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PROFESSIONAL RISKS FOR AGRICULTURAL PERSONNEL TREATING BERRIES AND MELON CROPS WITH PESTICIDES

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ABSTRACT
The aim: Hygienic assessment of labour conditions and risks for the Ukrainian agricultural personnel treating berries and melon crops with fungicides, herbicides and insecticides for justification of their safe use regulations.
Materials and methods: Natural studies of labour conditions and risk correspond to the acting laws of Ukraine. The results were statistically treated using IBM SPSS StatisticsBase v.22.
Results: The natural studies of fungicides, insecticides, used for treatment of berries and melon crops, show that labour air environment corresponds to hygienic standards. The authors have established that the hazard index of complex fungicides effect on spray fueling attendants and tractor drivers is 0.110±0.046 and 0.155±0.071, that of herbicides – 0.34±0.025 and 0.380±0.257, that of insecticides – 0.221±0.111 and 0.222±0.110, respectively; hazard index of combined effect of several acting substances makes up– 0.239±0.088 and 0.336±0.140 for spray fueling attendants and tractor drivers, respectively. The statistical analysis shows that the hazard coefficients of inhalation and percutaneous penetration do not differ statistically between spray fueling attendants and tractor drivers ($p>0.05$). The percutaneous risk (%) of various pesticide groups for spray fueling attendants ranges 65.74-97.58 %, for tractor drivers – 50.72-95.23 %.
Conclusions: The analysis has shown that the professional risk of fungicides, herbicides, insecticides, during agricultural treatment of the berries and melon crops does not exceed standards.

KEY WORDS: Fungicides, Insecticides, Herbicides, labour conditions

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INTRODUCTION
Pesticide plant treatment is an obligatory condition of today agriculture [1]. Pesticide treatment has been emphasized recently, which is confirmed by the laws and legal acts on their environmentally conscious application. Preliminary analysis of relation between pesticide treatment and personnel health risks is complicated [2]. Pesticides applied within agriculture may lead to acute poisoning, chronic diseases, neurological disorders, cancer, etc [3-5]. So, the issues of environmental protection and personnel chemical safety are relevant. Assessment of labour conditions makes a necessary component of the pesticides' negative effects risk justification [6].

THE AIM
Hygienic assessment of labour conditions and risks for the personnel dealing with fungicides Kitch, Trinol, Switch, Signum, Sercadis Plus, and Ridomil Gold; herbicides Stomp Aqua, and Herbolex; insecticides Protect, and Vertimek, regarding safe treatment of berries and melon crops in agriculture of Ukraine, and justification of their safe use regulations.

MATERIALS AND METHODS
The authors studied natural labour conditions of the personnel, treating the berries and melon crops with pesticides. The pesticides treatment conditions are represented in table I. The authors hygienically assessed labour conditions and professional risk of the preparations, according to the acting laws of Ukraine [7]. During the treatment manipulations, all personnel were wearing special clothes: synthetic overalls and shoes, rubber gloves and respirators. All personnel were trained and permitted to deal with pesticides and agricultural chemical items. Before and after pesticide treatment procedure, we examined the personnel: measured arterial pressure, pulse, assessed skin condition, noted their general complaints. The climate conditions during pesticide treatment (table II) corresponded to standards [8].

We assessed labour conditions of tractor drivers and pesticide spray filling attendants, treating berries and melon crops with pesticides, by the acting substances content in

Table I. Conditions of pesticide treatment of berries and melon crops in agriculture of Ukraine

Preparation name	Acting substances	Berry/melon crop	Preparation use standards, kg(l)/ha	Liquid use standards, l/ha	Facilities
			Fungicides		
Kitch	Fludioxonil Cyprodinil	strawberry blueberry raspberry blackberry	1,0	300	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Trinol	Fenhexamid	strawberry	1,5	300	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Switch	Fludioxonil Cyprodinil	blueberry	1,0	250	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Signum	Boskalid Piraclostrobin	strawberry	1,5	1000	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Sercadis Plus	Difenoconazole Fluxapyroxad	watermelon	1,2	300	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Ridomil Gold	Metalaxyl-M Copper chloride oxide	watermelon	5,0	250	Calibrated sprayer "OPSH 400", tractor DongFang
			Herbicides		
Stomp Aqua	Pendimethalin	strawberry	3,5	300	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Herbolex	Glyphosate	melon	8,0	300	Calibrated sprayer "OPSH-500", tractor MTZ-82
			Insecticides		
Protect	Spirodiclophen	strawberry	0,6	200	Calibrated sprayer "OPSH-2000", tractor MTZ-82
Vertimek	Abamectin	strawberry	1,0	300	Calibrated sprayer "OPSH-2000", tractor MTZ-82

