

DEVELOPMENT OF THE DERMAL EFFECT OF PESTICIDES ON PROFESSIONAL CONTINGENTS USING INNOVATIVE 3RIVE 3D TECHNOLOGY

Olena P. Shevchenko, Pavlo V. Bardov, Andrii A. Borysenko, Anna M. Antonenko, Sergii T. Omelchuk, Olexandr I. Kovalchuk, Olena V. Dema

Bogomolets National Medical University, Kyiv, Ukraine

Summary

The skin is the most vulnerable organ when spraying pesticides on fields. Farmers are also exposed to pesticides during mixing, loading of pesticides, and when cleaning equipment and disposing of empty containers.

The aim. To study and analyze the features of the risk of pesticides dermal exposure to professional contingents during treatments using the innovative 3RIVE 3D pesticide application technology.

Materials and methods. The 3RIVE 3D innovative technological system of introducing was used to applicate Brigade 3Rive 3D, SC formulation. Field experiments on the study of working conditions when using the pesticide were conducted in various soil and climatic regions of Eastern Europe. Statistical processing of the results was carried out using a package of licensed statistical programs IBM SPSS StatisticsBase v.22 and MS Excel.

Research results and discussion. During the conducted research, no bifenthrin contamination was found on the open skin of the operator and the tractor driver, who were processing corn crops with the Brigade 3Rive 3D, SC formulation. However, the operator's gloves were found to contain 0.025 mg of bifenthrin.

Calculation of the unitless CASd value on the possibility of skin acute effects when applying the formulation showed that bifenthrin and the Brigade 3Rive 3D, SC formulation based on it are characterized by sufficient selectivity of action on the target object (CASd – 645 and 162, respectively, i.e. > 100) and a low level of danger acute dermal toxic effects for workers, which is due to low values of effective consumption rates.

The real dermal risk of bifenthrin exposure when using the Brigade 3Rive3D, SC formulation was significantly lower compared to the risk of workers involved in «traditional» air treatment and treatment with unmanned aerial vehicles (UAVs) ($p=0.009-0.048$ according to Wilcoxon's *W*-criterion); in comparison with rod and fan processing – it is non-significantly lower ($p=0.262-1.000$). There was a similar picture in comparison with the dermal aggravated risk – significantly lower in comparison with the risk of workers involved in «traditional» air treatment and processing with the help of UAVs ($p=0.009$ according to Wilcoxon's *W*-criterion); in comparison with rod and fan treatment – non-significantly lower ($p=0.262-1.000$).

Conclusions. It was established that the studied active substance bifenthrin and the Brigade 3Rive 3D, SC formulation based on it are characterized by sufficient selectivity of dermal action on the target object and a low probability of acute dermal effects. A higher probability of acute inhalation poisoning than dermal exposure was revealed.

Keywords: pesticide, innovative application technology, skin, toxicology, occupational risk

INTRODUCTION

Despite their popularity and widespread use, pesticides have raised serious concerns about the health

risks posed by exposure to farmers during their work. It is obvious that exposure to pesticides is a constant health hazard, especially in the agricultural work environment [5, 10].

The skin is the most vulnerable organ when spraying pesticides on fields. Farmers are also exposed to pesticides during mixing, loading of pesticides, and when cleaning equipment and disposing of empty containers. Other activities associated with exposure include planting pesticide-treated seeds, weeding, and harvesting previously sprayed crops [6, 7, 8, 9]. In the first decades of pesticides use, the main problem was the risk of acute intoxication among people who were occupationally exposed. But nowadays, the problem of diseases not directly related to the toxic potential of pesticides, most of which are non-toxic dermatoses, is gaining more and more interest [6, 7, 8, 9]. Most of the dermatoses associated with pesticide application are contact dermatitis, both allergic and irritant. There are also rare clinical forms, including urticaria, erythema multiforme, ashen dermatosis, parakeratosis multicolor, porphyria cutaneous late, chloracne, skin hypopigmentation, nail, and hair disorders [6, 7, 8, 9]. Farmers exposed to arsenic pesticides are at risk of occupational skin cancer, mainly Bowen's disease (carcinoma in situ), multiple basal cell carcinomas, and squamous cell carcinomas [6, 7, 8, 9].

