INFLUENCE OF DRAINPIPE SPACINGS ON ATRAZINE LEACHING

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Abstract: Maize (Zea mays) is the leading culture according to sow area in Croatia. Herbicide products based on atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine) are most widely used for weed control in corn crops. Therefore the aim of this study was to determine the concentration and leaching of atrazine in drainage water in four different variants of pipe drainage spacing (15 m, 20 m, 25 m and 30 m). The study was conduced on the Jelenscak reclamation test field, on hydroameliorated Gleyic Podzoluvisol during four years. Atrazine extracted from the samples of drainage waters was determined by gas chromatography. Data were statistically processed by means of analysis of variance. The concentrations of the atrazine recorded in drainage waters varied in a wide range, with maximum values recorded soon after its application and at the start of higher drainage discharge. The results indicate that maximal and average concentrations of atrazine in drainage waters exceeded the maximum allowable concentration (MAC) for single herbicides in drinking water (0,1 $\mu g\ l^{-1}$), respectively, in the larger part of the year in all variants of pipe drainage spacing. There were no statistically significant differences between the tested drainage systems in drainage water contamination with atrazine.

Keywords: hydroameliorated Gleyic Podzoluvisol, drainage water, atrazine, leaching

Introduction

Pesticides have many side effects on the environment – soil, water, food and organisms (Jolánkai et al. 2006, Kirsch et al. 2007, Varga et al. 2007, Varróet al. 2007 Velisková, 2006,). Among herbicides, atrazine is one of the most widely use in the world, mainly due its relatively low price and broad spectrum of activity. In Croatia, products of atrazine are used in formulations of pure atrazine or in ready mix combination with other herbicides applied in pre-emergence or post-emergence. Due to its chemical properties, atrazine is characterized by high water mobility and environmental persistence. Because of these atrazine properties and its longlasting use as a plant-protecting agent in Croatia, residues of this contaminant have been identified in the samples of surface, ground and drinking waters (Vargha et al. 2004, Gojmerac et al. 2006, Sraka et al. 2007). Atrazine is most effective in wet soil, so it is usually applied in early spring, when soil is at field water capacity. It is moderately hydrophilic and in aquatic environment may persist for years. Atrazine has a greater mobility in soil than many other herbicides (Buhler et al. 1993) and is the most commonly detected herbicide in the groundwater of many countries. Their excessive quantities in drinking water may pose other dangers to humans, animals and plants. For this reason, its use has been restricted or banned in some Europian countries.

The aim of the research carried out during 1991/92, 1993/94, 1996/97, 1999/00 was:

- to determine the concentration and leaching of atrazine in drainage waters for four different drainpipe spacings (15 m, 20 m, 25 m and 30 m)

- to determine, whether there is a statistical significant, difference in concentration of atrazine in drainage water and its leaching between different drainpipe spacings.

Materials and methods

Trials were carried out on the Jelenscak reclamation test field, on hydroameliorated Gleyic Podzolluvisol during four years, which is located in the Sava river valley. Trial variants involved four different variants of drainpipe spacing (15 m, 20 m, 25 m and 30 m), set up in four replications. All variants were combined with gravel as contact material (ø 5-25 mm) in the drainage ditch above the pipe. Drainpipe characteristics were: length 95 m, diameter 65 mm, average slope 3‰ and average depth 1 m. Drainpipes discharged directly into open canals. Variants covered areas of: 1425 m^2, 1900 m^2, 2375 m^2 and 2850 m^2. Plastic (PVC)-annular-ribbed and perforated pipes were used. Maize was grown as the trial crop and the same agricultural practices were applied in all pipe drainage variants in each trial year. During intensive growing of maize weed control involved application of herbicide Primextra 500, based on active substance – atrazine 20% + metolachlor 30% (1991, 1993, 1996 i 1999 with 6 l ha^{-1}). Drainage discharge was measured continually by means of automatic electronic gauges – limnimeters. Drainage water was sampled every day during the discharge period. Atrazine extracted from the samples of drainage waters was detected by gas chromatography. The detection limit for atrazine in drainage waters was lowered than 0,05-0,01 µg l^{-1}. Total annual quantities of atrazine leached were estimated on the basis of average monthly concentration and monthly quantity of drainage discharge. Data were statistically processed by means of the ANOVA.

