• выкапывание траншей при прокладке инженерных сетей производить от ствола дерева: при толщине ствола 15 см - на расстоянии не менее 2 м, при толщине ствола более 15 см - не менее 3 м, от кустарников - не менее 1,5 м, считая расстояния от основания крайней скелетной ветви;

• контроль за водопотреблением и водоотведением;

• хранение отходов на специально оборудованных гидроизолированных площадках в герметичных контейнерах;

• организация регулярной уборки территории котельной для предотвращения загрязнения поверхностных сточных вод;

• организация отвода поверхностных дождевых сточных вод осуществляется через очистные сооружения ливневых стоков (площадь водосбора составляет S = 0,371 га). Сброс поверхностных сточных вод будет осуществляться в проектируемые поля подземной фильтрации.

• проведение своевременного ремонта дорожных покрытий.

В целом для снижения потенциальных неблагоприятных воздействий от проектируемого объекта на природную среду и здоровье населения при реализации проекта необходимо:

– строгое соблюдение требований законодательства в области охраны окружающей среды и рационального использования природных ресурсов;

– строгое соблюдение технологий и проектных решений.

ЛИТЕРАТУРА

1. Закон Республики Беларусь №399-З «О государственной экологической экспертизе, стратегической экологической оценке и оценке воздействия на окружающую среду» [Текст]: принят Палатой представителей 16 июня 2016 года (с учетом изменений в редакции от 15.07.2019 № 218-З). – Национальный правовой Интернет-портал Республики Беларусь, 26.07.2019, 2/2657 – 23 с.

2. ЭкоНиП 17.01.06 – 001-2017, «Охрана окружающей среды и природопользование. Требования экологической безопасности» [Текст]: санитарные нормы, правила и гигиенические нормативы. – Утвержденные постановлением Министерства природных ресурсов и охраны окружающей среды №5-Т от 18 июля 2017 г. (в ред. постановлений Минприроды от 20.12.2018 N 9-Т, от 18.12.2019 N 6-Т). – Минск: Минприроды – 139 с.

3. Закон Республики Беларусь «О питьевом водоснабжении» [Текст]: принят Палатой представителей 24.06.1999 г. №271-З (в ред. Законов Республики Беларусь от 05.01.2022 N 148-З). – Национальный правовой Интернет-портал Республики Беларусь, 11.01.2022, 2/2868 – 23 с.

4. Закон Республики Беларусь «Об охране окружающей среды» [Текст]: принят Палатой представителей 26 ноября 1992 г. № 1982-XII (в редакции Закона Республики Беларусь от 04.01.2022 г. N142-З). – Минск: Белорусский научно-исследовательский центр «Экология», 2022. – 73 с.

5. Нормативы предельно допустимых концентраций загрязняющих веществ в атмосферном воздухе и ориентировочно безопасных уровней воздействия загрязняющих веществ в атмосферном воздухе населенных пунктов и мест массового отдыха населения [Текст]: постановление. – Утвержденные Министерством здравоохранения Республики Беларусь от 08.11.2016 г. № 113 – Минск: Министерство здравоохранения Республики Беларусь – 129 с.

NEGATIVE EFFECTS OF PESTICIDES AND THE USE OF ELICITORS AS A WAY TO REDUCE PESTICIDE LOAD

ОТРИЦАТЕЛЬНОЕ ВОЗДЕЙСТВИЕ ПЕСТИЦИДОВ И ИСПОЛЬЗОВАНИЕ ЭЛИСИТОРОВ КАК СПОСОБ УМЕНЬШЕНИЯ ПЕСТИЦИДНОЙ НАГРУЗКИ

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Elicitors are substances of a diverse chemical nature that can cause an immune response in plants under conditions of biotic or abiotic stress. These compounds do not exhibit toxicity, are not harmful to the ecological system, and are also safe for humans. In addition, treatment with elicitors is a kind of immunization of plants, as a result of which they become prepared for infections. It is these qualities that allow them to be used to improve the efficiency of agriculture. Including the use of elicitors significantly reduces the use of pesticides. The article describes

the negative impact of pesticides on the biosphere and humans, presents the classification of pesticides and elicitors, the mechanisms of the immune response in plants, as well as the features of the use of elicitors in agriculture.

