

Comparative hygienic assessment of working conditions and occupational risk in the application of pesticides (on the example of fungicide Amistar Extra 280, SC) using different types of sprayers

Type

Original paper

Keywords

injector nozzle, type of spraying, complex, combined occupational risk

Abstract

Aim

Comparative hygienic assessment of working conditions and occupational risk in the application of fungicide Amistar Extra 280, SC using slotted and injector sprayers.

Material and methods

Sprayers Super Poly 110-04 (variant №1) and Guardian Air GA110-04 (variant № 2), and certified equipment were used. The occupational risk was assessed in accordance with the methodological recommendations proposed by the L.I. Medvedia Scientific Center for Preventive Toxicology, Food and Chemical Safety specialists.

Results

When using the slotted sprayer Super Poly 110-04 in the air of the working zone of the tractor driver the content of azoxystrobin was 0.0015 mg/m³, cyproconazole – 0.085 mg/m³, at a distance of 10 m from the edge of the field on the leeward side – 0.003 and 0.11 mg/m³, respectively. Visual analysis of water-sensitive cards after using slotted sprayers showed the presence of single drops of pesticide working solution in the wear zone.

When applying the pesticide using a Guardian Air GA110-04 injector sprayer in the air of the working zone of the tractor driver, areas of possible wear, the concentration of azoxystrobin and cyproconazole was below the limit of quantification of the method.

When assessing the complex risk for tractor drivers, a statistically significant difference was found for azoxystrobin ($p = 0.002$) and cyproconazole ($p = 0.001$) when using a variant №1 and variant №2.

Conclusions

Values of the combined complex risk of application of the Amistar Extra 280, SC formulation for tractor drivers of variant №2 application were significantly lower than those for tractor drivers of variant №1.

1 **COMPARATIVE HYGIENIC ASSESSMENT OF WORKING**
2 **CONDITIONS AND OCCUPATIONAL RISK IN THE APPLICATION OF**
3 **PESTICIDES (ON THE EXAMPLE OF FUNGICIDE AMISTAR EXTRA**
4 **280, SC) USING DIFFERENT TYPES OF SPRAYERS**

5 **Abstract.**

6 **The aim** was a comparative hygienic assessment of working conditions
7 and occupational risk in the application of fungicide Amistar Extra 280, SC
8 using slotted and injector sprayers.

9 **Materials and methods.** Sprayers Super Poly 110-04 (variant №1) and
10 Guardian Air GA110-04 (variant № 2), and certified equipment were used. The
11 occupational risk was assessed in accordance with the methodological
12 recommendations proposed by the L.I. Medvedia Scientific Center for
13 Preventive Toxicology, Food and Chemical Safety specialists.

14 **Results.** When using the slotted sprayer Super Poly 110-04 in the air of
15 the working zone of the tractor driver the content of azoxystrobin was
16 0.0015 mg/m³, cyproconazole – 0.085 mg/m³, at a distance of 10 m from the
17 edge of the field on the leeward side – 0.003 and 0.11 mg/m³, respectively.
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19 presence of single drops of pesticide working solution in the wear zone.

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22 wear, the concentration of azoxystrobin and cyproconazole was below the limit
23 of quantification of the method.

24 When assessing the complex risk for tractor drivers, a statistically
25 significant difference was found for azoxystrobin ($p = 0.002$) and cyproconazole
26 ($p = 0.001$) when using a variant №1 and variant №2.

27 **Conclusion.** Values of the combined complex risk of application of the
28 Amistar Extra 280, SC formulation for tractor drivers of variant №2 application
29 were significantly lower than those for tractor drivers of variant №1.

30 **Key words:** injector nozzle, type of spraying, complex, combined
31 occupational risk.

32 **Introduction.** According to the International Labor Organization [1],
33 agriculture is among the most dangerous to life and health of workers in both
34 industrialized and developing countries. Agriculture employs almost half of the
35 world's workforce (1.3 billion people), killing up to 170,000 agricultural
36 workers each year as a result of accidents, injuries related to agricultural
37 machinery, poisoning by pesticides and other chemicals [2].

