

Необходимые меры безопасности при работе с пестицидами в сельском хозяйстве

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Резюме

Введение. Пестициды как биологически активные вещества при применении могут представлять опасность для здоровья работающих с ними, вызывать острые и хронические профессиональные отравления (заболевания). С пестицидами возможен контакт не только работающих в сельском хозяйстве, но также больших масс населения при применении их в личном подсобном хозяйстве (ЛПХ). Различные технологии применения пестицидов (наземное штанговое опрыскивание полевых культур, вентиляторное опрыскивание садов, авиационный метод опрыскивания полей и лесов, обработка теплиц, протравливание семян, фумигация зерна и складов, приготовление и применение приманок), требуют дифференцированного подхода к мерам безопасности при работе с ними. Меры безопасности при работе с пестицидами, на протяжении ряда лет разрабатываемые ФБУН «ФНЦГ им. Эрисмана» Роспотребнадзора, с появлением новых видов препаративных форм и технологий, изменением нормативных документов требуют доработки.

Цель работы. Обосновать меры безопасности для работающих с пестицидами в условиях сельского хозяйства с учетом класса опасности препаратов, различных технологий и техники применения.

Материалы и методы. Были проанализированы нормативные и методические документы, данные собственных многолетних исследований, а также сведения, опубликованные в открытой печати по проблеме безопасного применения пестицидов в сельском хозяйстве.

Результаты. Предложены меры безопасного применения пестицидов с позиции гигиены труда на основе соблюдения гигиенических регламентов обрабатываемых культур и правил их применения с учетом состояния используемой техники. Рекомендованы меры по профилактике острых отравлений пестицидами сельскохозяйственных работников, фермеров и пользователей.

Заключение. Необходимо разработать более подробного документа обобщающего требования гигиены труда и безопасности пестицидов для всех условий и технологий их применения.

Ключевые слова: пестициды, сельское хозяйство, отравления, безопасность применения.

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Necessary Safety Measures in the Use of Pesticides in Agriculture

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Summary

Introduction. Pesticides as biologically active compounds posing potential hazard to worker's health may cause both acute and chronic occupational poisonings (diseases). Apart from the occupational setting, many people get exposed to pesticides during their use in personal subsidiary plots. Various pesticide application techniques, such as ground-based boom spraying of field crops, air blast spraying of gardens, aerial spraying of fields and forests, treatment of greenhouses, seed dressing, fumigation of grain and warehouses, preparation and application of baits, require a differentiated approach to precautionary measures. Safety use practices for pesticides developed by F.F. Erisman Federal Scientific Center of Hygiene in the past shall be revised to incorporate changes in formulations, techniques, and regulations.

Objective. To substantiate hazard-specific safety requirements for various pesticide application techniques and equipment in the agricultural industry.

Materials and methods. We analyzed regulatory documents and guidelines, results of our own long-term studies, and publicly available information on the safe use of pesticides in agriculture.

Results. Based on our findings, we suggest measures for the safe use of pesticides complying with appropriate regulations for the processed crops and application rules and taking into account conditions of the equipment used. We also provide recommendations for prevention of acute pesticide poisoning for agricultural workers, farmers and users from the standpoint of occupational health.

Conclusion. It is important to develop a profound document summarizing occupational safety and health requirements for all pesticide use practices.

Keywords: pesticides, agriculture, poisoning, safety of use for workers.

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Introduction. Pesticides are a special group of chemical compounds that are intentionally introduced into the environment and possess high biological activity at low exposure levels inducing disruption of the hormonal regulation mechanisms, affecting immunocompetent systems, and having potential long-term effects [1–3].

Agricultural application of more than 800 pesticides is permitted in Russia¹. In 2016, 60 thousand tons of plant protection chemicals were used in the country [4].

Apart from the occupational setting, many people are exposed to pesticides during their use in personal subsidiary plots (PSPs).

As biologically active compounds, pesticides can pose workers' health risk and cause both acute and chronic occupational poisonings (diseases) [1–7]. According to the International Labor Organization (ILO)², agriculture is one of the most hazardous of all economic sectors employing almost half of the global workforce (1.3 billion people); at the same time, up to 170 thousand agricultural workers die annually from occupational accidents and injuries associated with agricultural machinery, poisonings with pesticide and other related chemicals. Registration of accidents (injuries, acute and chronic poisonings), as well as occupational disease incidence among agricultural workers, both in our country and around the world, remain incomplete [2, 8].