A comprehensive assessment of working conditions and estimated risk prediction of the potential negative impact of pesticide on farmers involved in their application

is one of the mandatory stages of pre-registration testing of pesticide formulations, including those that have already been previously studied and registered, but which are planned to be applied with the help of innovative agricultural technologies of application.

Such innovative technologies are very promising in terms of reducing the risk of local contact exposure to workers.

THE AIM

To study and analyze the features of the risk of pesticides dermal exposure to professional contingents during treatments using the innovative 3RIVE 3D pesticide application technology.

MATERIALS AND METHODS

Field experiments on the study of working conditions when using the Brigade 3Rive 3D, SC formulation were conducted in various soil and climatic regions of Eastern Europe, under acceptable meteorological conditions (table 1) in accordance with the current guidelines for the hygienic assessment of pesticides.

Table 1

Meteorological conditions for field studies using 3Rive3D technology

Name pesticide formulation	Date of treatment	Treatment conditions			
		The mean value of the meteorological parameter, units of measurement (n = 3)			
		t, °C	RH, %	V, m/sec	AP, Hg mm
Brigade 3Rive 3D, SC	23.06.2021	18 ± 1	65 ± 2	2 ± 0,2	745 ± 4

Notes: t – air temperature; RH – relative humidity; V – air movement speed; AP – atmospheric pressure

The 3RIVE 3D innovative technological system of introducing was used to applicate Brigade 3Rive 3D, SC formulation. The tillers subjected the soil to the simultaneous sowing of corn on an area of 1 ha. The pesticide was used at a consumption rate of 1.2 l/ha; working solution – 2.5-3.0 l/ha. The formulation mixes with water and air to form a voluminous foam into which the seed is placed when sowing in the 3D RIVE RESEARCH MACHINERY applicator without the involvement of a worker, which significantly reduces the risk of contact exposure to skin and mucous membranes. Saving water during processing/sowing is key in 3Rive 3D technology, thanks to which the principle of «fill once – plant all day» is achieved/ There is no need to refill the tank frequently, which again reduces the risk of the worker's skin contamination.

The duration of the operation to prepare the working solution was 7 minutes. Processing time was 30 minutes. The sprayer was refueled by a refueler and a tractor driver, who are licensed to work with pesticides and agrochemicals.

In accordance with the task, the assessment of the dermal effect of pesticides when using the latest application technology was carried out based on the results of determining the content of bifenthrin residual amounts in the following objects:

- washes from the workers' skin surface (face, hands, neck) after finishing treatment;
- 3-layer patches (outer layer – cotton fabric, middle layer – medical gauze, inner – «blue tape» filter), placed in a case with an open surface area of 1 or 0.33 dm², attached to overalls.

Washes from unprotected areas of the skin were carried out immediately after finishing the work on preparing the solution for treatment. For this, gauze napkins moistened with ethyl alcohol in water 1:1 solution were used. The level of contamination of work clothes was assessed using patches.

We also used Brilliant Blue FCF (E133), which has a blue color, to visualize and detect the degree of

contamination of personal protective equipment and skin. The presence of a pesticide solution with Brilliant Blue FCF on patches, gloves and the skin surface by visual inspection, the quantitative determination of the active substances and Brilliant Blue content was carried out by the high-performance liquid chromatography method.

The assessment of the acute toxic effects possibility when working with these pesticides, considering the selectivity of their effect, was carried out according to the methodology proposed by Sergeev S. G. et al. [2]. For this, we used an integral index – the coefficient of action selectivity (CAS), which allows us to quantitatively assess the danger of a pesticide acute effect on the human body.

To evaluate the indices, it was considered that the pesticide has an extremely low selectivity of effect when the value of $CAS < 1$, with CAS from 1 to 99 – low selectivity of effect, and with $CAS > 100$ – sufficient selectivity of effect [1].

To assess the risk of professional contingents' potential exposure to pesticides, in particular dermal ones, a methodology described in [1] was used. For a work shift, the real skin dose (Dsk) should not exceed the allowable skin dose (ADsk). That is, the ratio of the exposure dose to the allowable (hazard ratio) should not exceed 1.0.

At the same time, the sum of the ratios of exposure and allowable doses for different routes of exposure (hazard index) should also not exceed 1.0.

Statistical processing of the results was carried out using a package of licensed statistical programs IBM SPSS Statistics Base v.22 and MS Excel.