38 Improving chemical plant protection products (ChPPPs), applied
39 technologies and the integration of chemical, physical and biological knowledge
40 will truly optimize the use of pesticides without compromising the quality and
41 efficiency of agriculture or consumer and environmental protection [3].

42 The Directive [4], which regulates the actions of citizens to ensure the
43 sustainable and safe pesticides application, amended the safety requirements for
44 pesticide application machines. Particular attention is paid to assessing the risk
45 of using pesticide application machines, ensuring maximum deposition of
46 pesticides on target sites and minimizing losses in non-target areas, which will
47 ensure a high level of protection of human health and safety and the
48 environment.

49 The sprayer (nozzle) is a key element of the sprayer and the efficiency of
50 processing, economic, operational, hygienic and ecological indicators depend on
51 it. Properly selected nozzles and conditions for pesticide application ensure
52 efficient distribution of the working solution on the target surfaces [5], which
53 reduces the risk of impact on the ecosystem and workers involved in the
54 treatments.

55 Currently, hydraulic injectors are increasingly used, which, according to
56 manufacturers [6, 7] and literature sources [3, 8] have a number of significant
57 advantages in the effectiveness of ChPPPs application, economic and hygienic
58 aspects.

59 Therefore, **the aim** of our work was a comparative hygienic assessment of
60 working conditions and occupational risk when applying the fungicide Amistar
61 Extra 280 SC using slotted and injector sprays.

62 **Materials and methods.** Field studies were conducted in 2020 on the
63 basis of Bila Tserkva research station LLC “Syngenta” in the Kiev region using
64 the Amistar Extra 280, SC (80 g/l of cyproconazole and 200 g/l of azoxystrobin)
65 in the maximum application rate of the formulation (0.75 l/ha), working solution
66 – 250 l/ha on soybean crops. When applying the formulation certified equipment
67 was used (trailed boom sprayer AMAZON 1201 UF (1200 l), which was
68 combined with a tractor MTZ 82.1 Belarus). Super Poly 110-04 (variant №1)
69 and Guardian Air GA110-04 (variant № 2) sprays were selected for comparative
70 studies. The first of them is a universal slotted sprayer of a wide range, which
71 performs disintegration of the working solution; the second is an air-injector
72 sprayer, which due to its structure performs air ejection, mixing with liquid and
73 spraying drops with air inclusions.

74 The refueler carried out preparation of the formulations’ working solution,
75 the duration of the operation was 7-10 minutes. The soybean crops were
76 processed by a tractor driver for 20 minutes. The refueler and the tractor driver
77 were dressed in special protective clothing during the production operations:
78 overalls made of synthetic fabric and boots. Rubber gloves and respirators were
79 used as personal protective equipment.

80 Air sampling was performed using a portable aspirator “Typhoon”. Air
81 samples were taken on a paper filter “blue tape” and silica gel. When performing
82 each production operation at three parallel points, 3 samples were taken
83 sequentially. Cards, made of water-sensitive paper TeeJet 20301-1N

(76 mm×26 mm), were installed at a height of 0.5 m on an artificial support for visual assessment of the presence and density of working solution drops in a possible wear zone (10 m on the leeward side of the field). Evaluation of the result was performed by counting through a magnifying glass the number of drops on the cards that were used during the slotted and injection application of the pesticide. In each variant of the field study, 10 water-sensitive cards with their obligatory numbering were used.

Studies of the pesticides content on the skin surface of the workers were performed after the operation with degreased and soaked in ethyl alcohol diluted in water in a ratio of 1: 1, gauze napkins and stripes (3-layer stripes: outer layer – cotton fabric, middle layer – medical gauze, internal – the filter “blue tape”) on overalls.