Table II. Climate conditions during pesticide treatment of berries and melon crops (M±m, n=3)

Preparation	Air temperature, °C	Atmospheric pressure, mm Hg	Relative humidity, %	Air movement speed, m/sec
		Fungicides		
Kitch	16±1	764±5	70±5	1,5±0,1
Trinol	20±2	760±7	40±1	2,0±0,4
Switch	20±1	740±4	60±4	1,5±0,2
Signum	17±1	745±3	55±2	1,5±0,1
Sercadis Plus	25±2	740±5	60±5	1,5±0,3
Ridomil Gold	20±1	760±4	60±5	1,0±0,1
		Herbicides		
Stomp Aqua	25±3	750±5	59±2	1,0±0,2
Herbolex	23±1	750±4	75±4	1,0±0,1
		Insecticides		
Protect	23±2	745±5	41±2	2,0±0,4
Vertimek	22±1	743±2	75±4	2,0±0,1

Notes: 1. M – mean average; 2. m – mean average accuracy; 3. n – number of parallel trials.

labour environment, atmospheric air (in the area of possible preparation dissemination), in washouts from open and covered skin, and in clothes stripes. The absorbing surface represented with three-layer applicators (upper layer – cotton tissue, middle – medical gauze, internal one – "blue filter"), 1 dm^2. Air sampling, preparation and chromatography analysis of samples corresponded to the guides in table III.

To determine exposition inhalation substance dose, we simultaneously collected 2 parallel samples. The study established no penetration of active substances into the respiratory organs of calibrated spraying and filling attendants during preparation of working solution and filling the spray.

Table III. Hygienic standards and margins of acting substances in labour environment air, atmospheric air, soil, washouts from skin and clothes stripes

Acting substance	Study object									
	Working environment air			Atmospheric air			Soil			Washouts, stripes
	TSEL, mg/m³	№ Guid	LOQ, mg/kg³	TSEL, mg/m³	№ Guid	LOQ, mg/m³	TAC, mg/kg	№ Guid	LOQ, mg/kg	LOQ,mg
Fungicides										
Cyprodinil	0.1	82-97	0.02	0.05	82-97	0.02	0.2	65-97	0.05	0.002
Fludioxonil	1.0	48-97	0.1	0.002	430-2003	0.0016	0.2	31-97	0.2	0.002
Fenhexamid	2.0	605-2005	0.2	0.005	605-2005	0.004	0.65	604-2005	0.1	0.002
Difenoconazole	0.2	294-2001	0.1	0.001	294-2001	0.0008	0.3	6147-91	0.02	0.002
Boskalid	1.5	484-2004	0.5	0.01	484-2004	0.008	0.4	453-2003	0.1	0.002
Piraclostrobin	1.0	484-2004	0.5	0.01	484-2004	0.008	0.6	453-2003	0.1	0.002
Metalaxyl-M	0.5	138-99	0.25	0.01	138-99	0.008	0.05	206-2000	0.05	0.002
Fluxapyroxad	0.7	1208-2012	0.25	0.01	1208-2012	0.008	0.3	1238-2013	0.1	0.002
Copper chloride oxide	0.5	4823-88	0.004	0.003	3865-85	0.001	3.0	4770.6:2007	0.1	0.0003
Herbicides										
Pendimethalin	0.5	2781-83	0.025	0.002	562-2005	0.0013	0.2	139-99	0.01	0.002
Glyphosate	1.0	4379-87	0.25	0.01	4379-87	0.001	0.5	4363-87	0.07	0.001
Insecticides										
Spirodiclophen	0.2	970-2009	0.01	0.0007	970-2009	0.00056	0.4	1023-2010	0.02	0.001
Abamectin	0.04	1106-2011	0.001	0.0002	1106-2011	0.00016	0.3	1108-2011	0.01	0.00005

Notes: 1. Guid – Guidelines; 2. LOQ – limit of quantification; 3. TSEL – Tentatively safe exposure levels; 4. TAC – Tentatively allowable concentration.