Элиситоры – вещества разнообразной химической природы, которые могут вызывать иммунный ответ у растений в условиях биотического или абиотического стресса. Данные соединения не проявляют токсичности, не наносят вреда экологической системе, а также безопасны для человека. Кроме того, обработка элиситорами является своего рода иммунизацией растений, в результате которой они становятся подготовленными к инфекциям. Именно эти качества позволяют использовать их для повышения эффективности сельского хозяйства. Применение элиситоров значительно сокращает использование пестицидов. В статье описано негативное воздействие пестицидов на биосферу и человека, представлена классификация пестицидов и элиситоров, механизмы иммунного ответа у растений, а также особенности применения элиситоров в сельском хозяйстве.

Keywords: elicitors, pesticides, phytopathogens, pests, resistance, stress.

Ключевые слова: элиситоры, пестициды, фитопатогены, вредители, устойчивость, стресс.

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Introduction. Increase in the population number around the globe has caused the necessity of harvest preservation. For a long time, there has been a noticeable tendency to increase crop losses from plant diseases and pests. The use of chemical pesticides is the most well-known and most commonly used method for plant protection, although it has long been known about the ability of phytopathogens and pests to acquire resistance to the chemicals used. But besides the fact that they stop being sensitive to chemicals, they become more aggressive. All this, in turn, leads to the fact that plants are constantly under stress.

In fact, the use of various chemical compounds against pests or phytopathogens is not new to the humanity. There are reports of Homer (1000 BC) about the use of sulfur as an insect repeller and Alinium (70 BC) about arsenic as a pest killer. Later, copper salts of arsenic acids and nicotine-based drugs began to be used. And in 1925, the first synthetic organic preparations appeared.

So, the main purpose of using pesticides is to ensure maximum efficiency of agriculture. Their rational use dramatically reduces crop yield losses, reduces agricultural costs by 2-3 times, and allows saving agricultural products by 10–12 billion rubles annually [4]. It is important to know that pesticides are used in a wide variety of cases: to control pests and phytopathogens, weeds, ectoparasites of domestic animals and vectors of human and animal diseases.

Today, the total number of known pesticides is hundreds of thousands, despite the fact that 10-15 new chemical compounds are synthesized annually [2].

Due to the particularly high toxicity of some pesticides, their use is significantly reduced, up to a complete ban in countries (such as DDT). To a greater extent, people working in agricultural production are exposed to pesticides, but any other person is also at risk. Getting into the human body in various ways, including from the polluted environment or from plants consumed with food, pesticides can have not only toxic, but also carcinogenic effects [2].

In addition to human exposure, pesticides negatively affect domestic animals (including bees), wild fauna, soil and soil biota, air and water environments, aquatic biota, target and non-target vegetation. And when pests or phytopathogens acquire resistance, either an increase in the dose of drugs and the multiplicity of treatments is required, or the creation of new chemical pesticides. All this further aggravates the environmental situation.

A variety of pesticides. Pesticides are a group of quite diverse chemical compounds, including both organic and inorganic. In order to determine the use of the pesticide, it is important to understand its class. Depending on the objects against which they are used, the following types are distinguished:

1) herbicides (weed control);
2) algicides (weed control of reservoirs);
3) insecticides (insect control);
4) larvicides (control of larvae, as well as caterpillars);
5) limacids (control of mollusks);
6) acaricides (control of herbivorous mites);
7) anthelminths (control of helminths), etc.

There is also another classification according to the method of penetration of pesticides and the nature of their effect on harmful agents. Pesticides of the following action can be distinguished:

1) contact (death of organisms or suppression of their development occurs in contact with a pesticide);
2) systemic (chemicals penetrate into the vascular system of plants or animals and cause their death);
3) intestinal (enter the body of pests with food or water and cause their poisoning);
4) fumigant (are in a vapor or gaseous state, act on harmful organisms by penetrating them).

According to the chemical structure, many types can also be distinguished, but the most well–known include the following types of compounds:

1) organochlorine compounds;
2) organomercury compounds.;

3) organophosphorus compounds;
4) triazine derivatives;
5) derivatives of arylcarbamic and alkylcarbamic acids;
6) urea derivatives;
7) nitrophenols, etc.

Understanding the nature of this or that pesticide makes it easier for farmers and biologists to better select the proper ones to increase the amount of the harvest and, if necessary, to reduce there amount so that to eliminate bad-side effects on the humans and the environment. Besides, it enables them to combine certain types to facilitate their efficiency.