Sampling and quantification of the active substances content in the air of the working area, atmospheric air, in washes from exposed skin and gloves, stripes on overalls were performed by high performance liquid and gas-liquid chromatography. Methods, limits of quantitative determination and hygienic standards of the investigated active substances are given in Table I.

Occupational risk assessment was performed in accordance with the guidelines [9]. Because Amistar Extra 280, SC is a combined pesticide, the simultaneous action of two active substances is possible. Therefore, to assess, we calculated the magnitude of occupational risk in the combined exposure of both active substances in one formulation. The combined risk (CR) was determined by simply summing the risk values of several active substances in a complex intake:

$$CR = \sum_{i=1}^n \left(\frac{D_{i,ing.}}{PD_{i,ing.}} \right) + \sum_{i=1}^n \left(\frac{D_{i,derm.}}{PD_{i,derm.}} \right),$$

where CR – combined risk;

1,2, ... n – studied active substances;

D_{ing} – a dose of pesticide that enters the worker’s body by inhalation;

112 D_{derm} – the dose of pesticide that enters the worker's body through the
113 skin;

114 PD_{ing} – permissible inhalation dose for professional contingents;

115 PD_{derm} – permissible percutaneous dose for professional contingents.

116 Statistical processing of the results was performed using the licensed
117 statistical software package IBM SPSS Statistics Base v.22.

118 **Results.** As a result of field studies of working conditions during pesticide
119 application operations, it was found that the concentration of azoxystrobin and
120 cyproconazole in the air of the refueler's working zone and the zone of possible
121 wear in all variants of experiments was below the limit of quantitative
122 determination of the method (Table I).

123 When using the slotted sprayer Super Poly 110-04 (variant №1) in the air
124 of the tractor driver's working area the content of azoxystrobin was
125 $0.0015 \pm 0.0001 \text{ mg/m}^3$, cyproconazole – $0.085 \pm 0.002 \text{ mg/m}^3$. We also analyzed
126 the content of active substances of the Amistar Extra 280, SC formulation at a
127 distance of 10 m from the edge of the field on the leeward side. The
128 concentration of azoxystrobin in the wear zone when applying the formulation
129 using Super Poly 110-04 was $0.003 \pm 0.001 \text{ mg/m}^3$, cyproconazole – 0.11 ± 0.02
130 mg/m^3 . In the air of the treatment zone (above the field) after 1 hour, 3 days, 7
131 days and the zone of possible wear at a distance of 100 m from the edge of the
132 site after 1 hour, 3 days, 7 days the concentrations of active substances was
133 below the limit of quantification in atmospheric air.

134 When applying the pesticide using the injector spray Guardian Air
135 GA110-04 (variant №2) in the air of the tractor driver working area the
136 concentration of studied active substances was below the limit of quantification
137 of the method (Table II). In the air of the treatment zone, zones of possible wear
138 (10 and 100 m) in different time intervals the concentration of active substances
139 was below the limit of quantitative determination of the method (Table II).

140 Visual analysis of water-sensitive cards installed in a possible wear zone
141 (10 m on the leeward side of the field) using slotted sprayer, showed the
142 presence of single drops of pesticide working solution on cards № 1-5, 8, 9. On
143 cards № 6, 7, 10 visually, using a magnifying glass, the drops were not detected.
144 No color change was observed on any water-sensitive card when the pesticide
145 was applied by injection technology.

146 An analysis of the content of active substances in washes from exposed
147 areas of skin and stripes on staff overalls was performed. It was found that the
148 level of contamination of open (face, neck) and closed areas of the skin of the
149 refueler and tractor driver was below the limit of quantification of the relevant
150 methods. In strips on workers' overalls, the concentrations of active substances
151 were also below the limit of determination of the method.

152 The obtained factual data on the assessment of working conditions using
153 the injector sprayer Guardian Air GA110-04 and slotted one Super Poly 110-04
154 allowed us to calculate the occupational risk of complex intake through the skin
155 and respiratory tract, as well as the combined intake of several active substances
156 in one formulation. (Table III).