Table IV. Air content of fungicides during agricultural treatment of berries and melon crops (M±m, n=6)

Preparation	Acting substance	Air within respiration environment, mg/m³		Air above the processed environment (field center), mg/m³, after				Possible disseminated area, 300m from the field borders (side affected by wind), mg/m³, after			
		At	T	1 hour	3 hours	3 days	7 days	1 hour	3 hour	3 days	7 days
Fungicides											
Kitch	Fludioxonil	<0.1*	<0.1*	<0.1*	-	<0.1*	<0.1*	<0.016*	-	<0.016*	<0.016*
	Cyprodinil	<0.02*	<0.02*	<0.02*	-	<0.02*	<0.02*	<0.02*	-	<0.02*	<0.02*
Trinol	Fenhexamid	<0.2*	<0.2*	<0.2*	-	<0.2*	<0.2*	<0.004*	-	<0.004*	<0.004*
Switch	Cyprodinil	<0.02*	<0.02*	<0.02*	<0.02*	<0.02*	<0.02*	<0.02*	<0.02*	<0.02*	<0.02*
	Fludioxonil	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.016*	-	<0.016*	<0.016*
Signum	Boskalid	<0.5*	<0.5*	<0.5*	<0.5*	<0.5*	<0.5*	<0.008*	-	<0.008*	<0.008*
	Piraclostrobin	<0.5*	<0.5*	<0.5*	<0.5*	<0.5*	<0.5*	<0.008*	-	<0.008*	<0.008*
Sercadis Plus	Difenoconazole	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.0008*	<0.0008*	<0.0008*	<0.0008*
	Fluxapyroxad	<0.25*	<0.25*	<0.25*	<0.25*	<0.25*	<0.25*	<0.008*	<0.008*	<0.008*	<0.008*
Ridomil Gold	Metalaxyl-M	<0.25*	<0.25*	<0.25*	-	<0.25*	<0.25*	<0.008*	-	<0.008*	<0.008*
	Copper	<0.004*	<0.004*	<0.004*	-	<0.004*	<0.004*	<0.001*	-	<0.001*	<0.001*
Herbicides											
Stomp Aqua	Pendimethalin	<0.025*	<0.025*	<0.025*	<0.025*	<0.025*	<0.025*	<0.0013*	<0.0013*	<0.0013*	<0.0013*
Herbolex	Glyphosate	<0.25*	<0.25*	<0.25*	<0.25*	<0.25*	<0.25*	<0.001*	-	<0.001*	<0.001*
Insecticides											
Protect	Spirodiclophen	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.00056*	-	<0.00056*	<0.00056*
Vertimek	Abamectin	<0.001*	<0.001*	<0.001*	-	<0.001*	<0.001*	<0.00016*	-	<0.00016*	<0.00016*

Notes: 1. – At.– Pesticide Filling Attendant; 2. T – tractor driver; 3. «*» - below the limit of quantification (tab. 3); 4. «-» - the study was not held; 5. M – mean average; 6. m – mean average accuracy; 7. n – number of parallel trials.

Table V. Potential risk of hazard effect of fungicides for agricultural personnel treating berries and melon crops

Preparation	Acting substance	Hazard coefficients				Hazard indices				Percutaneous risk, %	
		percutaneous		inhalation		complex		combined			
		At*	T	At**	T	At***	T	At/	T	At//	T
Kitch	Fludioxonil	0.043	0.042	0.026	0.051	0.068	0.093	0.122	0.173	62.56	45.398
	Cyprodinil	0.029	0.028	0.026	0.051	0.054	0.079			53.020	35.662
Trinol	Fenhexamid	0.005	0.005	0.013	0.026	0.018	0.030	-	-	27.285	15.595
Switch	Cyprodinil	0.040	0.028	0.026	0.051	0.066	0.079	0.124	0.138	61.249	35.662
	Fludioxonil	0.057	0.057	0.001	0.003	0.059	0.059			97.827	95.684
Signum	Boskalid	0.016	0.016	0.002	0.007	0.018	0.023	0.046	0.056	90.604	70.045
	Piraclostrobin	0.026	0.026	0.001	0.005	0.028	0.033			95.400	84.716
Sercadis Plus	Difenoconazole	0.320	0.318	0.045	0.096	0.364	0.414	0.429	0.514	87.750	76.882
	Fluxapyroxad	0.032	0.032	0.032	0.068	0.064	0.100			50.466	31.769
Ridomil Gold	Metalaxyl-M	0.142	0.141	0.319	0.638	0.461	0.779	0.476	0.799	30.830	18.148
	Copper	0.010	0.010	0.005	0.010	0.015	0.020			66.151	48.330
Risk values, M±m		0.065± 0.028	0.064 ± 0.028	0.045 ± 0.028	0.091± 0.055	0.110± 0.046	0.155± 0.071	0.239± 0.088	0.336± 0.140	65.741± 7.468	50.717± 8.189

