XXVI INTERNATIONAL
ECO-CONFERENCE® 2022
21–23th SEPTEMBER

XII SAFE FOOD

PROCEEDINGS

NOVI SAD, SERBIA

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SAFE FOOD

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2022

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THE INFLUENCE OF PESTICIDES ON PLANTS, SOIL MICROORGANISMS AND FOOD SAFETY IN PLANT PRODUCTION

Abstract

Pesticides, is chemical agents for plant protection, and are mostly used in agriculture and forestry (90%), i.e. in plant production. In addition to accumulating in the environment, pesticides act on plants, microorganisms and other members of the biocenosis, and through the food chain, they reach the human body, where they exhibit active biological effects. In this study, the impact of pesticides on plants, soil microorganisms and food safety in crop production is considered.

Key words: *pesticides, plants, microorganisms, biological effect, food safety*

INTRODUCTION

The use of pesticides, i.e. chemical agents for plant protection, is the most radical measure of yield protection against pests, diseases and weeds. Pesticides include more than ten thousand preparations, based on 600 chemical compounds. Their intensive and uncontrolled application causes them to accumulate in the soil, especially in the fertile surface layer, where they affect beneficial microorganisms and other soil

organisms, carbon and nitrogen cycling and other biogenic elements, as well as plant nutrition. From the soil, pesticides get into groundwater, rivers, drinking water, and through food chains into the plant, animal and human body (Đukić et al., 2007; Lakić et al., 2018; Ikanović and Popović, 2020; Ikanović et al., 2020; Božović et al., 2020; Rajičić et al., 2020). In addition to dichloro-diphenyl-trichloroethane (DDT), the use of which was prohibited in most countries since the 1970s, a large number of other pesticides, which are used to increase yields in modern crop production, have negative effects on the environment and human health (Bagi and Bodnar, 2012; Anđelković, 2018). It has been proven that pesticides have an active biological effect, toxic, mutagenic and carcinogenic, on living organisms. Numerous studies have shown high correlations between exposure to pesticides and the occurrence of various types of cancer (Beard, 2006; Bassil et al., 2007). For the above reasons, the reduction of pesticide use, along with the intensification of preventive and biological protection measures, are the basic goals of sustainable agriculture and sustainable development. In this paper, the impact of pesticides on plants, soil microorganisms and food safety in crop production is discussed.

INFLUENCE OF PESTICIDES ON PLANTS, SOIL MICROORGANISMS AND FOOD SAFETY

Although pesticides are also used in veterinary medicine, the greatest application, as chemical agents for plant protection, is still found in agriculture and forestry (90%), that is, in plant production. They include more than ten thousand preparations, based on 600 chemical compounds. Pesticides were created precisely as a result of man's desire to produce a larger amount of healthy food, that is, to achieve higher yields in agriculture, but also the need to eradicate diseases, in which pests play the role of transmitters. However, although the application of pesticides represents the most radical measure of yield protection against pests, diseases and weeds, the impact that pesticides have on other members of the biocenosis, and through food chains on the health safety of food, is very complex and diverse (Đukić et al., 2007; Stajkovac et al., 2009).

Different types of pesticides exhibit numerous physiological activities in plant organisms. The impact of pesticides on plants begins from the moment of contact and penetration through the root, stem and leaf. Most herbicides and insecticides with systemic action, acaricides and some fungicides quickly penetrate and move around the plant and have a general effect on the entire plant organism. When developing plants are treated, pesticides penetrate the plant organism to the greatest extent through the leaves (cuticles and pores), in the form of liquid and vapor. In the absence of moisture in the plant, pesticides penetrate through the fatty components of the cell wall via the lipid pathway. Pesticides that are not able to move, are localized at the places of initial penetration into the plant and they have a local effect. The resistance of plants to the action of pesticides is determined by the anatomical and morphological characteristics of the plant, growth stages, applied agrotechnical measures in plant production, chemical composition, doses and forms of preparations. The basis of the resistance of

