, 2007), and increased exposure periods and higher doses of insecticides can cause physiological damage to earthworms (Yasmin and D'Souza, 2010). Various scientific studies have reported that pesticides affect the growth and reproduction of earthworms, and a study conducted in France showed that a combination of insecticides and fungicides at different concentrations caused neurotoxic effects in earthworms (Schreck et al., 2008).

Effects of pesticides on predators

Predators are organisms that feed on other organisms and they play a very crucial role in keeping pest populations under control. Predators (beneficial organisms) are also an important part of the "biological control" approach, which is one component of an integrated pest management strategy. Various comparative studies have been conducted, showing the negative impact of synthetic pyrethroids and neonicotinoids in relation to biopesticides. Namely, treatment with cypermethrin and imidacloprid caused higher mortality of ladybugs, parasitic wasps and predatory spiders compared to treatment with bio-pesticides and insecticides based on Neem (*Azadirachta indica*) (Ghananand et al., 2011). In foliar application, all systemic neonicotinoids such as acetamiprid, imidacloprid, thiamethoxam and thiacloprid were found to be highly toxic to natural enemies compared to buprofezin (IGR insecticides) and fipronil (phenylpyrazoles) (Kumar et al., 2012).

In addition, pesticides can affect both predator behavior and parameters that determine their lifespan, including growth rate, development time, and other reproductive functions. In Calabria, Italy, dimethoate has been shown to significantly reduce the body size and hemocyte count of the carabid beetle *Pterostichus melas italicus* (Giglio et al., 2011).

Effects of pesticides on pollinators

Pollinators are biotic agents that play a very important role in the pollination process. Some of the more important pollinators are various species of bees, bumblebees (*Bombus* spp.), honey bees (*Apis* spp.), fruit flies, some beetles, and birds. The use of pesticides causes direct loss of pollinating insects and indirect loss of crops due to lack of adequate pollinator population (Fishel, 2011). During our field research, we noticed that fertilization in pepper is reduced due to the absence of pollinators, which is the result of the use of insecticides.

Pesticide application also affects a variety of pollinator activities, including foraging, colony mortality, and pollen collection efficiency. Bees make up 80% of the insect pollinator population and the most of the current knowledge about the effects of pesticides on changing pollinator behaviour comes from various studies on bees. For example, many laboratory studies have demonstrated the

lethal effects of neonicotinoid insecticides (imidacloprid, acetamiprid, thiamethoxam, and thiacloprid), as well as their effects on bee behaviour, learning, and memory (Blacquie`re et al., 2012). Of the listed neonicotinoids, only acetaprimide is still used in plant protection, due to the minimal doses with which it is used and the immediate lethal effect it has on pests. Due to the application of neonicotinoids and pyrethroids mortality of worker bees, reduced pollen collection efficiency and eventual colony collapse occur. Lethal doses of imidacloprid (the most commonly used pesticide in the world) affected longevity and foraging in bees (*A. mellifera*). Microsporidial infections in the gut of bees were significantly increased after treating plants with imidacloprid. It is expected that interactions between pathogens (bacteria, viruses...) and imidacloprid could be the main reason for the mortality of honey bee colonies worldwide (Gill & Garg, 2014). There are also reports that imidacloprid reduces the fecundity of bumblebees by decreasing fertility (Laycock et al., 2012; Whitehorn et al., 2012).

HOW TO PROTECT BENEFICIAL ORGANISMS FROM PESTICIDES

Today, it is almost impossible to imagine modern agricultural production without the use of chemicals to destroy harmful insects. The chemical method gives quick and visible results, but in addition to the positive effects of their application, negative consequences were also quickly determined: resistance in insects, disturbance of the balance in agro-ecosystems, toxic effects on humans and domestic animals, environmental pollution.

Contemporary directions in plant protection go in two ways, namely: the development of new methods for controlling harmful insects and the development of means of protection with favourable toxicological properties and a selective character against the natural enemies of insects.

New methods for controlling the population of harmful insects are based primarily on the cultivation of resistant crop varieties, natural bioregulatory systems in agrobiocenoses, new plant protection products, with active substances based on microorganisms or their metabolites, and on synthesized protection products with new mechanisms of action and with favourable toxicological properties. The installation of new systems in plant protection is the result of realizing the negative side of the one-sided application of chemical agents. Current concepts for combating harmful insects aim to integrate all existing possibilities for pest control and reduce negative consequences for the environment.

The fight against insects in agricultural production must be seen from an ecological point of view, because regardless of which method is applied, it means the application of a certain environmental factor within the limits of the ecological valence for the population of the certain insect. In addition, the fight against insects automatically means a disturbance of the dynamic balance in agroecosystems. Therefore, the fight against harmful insects in agricultural production has an ecological content and must be based on solid knowledge of the biology and ecology of the individual harmful species and the knowledge of the individual agrobiocenses.

Concern for the environment and the production of safe food drives academic, government and industry research towards the development and promotion of a new and safe strategy for the control of harmful organisms in agricultural production, known as Integral pest management.

Integral pest management is a plant protection system, which implies the use of all available methods of combating pests, pathogens and weeds (growing resistant varieties, agrotechnical, mechanical, biological, chemical and others) in order to prevent the increase in their number across the border above which significant economic damages occur.

By implementing integral protection measures, the number of chemical treatments is reduced, thus protecting and enabling greater activity of natural enemies. Their role is so important that many authors, under the term integral protection, mean only the application of natural enemies and chemical protection. When choosing pesticides for chemical control, one should take into account their selectivity in relation to the most important natural enemies of pests in a given crop. Also, unnecessary and

excessive use of chemicals should be avoided. By treating the entire surface to suppress soil pests, almost all natural enemies are destroyed, and the same effect is achieved by introducing chemical agents only in the rows of plants, which preserves many beneficial organisms.

The application of the system of integral protection leads to less use of pesticides, and therefore to cheaper protection. In addition, environmental pollution is also reduced.

CONCLUDING REMARKS

Synthetic insecticides are used to control the weeds and insect pests, affecting the agricultural systems. Water, soil and air serve as an important medium for transportation of insecticides from one site to another. Insecticide contamination is a serious problem for each ecosystem and is harmful for all associated organisms. So, in order to control insecticide usage, new methodologies and techniques are needed in assessing the effect of widespread use of insecticides on ecosystem and efforts should be made to provide awareness among public to minimize the application of harmful insecticides. Use of bioinsecticides should be encouraged over chemical pesticides.

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ВЛИЈАНИЕ НА ИНСЕКТИЦИДИТЕ ВРЗ КОРИСНИТЕ ОРГАНИЗМИ

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Резиме

Во процесот на зголемување на растителното производство, употребата на инсектицидите е многу поголема отколку во минатото. Овие хемикалии во голема мера се појавија по воведувањето на синтетичките инсектициди во 1940 година, кога органохлорните инсектициди беа првите користени за контрола на штетниците. Инсектицидите сега се составен дел од нашиот современ живот и се користат за заштита на земјоделското производство, складираните производи, како и за уништување на штетници кои пренесуваат опасни заразни болести. Би било идеално доколку применетите инсектициди се токсични само за целните организми, биоразградливи и до одреден степен еколошки. Но, повеќето од нив се неспецифични и, покрај штетниците, уништуваат и организми кои се безопасни или корисни за екосистемот (предатори, опрашувачи) или влијаат на нивниот правилен раст и развој.

Клучни зборови: *штетници, инсектициди, предатори, опрашувачи, дождовни црви, биолошка контрола.*