RESEARCH RESULTS AND DISCUSSION

During the conducted research, no bifenthrin contamination was found on the open skin of the operator and the tractor driver, who were processing corn crops with the Brigade 3Rive 3D, SC formulation. However, the operator's gloves were found to contain 0.025 mg of bifenthrin. Despite this, workers who worked with the Brigade 3Rive 3D formulation neither experienced deterioration of well-being after the end of work, nor mucous membranes of the eyes and skin irritation. The skin and mucous membranes had the same appearance as during the control examination before the treatment: clean, natural color, no rashes, irritations, pigmentation; employees did not complain about unpleasant sensations, like burning, itching, etc. The obtained data indicate that the personal protective equipment use reliably protects workers from exposure to the pesticide formulation (fig. 1).

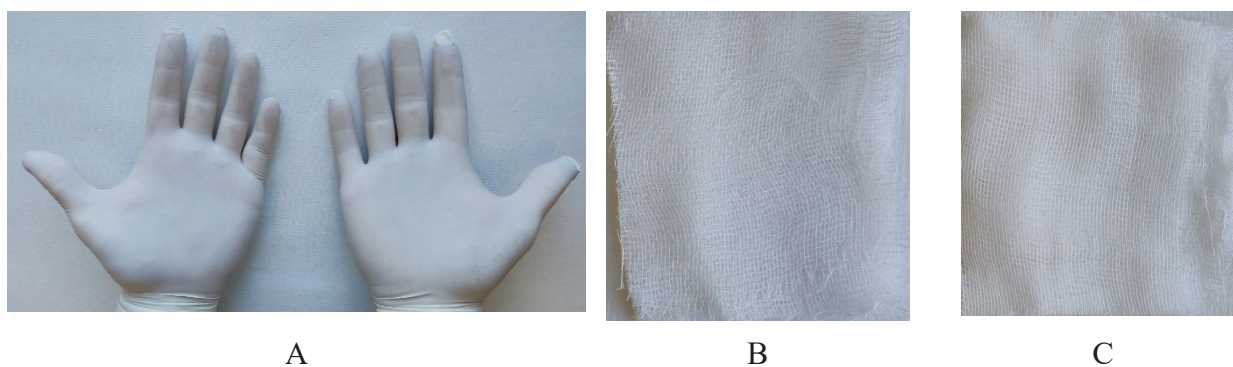


Figure 1. Protective gloves of operator of the 3RIVE 3D application technological system (A), patches from the operator's (B) and tractor driver's (C) special clothing

Calculation of the unitless CASd value on the possibility of skin acute effects when applying the formulation showed that bifenthrin and the Brigade 3Rive 3D, SC formulation based on it are characterized by sufficient selectivity of action on the target object (CASd – 645 and 162, respectively, i.e. > 100) and a low level of danger acute dermal toxic effects for workers, which is due to low values of effective consumption rates.

The Brigade 3Rive 3D, SC formulation and its active substance have a significantly higher CASd than CASing (by 2.2-17.6 times), which indicates a higher probability of acute inhalation poisoning among workers, which is a reason for mandatory control of their use of individual respiratory protective equipment.

To compare the risks arising when working with the studied pesticide, we performed statistical data processing: checking the normality of the distribution in the data series and direct comparison of the obtained risk values (depending on the type of work and the method of crop processing).

Hygienic risk assessment of the pesticide's application by the researched technologies in natural conditions will allow to solve the issue of the conditions of their safe use for workers.

The results of the calculations indicate that the dermal occupational risk when performing the above treatment/application method does not exceed the permissible level (< 1).

The distribution of dermal real risks during the work of workers involved in applying the pesticide together with the grain by the 3Rive3D system differed from the normal at the level of significance $p \leq 0.01-0.03$ ($W=0.737-0.845$).

The distribution of dermal aggravated risks was similar to the distribution of dermal real in the above-mentioned workers: the distribution of indices differed

from the normal one at the level of significance $p \leq 0.01-0.04$ ($W=0.773-0.857$). For comparison, the dermal risk when using a pesticide based on bifenthrin using rod processing is an order of magnitude higher than when using the innovative 3Rive3D technology (fig. 2), which is due to the peculiarity of mixing and applying the formulation without the direct participation of the worker (table 2).

Table 2

Exposure (real) and allowable dermal doses of bifenthrin when applying formulations based on it using different application technologies.