Much is being done to minimize those bad-side effects. At the moment, the use of organochlorine compounds in agriculture is minimized for the following reason. These chemical pesticides are highly soluble in organic solvents and fats, and are also extremely stable in the environment. This type of pesticides includes, for example, heptachlor, aldrin, dichlorodiphenyltrichloromethylmethane (DDT). In addition to the fact that they decay for a long time, they still linger mainly in the upper layers of the soil and slowly migrate to the depths. In the human body, they affect, as a rule, the nervous system, and accumulate mainly in adipose tissue. Unlike organochlorine pesticides, organophosphates are unstable and can be destroyed by temperature. But they easily penetrate through the skin and mucous membranes. Mercury-containing pesticides, as well as those that include arsenic, do not decompose and therefore they are in constant circulation between the environment and organisms.

The effect of pesticides on humans. As it was mentioned above, pesticides have harmful effect on the human body. One of the features of pesticides is that they are able to linger and accumulate both in the environment (soil) and in plant and animal organisms. Including this does not bypass a person. Reaching a certain level of concentration increases the likelihood of developing acute chronic diseases (including poisoning, pathologies, developmental abnormalities). Often, the negative impact of pesticides falls on the cardiovascular system, there is a blockage of blood vessels, their weakness occurs.

The consumption of foods that contain pesticides is one of the factors of embryo death in pregnant women and a number of other obstetric pathologies. The child's body and the adolescent's body are also at great risk. So, at a transitional age, girls may experience menstrual cycle failures.

But one should not think that only immature organisms or people with weakened immunity are the first to be in danger. Workers in agriculture, farms and industries expose their bodies to much greater danger. Very often they have pathologies of the respiratory system, various kinds of skin infections, as well as diseases in the subcutaneous layers. In addition to having a toxic effect, can cause the development of pathology. About 125,000 brain tumors and liver cancer are detected annually in young people and girls under the age of 18. A number of researcher's blame this on the destructive properties of toxic chemicals that enter the body together with food and water. [5]. One of the most terrible effects of chemical pesticides on the body is their effect on the human gene. There are a number of pesticides that contribute to the occurrence of mutations in the human body, which can cause various kinds of pathologies that will then be inherited from generation to generation.

Pesticides and the biosphere. It was mentioned earlier that chemicals are capable of bioaccumulation, but now it is also known about biotransformation processes. And here there is a problem associated with the fact that during decomposition, both detoxification of pesticides and their toxification can occur, during which even more toxic substances are formed. The environment is unpredictable and due to changes in temperature, humidity, illumination and other abiotic factors, it can affect these decomposition processes.

Unfortunately, compared to the self-purification of the atmosphere and hydrosphere, the self-purification of the soil is very slow. The result of this in the end was that a lot of pesticides remain there indefinitely (depending on the type of pesticides, it can vary, including unlimited) and have a negative impact on living organisms.

One of the characteristics of the biosphere is the presence of the process of migration (transfer) of atoms of elements and natural compounds. This also applies to xenobiotics. Therefore, it is thanks to such a process as migration that the components of pesticides spread over a long distance, depth and height. Thus, the use of a toxic chemical in one place can cause significant harm even on a global scale.

Classification of elicitors. Harmful effects of using pesticides gives rise to the necessity of using alternative ways of protecting plants. Unfortunately, at the moment it is impossible to completely abandon pesticides, but there are a number of other ways. One of them is to increase the immune potential of plants. It is this method of solving the problem that the use of elicitors refers to. This can occur in the form of tillage, spraying of plants (during the growing season), soaking of seeds, as well as the plants themselves. The increase in yield from the use of biogenic elicitors as immunizers ranges from 10 to 30 %, depending on the conditions of the year, plant varieties and, especially, the infectious load of pathogens [1]. And most importantly, the use of such resistance inductors allows the plant to acquire systemic resistance (which occurs in all tissues, not just those that came into contact with the elicitor) for the entire growing season).

Like pesticides, elicitors are not a specific chemical compound. By their origin, biotic and abiotic types are distinguished. The first group includes elicitors of pathogenic or plant origin, these can be: polysaccharides (pectin, cellulose, chitosan, chitin), oligosaccharides (galacturonides, mannans), proteins (cellulase, lactoferrin), pathogen toxins (coronatin). Abiotic elicitors are also divided into two groups: physical (CO_2, extreme temperatures, high pressure, UV radiation, etc.) and chemical (ethanol, acetic acid, inorganic salts (for example, $HgCl_2$, $CuSO_4$, $CaCl_2$, VSO_4), metal ions (for example, Co^{2+}, Fe^{2+}, Cu^{2+}, Cd^{2+}, Mn^{2+}), etc.).

If the elicitors are of plant origin, they are called endogenous, if they were synthesized by other organisms, then exogenous. The first include DAMPs (damage (danger)-associated molecular patterns). The second group includes MAMPs (microbe-associated molecular patterns) or their second name – PAMPs (pathogen-associated molecular patterns), HAMPs (herbivory-associated molecular patterns), VAMPs (virus-associated molecular patterns), NAMPs (nematode-associated molecular patterns).