Notes : 1. At – spray fueling attendant; 2. T – tractor driver; 3. * – no reliable difference between hazard coefficients of percutaneous effect for spray fueling attendants and tractor drivers by Student test, p>0.05 (df=20); t= 0.040; 4. ** – no reliable difference between hazard coefficients of inhalation effect foron spray fueling attendants and tractor drivers by Student test, p>0.05 (df=20); t= -0.750 ; 5. *** – no reliable difference between hazard coefficients of complex effect for spray fueling attendants and tractor drivers by Student test, p>0.05 (df=20); t= -0.533; 6. / – no reliable difference between hazard coefficients of complex effect for spray fueling attendants and tractor drivers by Student test, p>0.05 (df=8); t= -0.584; 7. // – no reliable difference between percutaneous risk for spray fueling assistants and tractor drivers by Student test, p>0.05 (df=20); t= 1.356.

Table VI. Potential risk of hazard effect of herbicides for agricultural personnel treating berries and melon crops

Preparation	Acting substance	Hazard coefficients				Hazard indices		Percutaneous risk, %	
		Percutaneous		Inhalation		total			
		At*	T	At**	T	At***	T	At/	T
Herbicides									
Stomp Aqua	Pendimethalin	0.362	0.110	0.006	0.013	0.369	0.123	98.271	89.599
Herbolex	Glyphosate	0.128	0.127	0.191	0.510	0.319	0.637	40.068	19.963
Risk values, M±m		0.245 ±0.117	0.11 ±0.009	0.09 ±0.093	0.262 ±0.249	0.34 ±0.025	0.380 ±0.257	69.17 ±29.102	54.781 ±34.818
Insecticides									
Protect	Spirodiclophenv	0.325	0.318	0.006	0.013	0.331	0.331	98.074	96.145
Vertimek	Abamectin	0.107	0.106	0.003	0.006	0.110	0.112	97.095	94.327
Risk values, M±m		0.216 ±0.109	0.212 ±0.106	0.005 ±0.002	0.010 ±0.004	0.221 ±0.111	0.222 ±0.110	97.58 ±0.490	95.23 ±0.909

Notes : 1. At – spray fueling attendant; 2. T – tractor driver; 3. * – no reliable difference between hazard coefficients of percutaneous effect for spray fuel attendants and tractor drivers by Student test, p>0.05 (df=6); t= 0.78; 4. ** – no reliable difference between hazard coefficients of inhalation effect for spray fuel attendants and tractor drivers by Student test, p>0.05 (df=6); t= -0.63 ; 5. *** – no reliable difference between hazard coefficients of complex effect for spray fuel attendants and tractor drivers by Student test, p>0.05 (df=6); t= -0.135; 6. / – no reliable difference between percutaneous risk for spray fuel attendants and tractor drivers by Student test, p>0.05 (df=6); t= 0.36.

The variance analysis and comparison of mean variables was performed by parametric and non-parametric tests, using software IBM SPSS StatisticsBase v.22 та MS Excel.

RESULTS

Natural studies of labour conditions of tractor drivers and spray filling attendants during pesticide treatment of berries and melon crops showed that the acting substances content in the air above the treated area and area of possible dissemination was less than the quantitative margin value (table IV), and approved levels of pesticides in labour environment and atmospheric air (table III).

During and after manipulations, the personnel had no health problems, with arterial pressure within standards. and no changes of skin and eye mucosa.

The authors observed no face, neck, and hand open skin contamination in the respondents during calibrated spraying (below quantitative margin (table III)), as the skin surface of the personnel was permanently protected with special clothes, and gloves during all manipulations.

The washouts from skin under special clothes showed no studied substances. The washouts from the gloves of spray filling attendants preparing the solution contained: cyprodinil (Kitch) - 0.0035 mg, fenhexamide – 0.003 mg, cyprodinil (Switch) – 0.0045 mg, fludioxonil – 0.003 mg, boskalid – 0.006 mg, pyraclostrobin – 0.002 mg, fluxapyroxad – 0.0041 mg, copper – 0.0013 mg, pendimethalin – 0.009 mg, spirodiclophen – 0.002 mg. The content of fungicides, herbicides, and insecticides in clothes stripes of calibrated spraying personnel was below the limit of quantification.