Formulation (a.i.)	Worker	Exposure (real dermal dose) (Dd), $\times 10^{-2}$	Allowable dermal dose (DDd), mg/kg
Treatment using 3Rive3D technology			
Brigade 3Rive3D, SC (bifenthrin)	operator	0.05	0.4
	tractor driver	0.04	
ROD processing using slot sprayers [3]			
Pirynex Super 420, CE (bifenthrin)	operator	0.11	0.4
	tractor driver	0.11	

Note. a.i. – active ingredient

The real dermal risk of bifenthrin exposure when using the it Brigade 3Rive3D, SC formulation was significantly lower compared to the risk of workers involved in «traditional» air treatment and treatment with unmanned aerial vehicles (UAVs) ($p=0.009-0.048$ according to Wilcoxon's *W*-criterion); in comparison with rod and fan processing – it is non-significantly

lower ($p=0.262-1.000$) [1, 4] (fig. 2). There was a similar picture in comparison with the dermal aggravated risk – significantly lower in comparison with the risk of workers involved in «traditional» air treatment and processing with the help of UAVs ($p=0.009$ according to Wilcoxon's *W*-criterion); in comparison with rod and fan treatment – non-significantly lower ($p=0.262-1.000$) [1, 4].

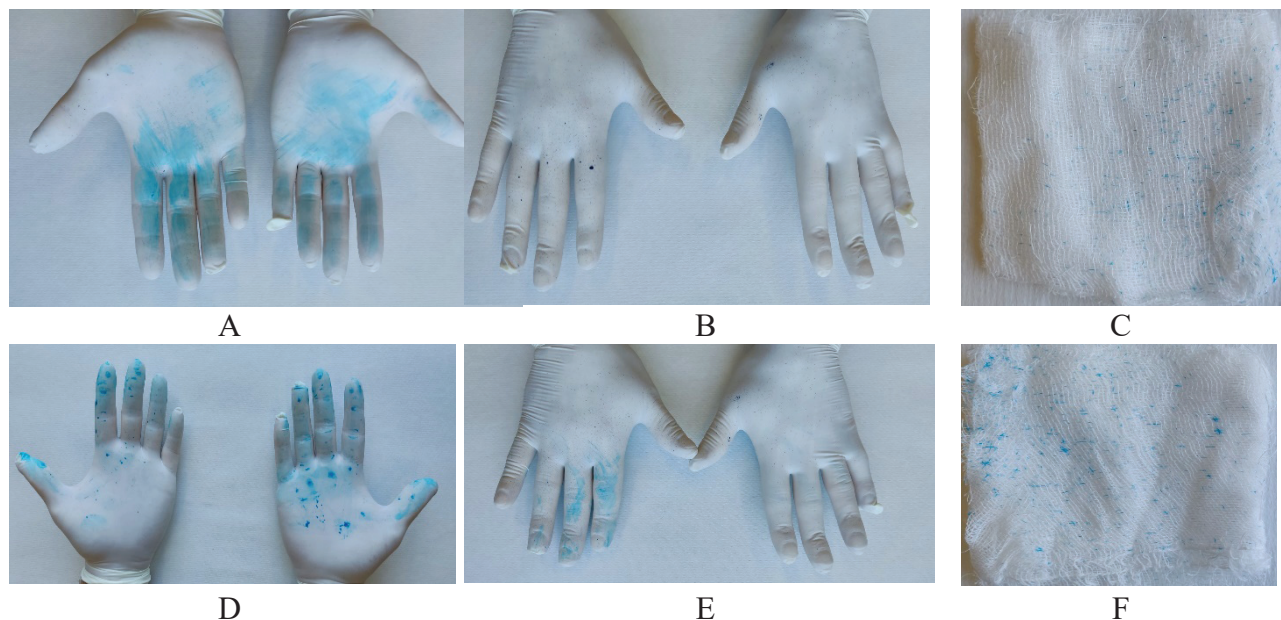


Figure 2. Protective gloves of a sprayer tank operator during rod processing (A), protective gloves of a tractor driver during rod processing (B), patches from the tractor operator's overalls (C), protective gloves of a sprayer tank operator during aviation processing (D), protective gloves of a signalman involved in aviation processing (E), patches from the signalman's protective clothing in aviation processing (F)

It is worth noting that most of the pesticide gets on the protective clothing (and, if safety rules are not followed, potentially on the skin) of the operator, because he is in open contact with the pesticide in a liquid

aggregate state, for which contact with the skin is easiest and penetration is highest. This possibility is eliminated when treat crops with the 3Rive 3D technology, since the pesticide formulation and the working solution are in

closed containers, their mixing occurs automatically in the system without the operator's participation directly before processing.