157 Analysis of the data of occupational risk calculations for complex and
158 combined exposure to pesticides showed that the difference in the risks for
159 refuelers of the sprayer tanks in variants №1 and №2 of field studies is not
160 significant according to Student's criterion ($p > 0.05$). This is completely
161 comparable to the expected result, as the technologies for preparing the working
162 solution and filling the sprayer tank were identical. The proportion of
163 percutaneous and inhalation risks in azoxystrobin refuelers was 77.4 and 22.6 %,
164 respectively. For cyproconazole, the percutaneous and inhalation risks were 13.4
165 and 86.6 %, respectively, and the combined risk was 0.04.

166 When assessing the complex risk for tractor drivers, a statistically
167 significant difference was found for azoxystrobin ($p = 0.002$) and cyproconazole
168 ($p = 0.001$) when using a slotted sprayer Super Poly 110-04 and injector

169 Guardian Air GA110-04. The proportion of percutaneous risk in variants № 1
170 and № 2 was lower for all active substances than the proportion of inhalation
171 risk. The values of the combined risk when using a slotted sprayer (0.46 ± 0.04)
172 significantly exceeded the data obtained when using an injector one ($0.02 \pm$
173 0.006).

174 **Discussion.** The results of the analysis of the working area air of persons
175 involved in the preparation of the working solution, filling the sprayer tank and
176 application of Amistar Extra 280, SC indicate compliance with the concentration
177 of active substances. But it should be noted that the concentration of active
178 substances in the working area of the tractor driver when slotted application is
179 higher. In the air of the wear zone at a distance of 10 m from the edge of the
180 field on the leeward side, the concentration of azoxystrobin and cyproconazole
181 was also higher in variant №1. It should be noted that even such a minimal
182 difference may be decisive in the implementation of the risk of negative impact
183 not only for professional contingents, but, for example, for the ecosystem (honey
184 insects in the neighboring field) or workers in the neighboring field (who doing
185 non-pesticide field work, of course, without personal protection means).

186 The results of visual analysis of water-sensitive paper cards in the variant
187 №1 of field studies confirmed the presence of wear of microdroplets, which can
188 cause loss of effectiveness of the formulation, impact on non-target objects and
189 create a burden on the environment as a whole. This problem becomes
190 especially relevant when applying pesticides in private farms or in areas where
191 compliance with the protection zone is difficult.

192 The obtained results correlate with the data given in [3, 8, 10, 11], i.e. we
193 can say about the advantage of injector sprays not only as “anti-drift”, but also
194 as means of providing lower concentrations of active substances under the same
195 conditions of application of formulations based on them.

196 The values of occupational risks in the complex and combined effects of
197 azoxystrobin and cyproconazole in the studied application technologies indicate

198 a statistically significant difference for tractor drivers of slotted and injector
199 application. According to [1, 5, 12] the proportion of inhalation risk is higher for
200 tractor drivers due to work during the disintegration of pesticides working
201 solutions; and for refuelers the proportion of percutaneous risk prevails, as
202 components of professional activity are unpacking, dosing pesticide and filling
203 the sprayer tank. The obtained results are comparable with the literature data,
204 but it should be noted that in studies with slotted sprayers complex and
205 combined risks for tractor drivers are significantly higher than for tractor drivers
206 with injector spraying and this difference is due to the high inhalation risk. From
207 the point of view of working conditions safety, the use of injectors is more
208 justified, especially in private farms, where the use of personal protective
209 equipment is not controlled by the employer and is often ignored by workers.

210 **Conclusions:**

211 1. It is established that in real conditions of carrying out treatment of soy
212 by the Amistar Extra 280, SC formulation with the use of Guardian Air GA110-
213 04 injectors and slotted Super Poly 110-04 in compliance with the recommended
214 agronomic and hygienic regulations for safe application, there is no excess of
215 hygienic standards in the air of the working and wear zone and it is proved that
216 occupational risk does not exceed acceptable (< 1).