Exposure to pesticides may occur through oral, dermal, and inhalation exposure routes. Oral exposure is usually accidental and associated with violation of safety measures in handling pesticides (e.g., eating or smoking while working, etc.). The inhalation exposure route is the most toxic and poses a real danger, especially for compounds with high inhalation toxicity. The dermal route is not less important: according to the results of our studies of over a hundred pesticide formulations used in mechanized processing of field and garden crops and in greenhouses, the dermal route

mainly determines the risk of adverse health effects of pesticide exposure. We established that the risk of dermal exposure was 1.5–4.7 times higher than that of the inhalation exposure route. This difference was less pronounced when using pre-sowing seed treatment and when applying pesticides in greenhouses and PSPs due to the presence of compounds in the breathing zone attributed to preparation of working solutions for seed treatment or by the use of knapsack sprayers [8, 9].

Of 103 reported cases of acute poisoning by fipronil-based spot-on solutions in the United States, 26 % were pest control operators tasked with premise termite treatment. The reasons for all poisonings included violations of instructions for safe use of pesticides, poor ventilation of premises, improper use of personal protective equipment (PPE), and high ambient temperatures [10].

The lack of coordination of plans for the use of pesticides in the fields among various land users, noted in almost 90 % of cases, may lead to poisonings in people indirectly exposed to pesticides only due to their drift outside the treated areas. Balan et al. [11] reported that the analysis of 310 cases of acute poisonings of agricultural workers showed that the reason for group poisonings of beet growers with 2,4-D-based herbicides in 76 % of cases and wine growers and gardeners with organophosphate pesticides (dimethoate, malathion) in 14.2 % of cases was a pesticide drift from neighboring grain crop fields treated with insecticides or herbicides [11].

In accordance with the Federal Law, the pesticide use in Russia is liable to state registration³ that permits production, usage, sale, transportation, storage, disposal, advertising, import, and export of a formulation. Federal Law No. 522-FZ, On amendments to the Federal Law on the safe handling of pesticides and agrochemicals, adopted on December 30, 2020, defines the powers of governmental authorities of the Russian Federation to exercise federal surveillance over implementation

¹ State Catalog of Pesticides and Agrochemicals Permitted for Use on the Territory of the Russian Federation. Moscow: Ministry of Agriculture of the Russian Federation; 2021.

² Labor protection in figures and facts. International Labour Organization. Accessed August 18, 2021. <https://www.ilo.org/global/lang-en/index.html>

³ Federal Law No. 109-FZ, On the safe handling of pesticides and agrochemicals.

of the legislation of the Russian Federation in the sphere of safe handling of pesticides and agrochemicals, rules for exercising control at border checkpoints, and aspects of international cooperation of the country on safe handling of pesticides and agrochemicals. Some provisions of the law are still being finalized by the government and will be adopted by separate regulations.

The issues of the safe use of pesticides are reflected in SP 2.2.3670–20 and SanPiN 2.1.3684–21^{4,5} developed within the framework of the Russian “regulatory guillotine”. It is unfortunate that occupational safety and health requirements for the pesticide use in the above documents are incomplete and disregard specifics of various application techniques, which requires the development of guidelines supplementing the already existing ones.

Objective. Our objective was to substantiate hazard-specific safety requirements for various pesticide application techniques and equipment in the agricultural industry.

Materials and methods. We used the results of numerous studies of inhalation and dermal exposures to pesticides conducted in 1996–2019 by F.F. Erisman Federal Scientific Center of Hygiene of the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing (Rospotrebnadzor) within the framework of participation in governmental registration testing of pesticides using various techniques to conduct risk assessment in accordance with the Russian model for assessing risks of pesticides⁶. We also evaluated all studied formulations according to the current classification of pesticides⁷ and analyzed publicly available information devoted to the safe use of pesticides in agriculture [1–7, 10–15, 17–19, 21].

Results. According to Federal Law No. 109-FZ, all pesticides recommended for use in the Russian Federation are liable to registration tests including human health risk assessment. The hazard class of a pesticide governs its application. In terms of toxicity, pesticides are divided into four hazard classes (1 – extremely hazardous, 2 – highly hazardous, 3 – moderately hazardous, and 4 – slightly hazardous). The use of hazard class 1 pesticides is limited to cases of extreme necessity under specific conditions, e.g. fumigants used for quarantine-related purposes. Hazard class 2 pesticides, if necessary, may be used only by professional pest control operators or under their supervision, or by specially trained individuals. The majority of pesticide formulations recommended for use in agriculture are hazard class 3 products. The use of pesticides by the general population is limited to the least dangerous formulations (hazard classes 3 and 4), which are allowed for sale in specialized stores and/or departments only. Small businesses engaged in small packaging of pesticides included in the State Catalog must fall in line with the regulatory and technical documentation for this process in the prescribed manner.

