

## 1. Introduction

In the structure of regional and planetary pollutants, pesticides rank in the top ten, and among food contaminants along with heavy metals – the first place in the world [1]. It is known that pesticides and agrochemicals, which belong to the group of biologically active compounds, are one of the important factors influencing the human body by the mechanism of toxic dyshomeostasis. Today, epidemiological and experimental data on the impact of pesticides on the health and morbidity of workers and the population are accumulating, not only as factors that have a pronounced effect, but also as low-intensity factors. The reason for this is the progressive saturation of their production and non-production environment [2, 3].

That is why the aim of the work was a comparative hygienic assessment of working conditions and occupational risk when using pesticides by different methods of application (knapsack, rod, ventilator, unmanned and aviation) on the example of the fungicide Amistar Extra 280 SC.

## 2. Materials and methods

Field studies were conducted in 2018–2021 in the Kyiv region using Amistar Extra 280 SCS (80 g/l of cyproconazole and 200 g/l of azoxystrobin) at the maximum application rate (0.75 l/ha) on soybean. When applying the formulation knapsack sprayer SOLO-10, trailed boom sprayer AMAZON 1201 UF and fan sprayer OPV-2000 combined with a tractor MTZ 82.1 Belarus, unmanned aerial vehicle (UAV) for spraying fields with AgraZ 2 amount, aircraft (equipment with valveless liquid cut-off) were used.

The refueler, tractor driver, signalman, and pilot were dressed in special protective clothing, rubber gloves, and respirators during production operations.

Studies of pesticide content on the skin surface of workers were performed using degreased

## COMPARATIVE HYGIENIC ASSESSMENT OF WORKING CONDITIONS AND POTENTIAL RISKS FOR WORKERS' HEALTH WHEN APPLYING PESTICIDES IN DIFFERENT TECHNICS

*Andrii Borysenko*<sup>1</sup>  
Corresponding author  
andrey-b.07@ukr.net

*Inna Tkachenko*<sup>1</sup>

*Anna Antonenko*<sup>1</sup>

<sup>1</sup>Department of Hygiene and Ecology No. 1  
Bogomolets National Medical University  
13 Tarasa Shevchenko blvd., Kyiv, Ukraine, 01601

**Abstract:** In the structure of regional and planetary pollutants, pesticides are in the top ten, and among food contaminants along with heavy metals – they occupy first place in the world. It is known that pesticides and agrochemicals, which belong to the group of biologically active compounds, are one of the important factors affecting the human body.

**The aim:** comparative hygienic assessment of working conditions and occupational risk when using pesticides by different methods of application (knapsack, rod, ventilator, unmanned and aviation) on the example of the fungicide Amistar Extra 280 SC.

**Materials and methods.** Field studies were conducted in 2018–2021. When applying the formulation knapsack sprayer SOLO-10, trailed boom sprayer AMAZON 1201 UF combined with a tractor MTZ 82.1 Belarus, unmanned aerial vehicle (UAV) for spraying fields AgraZ T16, AN-2 aircraft combined with OZh-2 were used.

**Results.** As a result of field researches of working conditions of employees during the performance of production operations on the pesticides application, it was found that in the air treatment areas and in areas of possible drift the levels of studied active ingredients were below the limit of quantification of the method. The difference between azoxystrobin ( $0.04 \pm 0.003$ ) and cyproconazole ( $12.4 \pm 0.5$ ) for the tank refueler and the UAV external pilot in the field studies is significant according to Student's criterion ( $p > 0.05$ ). For the operator who applied the pesticide with a knapsack sprayer, the values of inhalation risks were significantly higher than for the tankers of the sprayer tank at  $p > 0.05$ . The values of the combined risk when using a fan sprayer ( $0.46 \pm 0.02$ ) significantly exceeded the data obtained when using a rod sprayer ( $0.14 \pm 0.006$ )

**Conclusions.** Analysis of the obtained results showed that the values of the combined risk are significantly higher for the operator/tractor driver, signalman than for their refuelers (at  $p < 0.05$ ). The values of the combined risk of the external pilot were significantly lower than those of the tanker when using a pesticide using a UAV.

**Keywords:** pesticides, production environment, working conditions, occupational risk, fungicides, field studies, air samples, complex risk, inhalation risk, combined risk.

cohol with water (1:1) gauze napkins and stripes (cotton cloth+medical gauze+filter «blue tape») on overalls.