The hazard inhalation effect coefficients of fungicides were (0.045±0.028) and (0.045±0,028), herbicides – (0.09±0.093) and (0.262±0.249), and insecticides – (0.005±0.002) and (0.010±0.004), for the spray fueling attendants and tractor drivers respectively. The hazard percutaneous effect coefficients of fungicides were (0.065±0.028) and (0.064±0.028), herbicides – (0.245±0.117) and (0,11± 0.009), insecticides – (0.216±0.109) and (0.212±0.106), for the spray fueling attendants and tractor drivers respectively. No reliable difference was found for the hazard inhalation effect and hazard percutaneous effect coefficients of the spray fueling attendant and tractor drivers ($p>0.05$) (table V – VI).

Pesticides percutaneous risk (%) for spray fueling attendants ranged 65.74-97.58 %, for tractor drivers – 50.72-95.23 %.

The combined fungicide inhalation and percutaneous penetration during agricultural calibrated spraying occurs within the permitted hazard index of complex (simultaneous action of acting substance with different ways of penetration) and combined (simultaneous action of several active substances) effect (<1). The analysis shows no reliable difference between inhalation and percutaneous effect hazard coefficients for spray fueling attendants and tractor drivers ($p>0,05$).

Similar results were obtained before, during natural studies of pesticides used to treat strawberries, which established that the combined hazard for the personnel is 0.45, and it does not exceed the margin [9]. For pesticides used to treat potatoes, the percutaneous risk was 56.3±7.3 % for spray fueling attendants, and 43.9±7.3 % for tractor drivers. The hazard indices of complex and combined effect were within the standards [10].

The studies of professional risk of new agricultural treatment methods revealed that the combined risk values are reliably higher for tractor drivers than for spray fueling attendants. The values of the combined risk of the pilot were significantly lower than operator of nmanned aerial vehicle. The combined risk for all professional groups during various operations did not exceed the standard, making up approximately 0.46±0.02 [11].

It was established that the hazard coefficient ranged from 0.5×10^{-4} to 10.0×10^{-4} during inhalation exposure on workers of insecticide Oberon Rapid, which includes two active substances spiromesifen and abamectin for garden crops treatment. Inhalation hazard coefficient was for ten times higher than percutaneous exposure, which was 0.04×10^{-4}– 1.5×10^{-4}. The combined risk was less than allowable (less than 1) to 7.8×10^{-4} for the operator and for the tractor driver – 11.1×0^{-4} [12].

It was shown according to the results of research carried out during treatment oil crops in the agro-industrial sector with the fungicides Akanto, Retengo, Amistar Gold, the indices of the harmful effects of active substances of picoxystrobin, pyraclostrobin, azoxystrobin, and difenoconazole in the case of complex intake by inhalation and dermal exposure under the conditions of ground and aviation processing are less 1 [13].

In the given literature emphasizes the use of personal protective equipment during working with pesticides. The use of personal protective equipment during working with pesticides is the most effective preventive measure [9-13].

The experience of many countries has shown that prevention of health risks for worker's health caused by pesticides is technically feasible and economically beneficial for individuals and society as a whole. Proper risk assessment and management of pesticide use is an important component of prevention of occupational poisoning and diseases [14].

In addition, the use of appropriate and well-maintained spraying equipment, with taking all necessary ruelses of using at all stages of treatment of plants by pesticides, can minimize human exposure to pesticides and their potential negative impact on the environment [15].

DISCUSSION

The results evidence about necessity of individual protection during treatment of berries and melon crops with pesticides.

CONCLUSIONS

1. The article shows that treatment of berries and melon crops with different pesticides is not associated

with exceeded hygienic standards, if agrotechnical and hygienic standards are kept.
2. The authors have established that hazard index of complex effect of fungicides on spray fueling attendants and tractor drivers is respectively 0.110±0.046 and 0.155±0.071, that of herbicides – 0.34±0.025 and 0.380±0.257, that of insecticides – 0.221±0.111 and 0.222±0.110; hazard index of combined effect of several acting substances is 0.239±0.088 and 0.336±0.140. The authors have proven, that the professional risk of chemicals does not exceed the standards.
3. Statistical analysis shows, that the hazard coefficients of inhalation and percutaneous penetration do not differ statistically between spray fueling attendants and tractor drivers, by Student test ($p>0,05$). The percutaneous risk of various pesticides for spray fuel attendants ranges within 65.74-97.58 %, tractor drivers – 50.72-95.23 %.
4. Obtained results will be useful for prediction of hazards during treatment of other agricultural plants with the studied pesticide groups and classes, and further monitoring is recommended.

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