217 2. Statistical analysis of the obtained results showed that the values of
218 inhalation risk are significantly higher for tractor drivers when using slotted
219 sprayers than in tractor drivers involved in the application of pesticides by
220 injector sprayers (at $p < 0.05$). Values of the combined complex risk of
221 application of the Amistar Extra 280, SC formulation for tractor drivers of
222 variant №2 application were significantly lower than those for tractor drivers of
223 variant №1.

224 3. Absence of even insignificant wear of active substances of the
225 investigated formulation outside of the processed field at use of injector sprayers
226 is shown. This, on the one hand, will provide greater biological and economic

227 efficiency of the formulation application by this method; on the other hand, it
228 further reduces the risk of negative impact not only on the pesticide treatment
229 workers, but also on other people and the ecosystem as a whole.

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Hygienic standards and limits of quantitative determination (LQD) of the studied active ingredients in the air of the working zone, atmospheric air, washes from the skin surface and stripes from the overalls of personnel

Sample type	Current norms, LQD	Azoxystrobin	Cyproconazole
The air of the working zone, mg/m ³	TSEL	1.0	0.1
	LQD	0.001 (HPLC)	0.05 (GC)
Atmospheric air, mg/m ³	TSEL	0.01	0.01
	LQD	0.001 (HPLC)	0.008 (GC)
Washes, stripes, mg	LQD	0.002 (HPLC)	0.002 (GC)

Notes: TSEL – tentatively safe level of exposure; LQD – limit of quantitative determination; HPLC – high performance liquid chromatography; GC – gas-liquid chromatography.

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Table 2
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Table II

The content of active ingredients of the Amistar Extra 280, SC formulation in air samples using different spraying technologies, mg/m³

Type of nozzle	Active ingredient	Air in the respiratory zone		Air in the treatment zone after			Air in zone of			
		refueler	tractor driver	1 hour	3 days	7 days	10 m from the edge of the field	possible wear * after		
								treatment time	1 hour	3 days
Super Poly 110-04 (slotted sprayer)	azoxystrobin	<0.001**	0.0015	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
	cyproconazole	<0.05	0.085	<0.008	<0.008	<0.008	0.11	<0.008	<0.008	<0.008
Guardian Air GA110-04 (injector sprayer)	azoxystrobin	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	cyproconazole	<0.05	<0.05	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008

Notes: 1. * - the study was conducted at a distance of 100 m from the edge of the site; 2. ** - below the limit of quantitative determination of the method in the air of the working zone and atmospheric air.

Table 3

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The magnitude of the potential risk of hazardous exposure to the drug Amistar Extra 280 SC, hp for refuelers and tractor drivers when using different sawing technologies

Type of nozzle	Active ingredient	Risk values						Proportion of inhalation risk, %		Proportion of dermal risk, %		Combined risk	
		inhalation, $\times 10^{-2}$		dermal, $\times 10^{-2}$		complex, $\times 10^{-2}$		R	TD	R	TD	R	TD
		R	TD	R	TD	R	TD	R	TD	R	TD	R	TD
Super Poly 110-04 (slotted sprayer)	Azoxystrobin	0.01	0.12*	0.04	0.03	0.05	0.16*	22.6	79.3	77.4	20.7	0.04	0.46*
	Cyproconazole	3.4	46.2*	0.53	0.48	3.93 ²	46.72*	86.6	98.9	13.4	1.1		
Guardian Air GA110-04 (injector sprayer)	Azoxystrobin	0.01	0.04*	0.04	0.03	0.05	0.07*	22.6	56.0	77.4	44.0	0.04	0.02*
	Cyproconazole	3.4	13.6*	0.53	0.48	3.93	14.1*	86.6	96.6	13.4	3.4		

Notes: 1. R – refueler; 2. TD – tractor driver; 3. * – the values of the risk when using a slit sprayer are significantly higher according to the Student's criterion at $p < 0,05$.

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Tables

Table 1 - [Download source file \(12.48 kB\)](#)

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