Air samples were taken on a paper filter «blue tape» and silica gel. When performing each production operation at three parallel points, 3 samples were sequentially taken. Quantitative determination of the active ingredients content was performed by high performance liquid and gas-liquid chromatography.

Occupational risk assessment was performed in accordance with the guidelines [4]. Statistical and mathematical data processing (results were processed by methods of variation statistics with calculation of arithmetic mean, variance, standard deviation and error. The significance of the discrepancies (testing the hypothesis of equality of the mean two independent samples) was assessed by Student's t-test or non-parametric criteria in the case of differences in the distribution of law from normal. Statistical processing of the results was performed using the licensed statistical software package IBM SPSS Statistics Base v.22.

## 3. Results

As a result of field studies of working conditions of workers when performing production operations on the pesticides application, it was found that in the air of the treatment area (above the field) after 1 hour, 3 and 7 days with knapsack and UAV, as well as after 3 and 7 days for other types of application were below the limit of quantitative determination of the method in atmospheric air (azoxystrobin  $< 0.001$  mg/m<sup>3</sup>, cyproconazole  $< 0.008$  mg/m<sup>3</sup>). Similarly, in the zone of possible drift at a distance of 10, 100 and 500 m from the edge of the site after 1 hour, 3 and 7 days in knapsack application and by UAV, as well as at a distance of 500 m for other types of application. In other cases, the concentrations of azoxystrobin and cyproconazole at these points ranged

and moistened with ethyl alcohol from 0.001 to 0.25 mg/m<sup>3</sup>. In most cases, small amounts of test

compounds (0.002–0.09 mg/m<sup>3</sup>) were detected in the air of the working zone.

Analysis of calculations for the determination of inhalation (for azoxystrobin (0.12±0.004) and cyproconazole (54.2±1.23)), complex (for azoxystrobin (0.52±0.01) and cyproconazole (58.4±1.8)) and combined (0.59±0.01) risks, showed that they are the highest for the signalman (Table 1). The difference between azoxystrobin (0.04±0.003) and cyproconazole (12.4±0.5) for the tank refueler and the UAV external pilot in the field studies is statistical significant ( $p>0.05$ ). For the operator who applied the pesticide with a knapsack sprayer, tractor drivers during rod and fan application the values of inhalation risks were significantly higher than for the tankers of the sprayer tank at  $p>0.05$  (Table 1). The calculated percutaneous risk of the drone tank refueler is also significantly higher for cyproconazole. Significantly higher levels of inhalation and percutaneous risks for the tanker of the UAV sprayer tank caused a significant difference between the complex (azoxystrobin and cyproconazole) and combined risks. The combined risk values of the UAV refueler (0.15±0.004) significantly exceeded the data obtained for the external pilot (0.009±0.003) (Table 1).

When assessing the complex risk for tractor drivers with rod and fan application, a statistically significant difference was found for azoxystrobin and cyproconazole ( $p=0.001$ ). The share of percutaneous risk in rod and ventilator application was lower for all active substances than the share of inhalation risk. The values of the combined risk when using a fan sprayer (0.46±0.02) significantly exceeded the data obtained when using a rod sprayer (0.14±0.006) (Table 1).

#### 4. Discussion

Significantly lower risks of adverse environmental effects on the health of sprayer tank refuelers than operator / tractor driver, aircraft pilot and signalman should be noted. Moreover that inhalation, percutaneous, complex and combined risks are significantly higher only in the drone tanker refueler compared to the data for the external pilot when applying the pesticide from the air. This can be explained by the less productive operating time of the UAV pilot (28–30 minutes) than the time to refuel the drone sprayer (42–45 minutes) in the studied technology of pesticide application. Also, this technology separates the person applying the pesticide (external pilot) from direct contact with the spray, and as a result exponentially reduces the risks to a level no more than that of an outside observer, about 2–3 orders of magnitude less [5].

Comparing the working conditions of the UAV tanker and the knapsack sprayer tanker, we can state the absence of significant differences. The advantage of using rod and fan spraying is a one-time filling of the sprayer tank and the presence of an automated system for mixing the working solution.

The obtained results of the analysis of the drift zone air, selected by the aspiration method, indicate that the drift of the pesticide did not exceed 500 m during ventilator and aviation application of the formulation. The drift zone of pesticide up to 1 % of the total amount when applied with a UAV and a knapsack sprayer decreased from the edge of the field by a distance of up to 10 m in the wind. This correlates with [6]. But, in our opinion, the potential drift is higher when using a UAV than a knapsack sprayer, due to the operation of the drone rotors, which create vortices of air flow, thereby enhancing the drift potential.