No significant difference between dermal real and dermal aggravated risk within the limits of one method of pesticide application was found among the studied series ($p > 0.05$ according to Wilcoxon's W -test).

When performing 3Rive3D technology, the distribution of dermal (real, aggravated) risks did not differ from normal at the level of significance $p \geq 0.1$ ($W = 0.861 - 0.902$).

CONCLUSIONS

It was established that the studied active substance bifenthrin and the Brigade 3Rive 3D, SC formulation based on it are characterized by sufficient selectivity of dermal action on the target object and a low probability of acute dermal effects. A higher probability of acute inhalation poisoning than dermal exposure was revealed.

It was established that in real conditions, application pesticides with 3Rive 3D technology in compliance with the recommended agrotechnical and hygienic regulations of safe use, the potential risk of harmful effects on the body of agricultural workers when entering through the skin did not exceed 1 conditional units, and therefore is allowable. No skin reactions or changes in the mucous membranes were detected after the treatments.

It was found that during treatment using 3Rive3D technology, the distribution of dermal (real, aggravated) risk did not differ from normal at the level of significance $p \geq 0.1$ ($W = 0.861 - 0.902$). No significant difference in risks was found between rod treatment (different types of sprayers) and 3Rive3D technology ($p = 0.602 - 1.000$ according to the Wilcoxon W -test), although the dermal

risk for the latter was an order of magnitude smaller. The lowest dermal risk was during on-ground processing.

It is shown that in most cases, the risk of dermal exposure when using 3Rive 3D application technology is significantly lower than when using other methods (significant compared to air and UAV, non-significant – with other on-ground methods). This is due to the peculiarity of the proposed technology itself: the operator and the tractor driver do not have long-term contact with the pesticide, because the mixing of components, the formation of foam and the processing of seeds are carried out automatically in a closed system. In addition, the water saving system allows you not to refill the faucet several times per shift.

Prospects for further research. Further research is planned to be directed to the study of the risk of pollution of environmental objects and the safety of agricultural products when using the 3Rive 3D technology.

FUNDING AND CONFLICT OF INTEREST

There are no potential and obvious conflicts of interest related to the manuscript. The manuscript is a fragment of the department's proactive research topics: «Comparative hygienic assessment and scientific substantiation of approaches to hygienic regulation of innovative technologies for the use of pesticides» (state registration number 0122U000634, 2022-2024).

COMPLIANCE WITH ETHICAL REQUIREMENTS

In conducting the study, the authors adhered to ethical standards in accordance with Ukrainian Health Legislation and the Declaration of Helsinki of 2000, European Community Directive 86/609 On Human Participation in Biomedical Research.

LITERATURE

1. Вивчення, оцінка і зменшення ризику інгаляційного і перкутанного впливу пестицидів на осіб, які працюють з ними або можуть зазнавати впливу під час і після хімічного захисту рослин та інших об'єктів: методичні рекомендації: Наказ МОЗ України від 13.05.2009 р. № 324. URL: https://zakononline.com.ua/documents/show/79319___79319.
2. Сергєєв С. Г., Чайка Ю. Г. Оцінка можливості виникнення гострих токсичних ефектів при роботі з пестицидами з урахуванням їх вибіркової дії. Сучасні проблеми токсикології. 2008. Вип. 4. С. 29-31.
3. Comparative hygienic assessment of the potential diquat hazard to the population when consuming agricultural crops treated with the Reglone Air 200 SL formulation using different application technologies (UAV, aerial, high-clearance rod sprayer treatment) / A. A. Borysenko, A. M. Antonenko, V. D. Aleksiiichuk et al. Wiadomosci Lekarskie. 2023. T. 76. № . 6. С. 1478-1484. <https://doi.org/10.36740/wlek202306122>.
4. Ecological and hygienic assessment and regulation of innovative technology of pesticide application using unmanned aerial vehicles / A. Borysenko, A. Antonenko, S. Omelchuk et al. Rawal Medical Journal. 2022. T. 47. № . 1. С. 213-216.
5. Pesticides and farmers' health: an analysis of variables related to management and property / A. Evaristo,