What is worth mentioning is that plant hormones can also be considered as elicitors. For example, salicylic acid (SA) and jasmonic acid (JA), while SA contributes to increased resistance to biotrophs, whereas JA – necrotrophs. These acids, among other things, are messenger molecules and are involved in intracellular signal transmission. It is also indicated that SA plays a crucial role in the systemic protective reactions of plants.

Finally, elicitors can be specific and non-specific. The first trigger protective reactions that lead to disease resistance only in certain plants (they carry the gene for resistance to the desired pathogen). Non-specific ones practically do not differ in the way they affect different varieties of the same species (they include DAMPs, MAMPS) [3].

The basic principles of the action of elicitors. To better understand the ways of elicitors application in farming, we will consider the mechanism of their affecting the plant. It all starts with the interaction of the elicitor with the receptor on the cell surface. Then, the receptors have a general plan of structure, regardless of what the nature of the elicitor binding to them is. The receptor includes 3 sites: a site located outside the cell, an intramembrane site and a site immersed in the cytoplasm. The outer N-end of the receptor is specific to the elicitor, and the inner C-end is specific to the enzyme associated with the receptor, which determines which of the signaling systems will interact with [3]. After the recognition of the elicitor molecule by the receptor, a signal is transmitted to the intracellular space by means of proteins and messenger molecules (hydrogen peroxide, nitric oxide, as well as the above-mentioned salicylic and jasmonic acids). It is also important that the signal is not only transmitted, but also amplified, which allows the plant to react faster to any changes.

Further ways of the process development are very diverse. One of the early reactions of plant cells to elicitors is the synthesis of activated oxygen forms (ROS), of which hydrogen peroxide and superoxide anion are of particular importance. Most likely, ROS have a direct antimicrobial effect, and are also involved in signal transduction or cell death (the result of a hypersensitivity reaction). It is worth noting that ROS are present in the cell under optimal conditions, although their number is much smaller. They are mainly located in organoids such as mitochondria, chloroplasts and peroxisomes. It is important that the generation of ROS also occurs under abiotic stress, especially in the event of drought, frost, high temperature. The aforementioned salicylic acid is one of the main inducers of ROS formation.

An important role is played by peroxidases, the number and activity of which increases significantly after a surge of ROS. In addition to the fact that peroxidases reduce the negative effects of ROS, they are involved in the oxidation of phenolic compounds to quinones, as well as in the activation of the formation of lignin, one of the components of the plant cell wall, which gives it strength. In addition to the fact that phenols participate in strengthening the cell wall, they also have anti-oxidant and antimicrobial activity.

One of the main protective substances that are synthesized by plants are phytoalexins – antibiotics of plant origin. Currently, about 350 phytoalexins produced in plant tissues in response to the action of elicitors have been characterized [3]. These are usually hydrophobic compounds that are localized around the infected site. Their synthesis is also associated with the previously mentioned hypersensitivity reaction. As a result of this process, dead cells become a place where phytoalexins accumulate and do not allow phytopathogens to spread further. In response to biotic stress, not only phytoalexins are synthesized, but also PR proteins. For example, these include enzymes such as chitinases and β-1,3-glucanases. They are involved in the destruction of the cell wall of fungi.

It is important to note that in addition to the synthesis of compounds aimed at directly countering the stressor, changes also occur with intracellular metabolic processes. Thus, stress proteins affect the increase in the functional activity of some cell organelles (chloroplasts, mitochondria), the power of enzyme systems, the stabilization of membranes. The main role in all reactions occurring after the interaction of the elicitor with the receptor is played by resistance genes. They directly activate the plant's defense mechanisms. But at the same time there is a connection between the signaling system and the genome, which makes it possible to form an adequate response from the cell.

Preparations based on elicitors. Using elicitors has its own features. Unlike pesticides, elicitors do not show toxicity, are not harmful to the ecological system, can have a low cost, and are also safe for humans. Another valuable quality is that they prepare plants for subsequent infections or the action of abiotic factors.

It was mentioned earlier that the increase in plant resistance is mainly due to the synthesis of PR proteins, phytoalexins, cell wall components (including lignin), phenolic compounds and many other compounds. Protein synthesis can also be stabilized, which leads to the stabilization of cell membranes, including chloroplast membranes. This helps the active flow of photosynthesis during drought.