Table 1

Values of potential risk of dangerous influence of the Amistar Extra 280 SC formulation when applied by different methods of application

Method of application	Active ingredient	Risk values															
		Inhalation, ×10 <sup>-2</sup>				Percutaneous, ×10 <sup>-2</sup>				Complex, ×10 <sup>-2</sup>				Combined			
		R	O/T	P	S	R	O/T	P	S	R	O/T	P	S	R	O/T	P	S
Knapsack sprayer	Azoxystrobin	0.03	0.1**	-	-	0.04	0.03	-	-	0.07	0.13**	-	-	0.1	0.12**	-	-
	Cyproconazole	9.4	11.4**	-	-	0.53	0.5	-	-	9.93	11.9**	-	-				
Trailed boom sprayer	Azoxystrobin	0.01	0.04**	-	-	0.04	0.03	-	-	0.05	0.07**	-	-	0.04	0.14**	-	-
	Cyproconazole	3.4	13.6**	-	-	0.53	0.48	-	-	3.93	14.1**	-	-				
Fan sprayer	Azoxystrobin	0.01	0.12**	-	-	0.04	0.03	-	-	0.05	0.16**	-	-	0.04	0.46**	-	-
	Cyproconazole	3.4	46.2**	-	-	0.53	0.48	-	-	3.93	46.72**	-	-				
Unmanned aerial vehicle	Azoxystrobin	0.04*	-	0.02	-	0.18	-	0.17	-	0.22*	-	0.19	-	0.15*	-	0.09	-
	Cyproconazole	12.4*	-	7.08	-	2.73*	-	2.51	-	15.13*	-	9.59	-				
Aircraft	Azoxystrobin	0.04	-	0.1	0.12	0.18	-	0.25	0.4'	0.22	-	0.35	0.52'	0.13	-	0.13	0.59'
	Cyproconazole	10.2	-	9.2	54.2'	2.43	-	2.91	4.2'	12.63	-	12.1	58.4'				

Note: R – refueler; O/T – operator/tractor driver; P – pilot; S – signalman; \* – the risk values of the tank refueler are statistically significantly higher at  $p>0.05$  ( $df=17$ ); \*\* – the risk values of the operator/tractor driver are statistically significantly higher at  $p>0.05$  ( $df=17$ ); ' – the values of the signalman's risk are significantly higher at  $p>0.05$  ( $df=17$ )

According to [7] the sprayer tank refueler has a higher risk of harmful effects than a tractor operator working on a tractor aggregated with a boom sprayer, which does not correlate with the data obtained in our study. We believe that this is primarily due to the duration of work of the tractor driver and refueler during the work shift: the tractor driver has it much higher. There is also a much higher potential for drift of the pesticide during rod and fan treatments compared to knapsack application and UAVs, according to [8] it can reach more than 25 m.

When comparing the technology of application of plant protection products from the air by UAV with the classical aviation method [9], it should be noted that the risks of inhalation and percutaneous effects are higher, because the air of the pilot's breathing zone and the airspace in which the sprayer tank is located are one. According to [10], the drift of the working solution particles is more than 300 m, which is significantly higher than the results obtained by us during unmanned application.

**Limitations of the study.** In accordance with the limitations of this study, the results can be determined as preliminary. For further detailed analysis, we plan to continue this study with a large number of pesticides in different weather conditions (air temperature, humidity, air movement speed).

**Prospects for further research.** It is planned to further study the working conditions of workers and the impact on the environment of pesticides when applied from the air by UAVs. Scientific substantiation of approaches to hygienic regulation of this technology of pesticide application for wide introducing in word agriculture as safer for workers health and environment method.

## 5. Conclusions

The obtained actual data and calculated values of risks for persons involved in the application of Amistar Extra 280 SC from the air, we can say that the safety of the production environment for workers at all technological stages of work is reliably guaranteed subject to compliance the requirements for transportation, storage and use of pesticides in national economy. Statistical analysis of the obtained results showed that the values of the combined risk are significantly higher for the operator/tractor driver, signalman than for their refuelers (at  $p < 0.05$ ). The values of the combined risk of the external pilot were significantly lower than those of the refueler when applying the pesticide using a UAV.

## Conflicts of interest

The authors declare that they have no conflicts of interest.

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