different plant species to pesticides is their biochemical differences in the exchange of matter during the physiological reaction to these compounds. Depending on the applied dose and type of preparation, pesticides introduced into the soil can change the composition of the soil microflora. There is no doubt that the intensive and uncontrolled application of pesticides causes their accumulation in the soil, especially in the fertile surface layer, where they affect beneficial microorganisms and other soil organisms, the cycle of carbon and nitrogen and other biogenic elements, as well as the nutrition of plants (Đukić at al., 2007, Stajkovac et al., 2009). In addition to plants, soil microorganisms are a key factor that enables the cycling of matter in all ecosystems on the planet and the maintenance of life in the biosphere (Đukić and Đorđević, 2004; Šarčević-Todosijević et al., 2020). A general indicator of the effect of pesticides on the microflora is the biological activity of the soil or the intensity of soil respiration (sorption of O_2, release of CO_2). Soil fungicides and fumigants, as a rule, have a negative effect on soil microflora. Fumigants are strong inhibitors of soil microorganisms and are therefore often called soil sterilizers. They prevent the development of heterotrophic microorganisms and stop soil respiration. Fungicides that do not pass into the gaseous phase, that is, do not have a fumigation effect, show a less pronounced sterilization effect, which is caused by their uneven distribution in the soil and heterogeneous soil structure. Đukić et al. (2007) point out that different types of soil fungi are differently sensitive to fungicides. Among the saprophytes, representatives of the genera *Trichoderma*, *Fusarium* and *Penicillium* are the most resistant to fungicides, so in soils treated with fungicides, the mentioned genera dominate in the population of soil fungi. In the doses recommended against soil pests, organochlorine insecticides generally do not have a negative effect on the abundance of soil microorganisms. They have a stimulating effect on the development of certain groups of microorganisms, while at higher doses they initially suppress and then stimulate the soil microflora. Herbicides break down relatively quickly in the soil and their application in the recommended doses does not have a negative impact on the soil microflora. Đukić et al. (2007) state that production doses of herbicides: products of phenyl carboxylic acid, chlorine-substituted aliphatic acids, sym-triazine do not have a clearly expressed effect on the qualitative and quantitative composition of soil saprophytic fungi, bacteria and actinomycetes. However, when herbicides are introduced into the soil in increased doses, there is a temporary regrouping of the composition of the microflora (Đukić and Đorđević, 2004; Đukić et al., 2007; Stajkovac et al., 2009). When considering the impact of pesticides on soil microorganisms, it is important to mention the microbiological transformation of pesticides in the soil. Đukić at al. (2007) point out that in this process in the soil, as well as in the culture of microorganisms, stable products of pesticide transformation can be formed, whose presence and accumulation in the environment and plants is harmful. Favorable conditions for the microbiological synthesis of such compounds, in combination with pesticides, are also created by high doses of applied nitrogen fertilizers. Therefore, during the application of chemical plant protection agents, it is necessary to take into account their interaction in the system pesticides – mineral fertilizers - microorganisms (Đukić et al., 2007).

From the soil, pesticides get into groundwater, rivers, drinking water, and through food chains into plant, animal and human bodies. Although the use of the oldest pe-

sticide dichloro-diphenyl-trichloroethane (DDT) has been banned in many countries since the 1970s, it has not yet been completely eliminated from the environment, and exposure to the pesticide is still widespread. In developed countries, the slow elimination from the body means that a large part of the population still has detectable levels of DDT, or its metabolite DDE, in their serum or adipose tissue. In developing countries, the pesticide is still used for vector control and a significant proportion of infants have daily intakes above recommended levels. However, recent breast cancer research, conducted using cohort studies, has allowed for a more rigorous assessment of the role of DDT in the etiology of the disease. However, recent breast cancer research, conducted using cohort studies, has allowed for a more rigorous assessment of the role of DDT in the etiology of the disease (Beard, 2006).

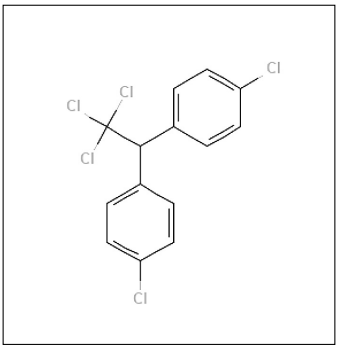

Figure 1. Chemical structure of dichloro-diphenyl-trichloroethane (DDT) (source: National Library of Medicine/National Center for Biotechnology Information https://pubchem.ncbi.nlm.nih.gov/compound/Clofenotane#section=2D-Structure)

A large number of other pesticides, which are used to increase yields in modern crop production, have negative effects on the environment and human health (Bagi and Bodnar, 2012; Anđelković, 2018). It has been proven that pesticides have an active biological effect, toxic, mutagenic and carcinogenic, on living organisms (Đorđević et al., 2020). Toxins are substances that are dangerous for living organisms due to the harmful effects they cause in cells, tissues, organs and biochemical processes. The fate of toxins in the body depends on the way they are ingested; toxic substances that are present in food and water enter the body through the digestive tract (Anđelković, 2018). Margni et al. (2002) state that the intake of pesticide residues through food results in the highest exposure of the human body to their toxic effect, as much as 103 to 105 times greater than the intake of pesticides into the body through drinking water or inhalation. Based on this, they emphasize that monitoring pesticide residues in food should be a priority in the production of health-safe food (Margni et al., 2002). However, the organophosphate pesticide parathion is easily adsorbed through the skin, lungs or digestive tract and is equally toxic regardless of how it enters the human body (Anđelković, 2018). The common biochemical mechanism of action of organophos-

phates in the composition of this group of pesticides is based on inhibition of the activity of the enzyme AChE (acetylcholinesterase) of blood, brain and other tissues. Inhibition of AChE causes the accumulation of ACh (acetylcholine) at the central and neuroeffector synapses of the cholinergic nervous system, which leads to impaired neurotransmission. Irreversible AchE inhibitors can thus lead to muscle paralysis, convulsions and bronchoconstriction, and death due to asphyxiation. In addition to the above, organophosphates also have a non-specific effect on other enzyme systems, as well as a general toxic effect, especially on the liver and blood components (Massoulié et al., 2008; Pohanka, 2011).