- D. O. Pedroso, N. L. Rech et al. *Anais da Academia Brasileira de Ciências*. 2022. T. 94. <https://doi.org/10.1590/0001-376520220211335>.
6. Dermal Exposure Associated with Occupational End Use of Pesticides and the Role of Protective Measures / E. MacFarlane, R. Carey, T. Keegel et al. *Safety and health at work*. 2013. № 4(3). P. 136-141. <https://doi.org/10.1016/j.shaw.2013.07.004>.
 7. The Dermatologic Care Needs of a Rural Community in South Florida / S. M. Asbeck, B. U. Imo, O. E. Okobi et al. *International journal of environmental research and public health*. 2023. № 20(4). <https://doi.org/10.3390/ijerph20043071>.
 8. Spiewak R. Pesticides as a cause of occupational skin diseases in farmers. *Annals of agricultural and environmental medicine*. 2001. № 8(1). P. 1-5.
 9. Febriana S. A., Khalidah M., Huda F. N. Prevalence of pesticide related occupational diseases among Indonesian vegetable farmers – A collaborative work. *Toxicology reports*. 2023. № 10. P. 571-579. <https://doi.org/10.1016/j.toxrep.2023.04.016>.
 10. Tarone R. E. On the International Agency for Research on Cancer classification of glyphosate as a probable human carcinogen. *European Journal of Cancer Prevention*. 2018. T. 27. № 1. P. 82-87. <https://doi.org/10.1097/CEJ.0000000000000289>

REFERENCES

1. Вивчення, оцінка і зменшення ризику інгаляційного і перкутанного впливу пестицидів на осіб, які працюють з ними або можуть зазнавати впливу під час і після хімічного захисту рослин та інших об'єктів: методичні рекомендації [Study, assessment and reduction of the risk of inhalation and percutaneous exposure of pesticides to persons who work with them or may be exposed during and after chemical protection of plants and other objects: Methodological recommendations]: Order of the Ministry of Health of Ukraine dated 13.05.2009 № 324. Available from: https://zakononline.com.ua/documents/show/79319__79319.
2. Sergeev, S. G., & Chajka, Ju. G. (2008). Otsinka mozhlivosti vynyknennia hostrykh toksychnykh efektiv pry roboti z pestytsydamy z urakhuvanniam yikh vybirkovosti dii [Assessment of the possibility of acute toxic effects when working with pesticides, taking into account their selectivity of action]. *Modern Problems of Toxicology*, 4, 29-31.
3. Borysenko, A. A., Aleksiichuk, V., Kondratiuk, M., & Pelo, I. (2023). Comparative hygienic assessment of the potential diquat hazard to the population when consuming agricultural crops treated with the Reglone Air 200 SL formulation using different application technologies (UAV, aerial, high-clearance rod sprayer treatment). *Wiadomosci Lekarskie*, 76(6), 1478-1484. <https://doi.org/10.36740/wlek202306122>
4. Borysenko, A., Antonenko, A., Omelchuk, S., Bilous, S., & Melnychuk, F. (2022). Ecological and hygienic assessment and regulation of innovative technology of pesticide application using unmanned aerial vehicles. *Rawal Medical Journal*, 47(1), 213-216.
5. Evaristo, A., Pedroso, D. O., Rech, N. L., Bombardi, L. M., Silva, B. F., Sieglach, A. E., & Agostinotto, L. (2022). Pesticides and farmers' health: an analysis of variables related to management and property. *Anais da Academia Brasileira de Ciências*, 94. <https://doi.org/10.1590/0001-376520220211335>
6. MacFarlane, E., Carey, R., Keegel, T., El-Zaemay, S., & Fritschi, L. (2013). Dermal exposure associated with occupational end use of pesticides and the role of protective measures. *Safety and health at work*, 4(3), 136-141. <https://doi.org/10.1016/j.shaw.2013.07.004>
7. Asbeck, S. M., Imo, B. U., Okobi, O. E., & Dorcé-Medard, J. (2023). The Dermatologic Care Needs of a Rural Community in South Florida. *International Journal of Environmental Research and Public Health*, 20(4). <https://doi.org/10.3390/ijerph20043071>
8. Spiewak, R. (2001). Pesticides as a cause of occupational skin diseases in farmers. *Annals of agricultural and environmental medicine*, 8(1), 1-5.
9. Febriana, S. A., Khalidah, M., Huda, F. N., Sutarni, S., Mahayana, I., Indrastuti, N., & Malueka, R. G. (2023). Prevalence of pesticide related occupational diseases among Indonesian vegetable farmers – A collaborative work. *Toxicology Reports*, 10, 571-579. <https://doi.org/10.1016/j.toxrep.2023.04.016>
10. Tarone, R. E. (2018). On the International Agency for Research on Cancer classification of glyphosate as a probable human carcinogen. *European Journal of Cancer Prevention*, 27(1), 82-87. <https://doi.org/10.1097/CEJ.0000000000000289>