The pesticides intended for use in agriculture and PSPs shall have original packaging and appropriate labels indicating the hazard class, warnings about potential adverse health effects such as acute toxicity, possible irritation of the skin and mucous membranes,

and long-term effects (teratogenicity, carcinogenicity, etc.), instructions for use including application rates and frequency and restricted-entry intervals, reference to safety regulations, and the necessity to use PPE according to Federal Law No. 109-FZ from July 19, 1997, *On the safe handling of pesticides and agrochemicals*, and SP 2.2.3670–20, *Sanitary and epidemiological requirements for working conditions*.

Responsible compliance with safety requirements specified on the product label significantly reduces the risk of acute and chronic intoxication with pesticides. Yet, the experience shows that failure to comply with instructions for safe use of pesticides causes poisonings and even death of pesticide users [8, 11–15].

Various techniques of application of pesticides (terrestrial boom-spraying of field crops, air blast spraying of gardens, aerial spraying of fields and forests, greenhouse treatment, seed treatment, fumigation of grain and warehouses, preparation and application of baits) require a differentiated approach to the development of safety measures [9, 16].

Safety measures are based on:

- the use of the least dangerous forms of pesticides such as aqueous solutions, suspensions, and emulsions. Wettable powder formulations posing the highest risk of inhalation exposure during preparation of working solutions today are packaged in water-soluble bags preventing their becoming airborne;
- the use of modern spraying techniques allowing for ground tractor (boom and air blast) and aviation spraying with the minimal formulation loss;
- the use of modern agricultural equipment (tractors, airplanes, helicopters) with improved pressurized air-conditioned cabins preventing the ingress of pesticides into the workplace air of operators;
- creation of highly automated plants for pre-sowing treatment of seeds with effective general and local exhaust ventilation systems, automated packing, loading, and unloading of treated seeds;
- careful selection of effective personal protective equipment (PPE) to protect the respiratory system and skin, and
- awareness raising on potential adverse health effects and their prevention among pesticide users.

Safety in the use of pesticides is majorly determined by the machinery. According to the research conducted by Kleffmann-Kynetec, 54 % of all tractors used in the Russian agricultural sector were assembled by Minsk Tractor Works (MTZ), Republic of Belarus, 37 % – by *Kirovets* St. Petersburg tractor factory (PTZ), Russian Federation, and 21 % – by John Deere, USA. The most popular tractor models, particularly in individual farms, are MTZ-82 and PTZ–*Kirovets* K-744; in agricultural holdings – John Deere 6195M [17, 18].

The most common agrochemical trailed sprayers OP–2500 *Argo* and OP–3000 *Bulgar* match the above-mentioned machinery very well, especially the MTZ-82 tractor. Equipping spraying equipment with precision farming tools, such as GPS agricultural navigators/GLONASS Commanders, TeeJet on-board automated guidance systems for crop sprayers, allows for real-time monitoring during pesticide application to large areas, control of the number of field applications and

⁴ Sanitary Regulations SP 2.2.3670–20, *Sanitary and epidemiological requirements for working conditions*. (In Russ.)

⁵ Sanitary Rules and Regulations SanPiN 2.1.3684–21, *Sanitary and epidemiological requirements for the maintenance of territories of urban and rural settlements, for water bodies, drinking water and drinking water supply, ambient air, soils, living quarters, maintenance of industrial and public premises, organization and implementation of sanitary and anti-epidemic (preventive) measures*. (In Russ.)

⁶ Guidelines MU 1.2.3017–12, *Risk assessment of occupational pesticide exposure*. (In Russ.)

⁷ Guidelines No. 2001/26, *Hazard-specific classification of pesticides*. (In Russ.)

conditions of sprayers, and alert in case of technological or technical malfunctions [17, 18].

In practice, the operator is sometimes forced to leave the tractor cab during pesticide application to clean clogged nozzles and faces the risk of high dermal exposure.

Despite all the success in agricultural machinery production, 70 % of the fleet consists of old, worn-out tractors with expired useful life and many farms lack sufficient machinery. On average, there are only three tractors per 1,000 hectares in Russia while in Canada, for instance, their number reaches 16⁸.

The use of outdated agricultural machinery may have an adverse effect on workers' health and performance. The absence of air conditioning is the reason for high temperatures in the cabin while poor tightness of the latter causes ingress and accumulation of pesticides on inner surfaces increasing the risk of inhalation and dermal exposures. High levels of noise and vibration may contribute to hearing loss and development of other diseases [19, 20]. The lack of machinery during the growing season causes a forced increase in the work shift duration, which must not exceed 6 hours, and elevates the risk of adverse health effects of work-related factors in tractor operators.