Mutagens are environmental agents that change the genetic information of organisms. A significant number of mutations introduce the cells of living organisms into malignant processes, so mutagens are carcinogens at the same time. Cancer is one of the leading causes of death in the world. Experiments performed on cell transformation in *in vitro* conditions, using DNA isolated from cancer cells, indicated the genetic mechanisms of carcinogenesis. Based on empirical data confirmed in numerous experimental models, it was concluded that mutation or activation of one gene is not enough, but can be a trigger for a cascade process, that is, mutation or activation of a number of other genes. There are three types of evidence for this claim: evidence based on DNA analysis from different stages of carcinogenesis; evidence based on the increased expression in cell cultures and experimental animals of oncogenes, that is, genes that encode proteins, which are capable of inducing carcinogenesis in a living organism; as well as evidence from epidemiology. Namely, all cancer cells have a clonal origin, and the incidence of cancer increases with age (Zimonjić i sar., 1990; Marinković and Marinković, 2012, Đorđević et al., 2020). It has been proven that certain types of pesticides can play a significant role in the described genesis of malignant processes in the body. Numerous studies have shown high correlations of exposure to pesticides with the occurrence of lymphoma, leukemia and solid tumors (especially brain and prostate). Illnesses generally occur as a result of long-term exposure to high doses of pesticides, and in some cases, specific pesticides have been identified that caused the illnesses (Bassil et al., 2007).

Back in 1983, Fujii and Inoue established specificity in the action of pesticides on organisms. They tested on soybeans the mutagenic activities of several types of pesticides used in agriculture. For several types of pesticides (lebaycid, diazinon, EPN, karphos), no mutagenic activity was determined. An increase in the mutation rate was found for ecatin. Then, tests were carried out for ecatin using *in vitro* or *in vivo* methods on microorganisms. However, systematic tests of bacteria gave negative results in all cases, so the authors conclude that the manifestation of mutagenic activity of ecatin is specific for plants (Fujii and Inoue, 1983).

Brkić et al. (2006), using the Ames test, examined the genotoxic properties of the herbicide GAL-57, containing two active ingredients; bentazon and dicamba. Taxons *Salmonella typhimurium* and *Escherichia coli* were tested. The authors state that the results showed that there was neither a biological nor a statistically significant increase in the mutation factor, on the basis of which they concluded that the herbicide GAL-57, has no genotoxic properties (with or without metabolic activation) under experimental conditions in the Ames test (Brkić et al., 2006).

Results like those obtained by Brkić et al. (2006) are encouraging. However, sustainable, rational and safe use of pesticides in crop production is necessary. The absence of a legal framework for the application of pesticides, significantly increased uncontrolled use of low quality pesticides in many parts of the world. With the aim of protecting the environment and human health, the maximum allowable concentrations (MACs) of pesticides and their decomposition products, which can be present in food, have been determined. These concentrations do not lead to health damage or any physiological effect in the most sensitive individuals (Bagi and Bodnar, 2012).

Reducing the use of pesticides, along with the intensification of preventive and biological protection measures, are the basic goals of sustainable agriculture and sustainable development. Biopesticides represent one of the most significant discoveries of biotechnology. Biopesticides reduce environmental pollution and enable preservation of food safety (Đukić et al., 2007; Šarčević-Todosijević et al., 2019; Popović et al., 2019; Stevanović et al., 2019). It is important to mention the use of microbial antagonists in the control of plant pathogens. Antagonistic microorganisms have shown the potential to inhibit the growth and proliferation of various phytopathogens, with little or no negative side effects on the environment.

CONCLUSION

Intensive and uncontrolled application of pesticides causes their accumulation in the soil, in which they affect beneficial microorganisms and other soil organisms, the cycling of biogenic elements, as well as the nutrition of plants. From the soil, pesticides get into groundwater, rivers, drinking water, and through food chains into the plant, animal and human body, in which they exhibit an active toxic, mutagenic and carcinogenic effect. Therefore, in the protection of the environment and the production of safe food, it is necessary to reduce the use of pesticides, while intensifying preventive and biological protection measures.

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UTICAJ PESTICIDA NA BILJKE, MIKROORGANIZME ZEMLJIŠTA I ZDRAVSTVENU BEZBEDNOST HRANE U BILJNOJ PROIZVODNJI

Rezime

Pesticidi, su hemijska sredstva za zaštitu bilja, i najviše se upotrebljavaju u poljoprivredi i šumarstvu (90%), odnosno u biljnoj proizvodnji. Pored akumuliranja u životnoj sredini, pesticidi djeluju na biljke, mikroorganizme i ostale članove biocenoza, a preko lanaca ishrane, dospevaju i u organizam čoveka, u kojem ispoljavaju aktivna biološka dejstva. U ovoj stidiji razmatra se uticaj pesticida na biljke, mikroorganizme zemljišta i zdravstvenu bezbednost hrane u biljnoj proizvodnji.

Ključne reči: *pesticidi, biljke, mikroorganizmi, biološko dejstvo, zdravstvena bezbednost hrane*

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