*Резюме***ФОРМУВАННЯ ДЕРМАЛЬНОГО ВПЛИВУ ПЕСТИЦИДІВ НА ПРОФЕСІЙНІ КОНТИНГЕНТИ ПРИ ВИКОРИСТАННІ ІННОВАЦІЙНОЇ ТЕХНОЛОГІЇ 3RIVE 3D****Олена П. Шевченко, Павло В. Бардов, Андрій А. Борисенко, Анна М. Антоненко, Сергій Т. Омельчук, Олександр І. Ковальчук, Олена В. Дема**

Національний медичний університет імені О. О. Богомольця, м. Київ, Україна

Вступ. Шкіра є найбільш уразливим органом під час розпилення пестицидів на полях. Фермери також піддаються впливу пестицидів під час змішування, завантаження пестицидів, а також під час очищення обладнання та утилізації порожніх контейнерів.

Мета. Вивчити та проаналізувати особливості ризику дермального впливу на професійні контингенти пестицидів при проведенні обробок з використанням інноваційної технології внесення пестицидів 3RIVE 3D.

Матеріали та методи. Для внесення препарату Брігейд 3Rive 3D, КС була використана інноваційна технологічна система внесення 3RIVE 3D. Натурні дослідження з вивчення умов праці при застосуванні препарату Брігейд 3Rive 3D, КС проводили у різних ґрунтово-кліматичних областях східної Європи. Статистичну обробку результатів проводили з використанням пакету ліцензійних статистичних програм IBM SPSS StatisticsBase v.22 та MS Excel.

Результати. В ході проведених досліджень не виявлено забруднення біфентрином відкритих шкірних покривів заправника і тракториста, які здійснювали обробку посівів кукурудзи препаратом Брігейд 3Rive 3D, КС. Проте, на рукавичках заправника виявлено вміст біфентрину в кількості 0,025 мг. Розрахунок безрозмірної величини КВДд. по можливості виникнення гострого ефекту при нанесенні препарату на шкіру показав, що біфентрин та препарат Брігейд 3Rive 3D, КС на його основі характеризуються достатньою вибірковістю дії на цільовий об'єкт (КВДд. – 645 та 162 відповідно, тобто > 100) та низьким рівнем небезпеки гострих дермальних токсичних ефектів для робітників, що обумовлено низькими величинами ефективних норм витрат. Дермальний реальний ризик впливу біфентрину при застосуванні препарату на його основі Брігейд 3Rive3D, КС був достовірно нижчим у порівнянні з ризиком у працівників задіяних у «традиційній» авіаобробці та обробці за допомогою БПЛА ($p=0,009-0,048$ за W -критерієм Вілкоксона); у порівнянні із штанговою та вентиляторною обробкою – недостовірно нижчий ($p=0,262-1,000$) [9, 10] (рис. 2). Аналогічна картина була і у порівнянні з дермальним агравованим ризиком – достовірно нижчий у порівнянні з ризиком у працівників задіяних у «традиційній» авіаобробці та обробці за допомогою БПЛА ($p=0,009$ за W -критерієм Вілкоксона); у із штанговою та вентиляторною обробкою – недостовірно нижчий ($p=0,262-1,000$).

Висновки. Встановлено, що в реальних умовах, внесення пестицидів за допомогою 3Rive 3D технології при дотриманні рекомендованих агротехнічних і гігієнічних регламентів безпечного застосування потенційний ризик шкідливого впливу на організм сільськогосподарських працівників при надходженні через шкіру не перевищував 1 у.о., а отже є допустимим. Не виявлено шкірних реакцій та змін слизових оболонок після проведення обробок.

Ключові слова: пестициди, інноваційна технологія застосування, шкіра, токсикологія, професійний ризик