In vegetable gardening, the use of automated planting machines for wet pesticide treatment of potatoes with simultaneous planting of tubers in soil excludes the ingress of pesticides into the workplace air and minimizes dermal exposures of the tractor operator. However, the machinery misuse and installation of an additional workplace for a sower increase the risk of inhalation and dermal exposures to pesticides by 4–6 times and by 3–4 times, respectively [19].

Awareness raising among pesticide users is one of the most important components of primary prevention of adverse health effects of pesticides. Its main purpose is to provide basic knowledge of sanitary and hygienic requirements for working conditions and environmental protection, as well as measures of ensuring technical safety of production processes and technological operations with pesticides. The content and scope of training shall depend on the target audience (agronomists, farmers, population, etc.) and, in the least, include the following:

- general information about pesticides and their health effects, routes of exposure, accumulation of pesticides in the body and environmental objects, first signs of poisonings, and first aid measures;
- safety requirements for storage, transportation, and use; and
- requirements for personal protective equipment and workwear, their use and storage, personal hygiene.

A prerequisite for working with pesticides is compliance with the requirements for waste neutralization and disposal, labeling and use of a rational set of protective equipment preventing or limiting inhalation and dermal exposures.

The scientific basis for choosing PPE is based on data on the level of contamination of the working environment (workplace air, equipment, skin and clothing), the hazard class of the formulation, the pulmonary ventilation volume, i.e. the severity of the work performed, and the contact area of skin with contaminated surfaces.

When selecting respiratory PPE equipment, it is necessary to consider the nature and duration of the operations performed in addition to the pesticide's hazard class.

Types RPG-67 and RC-60 respirators with mark “A” cartridges and 3M respirators with pre-filters for pesticides are most effective when the risk of inhalation exposure to pesticides is the highest, i.e. when preparing working solutions of liquid formulations, filling of equipment, and performing other periodical operations lasting 10 to 15 minutes. When working with pesticides during a work shift (in the greenhouse, during chemical treatment), the prolonged use of the aforementioned PPEs (over 30 minutes) causes additional physical strain to workers. It is therefore advisable to use lighter respirators such as *Alina*, *Nechernozemie*, *Uralets*, and Y-2GP with “A” or “D” cartridges, etc. [21].

Fumigation that envisages application of the most toxic pesticides dictates the use of gas masks.

Prevention of dermal exposure to pesticides is based on the correct choice of workwear and hand and arm protection. The use of cotton clothes decreases the risk of skin contamination by 7 times; workwear made of composite materials (polyether and cotton, clothes with fluoroorganic impregnations, etc.) like *Expert* and *Agrochem* costumes ensure effective skin protection against pesticides. Rubberized cotton fabric suits securely protect the skin from exposure to aerosol pesticides, but prolonged work in such costumes increases air temperature and humidity in between skin and cloth causing sweating and promoting resorption of toxins through the skin. Protective clothing must be supplemented with armbands and an apron made of rubberized materials to protect the skin from dissolved pesticides during manual spraying of plants [21–25].

It is important to protect hands from direct contact with pesticides. It should be noted that the range of PPE offered for hand skin is limited and the most affordable choices include rubber gloves for industrial or technical use and latex gloves. The use of these gloves when working with pesticides is not always effective: according to our findings, pesticides are often detected in wipe samples from hand skin after use. Gloves made of neoprene and butyl rubber have demonstrated their effectiveness in protecting the hand skin of workers from direct contact with pesticides [16, 26].

Conclusions. The basis for sanitary surveillance in the application of pesticides from the standpoint of occupational health is the compliance with hygiene regulations (application rates, terms and conditions of use, and restricted-entry intervals), spheres (cultivated crops) and rules of application. The Annual State Catalog of Pesticides and Agrochemicals permitted for use in the Russian Federation shall include only those formulations, which usage has been approved by the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing.

To prevent acute poisonings among agricultural workers, farmers, and private gardeners, it is necessary to comply with the requirements for personal and public safety upon acquisition, storage, and use of potentially hazardous compounds. It is important to observe correct application periods, temperature and humidity, take into account wind speed and direction, and coordinate schedules of the pesticide use not only with the local Rospotrebnadzor authorities but also with neighboring land users.

It is advisable to develop guidelines summarizing measures for the safe use of pesticides under all conditions and application techniques to supplement the already existing ones in view of the newly adopted

⁸ Russian agricultural machinery: “strategic” development, export and production of components. *Nivy Rossii*. 2017;(7(151)). (In Russ.) Accessed August 18, 2021. <http://svetich.info/publikacii/agrohimija/tatjana-filidova-segodnja-otechestvennym.html>

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