The preparations used may be microbiological, while others are chemically synthesized. At the same time, there are different bases for their creation: phytohormones, chitosan, bacterial cultures, organic compounds, inhibitors of chitin synthesis. And then the compounds included in the preparations are perceived by the plant as signaling substances, which leads to the induction of immune protection, the launch of anti-stress programs mentioned above.

Preparations based on arachidonic acid and its derivatives – immunocytophyte and biodux are already known. These chemicals stimulate the production of phytoalexins in plant tissues, which contributes to increased resistance to phytopathogens [3]. Chitosars are a series of drugs that are inducers of resistance to fungal, bacterial and viral diseases. Under the influence of albite, acquired resistance to many diseases develops. Salicylic acid can also be used as a stimulant of protective reactions of plants.

As a significant positive effect of elicitors, it should also be noted that the pesticide load is reduced (by 2 times or more), which contributes to the improvement of the ecological and functional state of agroecosystems [3].

Conclusions. Having considered all the previous characteristics, classifications and specifics of the use of both pesticides and elicitors, we came to the following conclusions.

Nowadays, there are two main strategies for combating phytopathogens and pests: the selection of plant varieties for resistance and the use of chemical pesticides. In both cases, there is a problem associated with the fact that harmful agents acquire resistance to chemicals and, among other things, become more aggressive.

Although the use of pesticides is now a fairly proven way to increase agricultural productivity, this does not negate all the consequences of their use. Environmental pollution, death of an organism that is not the purpose of processing, the accumulation of dangerous chemical compounds in animal and plant organisms, which then enter the human body with food, where they cause various changes related to their toxicity and carcinogenicity, the possibility of the formation of even more toxic substances during decomposition are the most evident and grave consequences of the use of chemical pesticides.

The mentioned above problems are the main reason why it is necessary to explore and develop new ways of effective farming. One of these can be called the use of elicitors – substances that can cause plants to respond to biotic and abiotic stress. These compounds are extremely diverse in chemical structure and origin and at the same time can contribute to the emergence of immunity against a particular pathogen, as well as a certain group of agents.

At the same time, it should be understood that the use of elicitors is not a panacea, they are only part of a laborious process to improve the process of growing plants. The use of such chemical compounds or preparations based on them is one of the ways to reduce the load of pesticides in the first place. Nevertheless, the problem needs further exploration. Much research is being done in this field, so there is a hope that optimal solutions will be found soon.

In addition, we should remember that the main harm that occurs in connection with the use of chemical pesticides is a consequence of their irrational use. Now that we have a lot of information about them and are still continuing to investigate their impact on organisms and ecosystems, it is worth aiming our efforts at making up and direct use of sanitary and hygienic standards. In addition, a significant role is played by research related to the clarification of the processes of self-purification of landscapes and their individual elements, as well as the processes of interaction of pesticides with other environmental compounds (radionuclides, metals, etc.). Together with the use of other methods to combat pathogens or counteract abiotic stress, this will help reduce the adverse side effects of pesticides to a minimum.

REFERENCES

1. *Яблонская, Е.К.* Применение экзогенных элиситоров в сельском хозяйстве / Е.К. Яблонская // Научный журнал КубГАУ. – 2015. – №109. – С.1–17.

2. *Омарова, З.М.* Влияние пестицидов на здоровье детей / З.М. Омарова // Российский вестник перинатологии и педиатрии. – 2010. – №1. – С. 59–64.

3. *Карпун, Н.Н.* Механизм формирования неспецифического индуцированного иммунитета у растений при биогенном стрессе / Н.Н. Карпун, Э.Б. Янушевская, Е.В. Михайлова // Сельскохозяйственная биология. – 2015. – Т. 50, № 5. – С. 540–549.

4. *Шевкопляс-Гурьева, Н.А.* Применение пестицидов и их влияние на окружающую среду и здоровье человека / Н.А. Шевкопляс-Гурьева, Г.А. Сивкова // Инновационная наука. – 2020. – №12. – С. 15–16.

5. *Завьялова, Я.С.* Влияние пестицидов на организм человека / Я.С. Завьялова, В.Д. Богданова // Гигиена. – 2017. – №1. – С. 16–18.

ЭЛЕКТРОМОБИЛИ: ПЕРСПЕКТИВЫ И ПРОБЛЕМЫ ИСПОЛЬЗОВАНИЯ

ELECTRIC VEHICLES: PROSPECTS AND PROBLEMS OF USE

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Переход на электротранспорт – один из основных мировых трендов. Динамично растет глобальный рынок электромобилей. Прогнозируется, что к 2030 году 20% мирового автопарка будет электрическим.