Results and discussion

To facilitate interpretation of research results, the factors of soil and precipitation were taken into consideration (Table 1 and 2), as well as hydrological relations (Table 3).

Table 1: Major properties of drained Gleyic Podzoluvisol

Profile	*Depth, cm*	*Content of particles, %*		*Porosity %*	*Capacity for, %*		*Permea-bility, $mday^{-1}$*	*Bulk density, gcm^{-1}*	*pH KCl*	*Organic mater, %*
		Silt	*Clay*		*Water*	*Air*				
Ap	0-35	47	46	48	44	4	0,011	1,35	5,8	3,0
Btg	35-75	45	48	49	45	4	0,010	1,41	5,5	
Gso	75-115	55	39	46	42	4	0,011	1,43	7,1	
Gr	115-130	63	25	49	45	4				

Table 2: Total monthly and annual precipitation and its mean values, l m^{-2}

Year	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	Σ
1991/92	156	20	160	52	50	152	108	21	15	45	78	59	916
1993/94	44	134	30	119	90	107	165	112	50	58	37	79	1025
1996/97	71	31	90	83	190	46	135	79	44	55	26	45	895
1999/00	107	89	86	66	95	72	92	104	29	37	63	77	917

Drainage discharge and its duration are important indicators of pipe drainage efficiency in draining excess water from soil. It can be seen (Table 3) that there were differences in the quantity and duration of drainage discharge, both between the tested variants in each year and between the trial years. There are several reasons for these differences, primarily the different total annual quantity and distribution of precipitation, different efficiency of each particular pipe drainage system, etc. Duration of drainage discharge in each year increases with the width of drainpipe spacing. Therefore systems with shorter duration of drainage discharge are more efficient.

Table 3: Quantities of drainage discharge (l m^{-2}) and total duration of drainage discharge (days) per variants

Spacing variants (m)	Year	Precipitation (l m^{-2})	Drainage discharge		Duration of drainage discharge (days)
			l m^{-2}	% of precipitation	
15	1991/92	916	228	24,9	134
20			219	23,9	136
25			213	23,3	139
30			229	25,0	141
15	1993/94	1025	266	26,0	167
20			271	26,4	170
25			268	26,1	177
30			277	27,0	182
15	1996/97	895	198	22,1	140
20			198	22,1	146
25			203	22,7	153
30			199	22,2	157
15	1999/2000	917	174	19,0	124
20			175	19,1	126
25			166	18,1	129
30			171	18,6	129

It can be seen from Table 4 that different maximum and average values were determined for atrazine concentrations in drainage water, both in trial years and at different drainpipe spacings. This was influenced by the date of atrazine application, quantity and distribution of rainfall, that is, the quantity of drainage discharge, and efficiency of each particular pipe drainage system. Maximum atrazine concentrations in drainage water were recorded soon after its application and at the start of higher drainage discharge (May 1991, June 1993, 1999 and September 1996); they decreased in all years with later drainage discharge. Namely, atrazine is highly water-soluble and it is readily transported with water and degraded in soil.

Table 4: Average and maximum concentrations of atrazine (µg l^{-1}) in drainage water, per variants

Spacing variants (m)	1991/92		1993/94		1996/97		1999/2000	
	Average	Max.	Average	Max.	Average	Max.	Average	Max
15	1,75	7,23	1,55	6,87	0,94	2,88	1,15	5,05
20	1,79	7,46	1,71	6,2	0,86	2,32	1,31	5,70
25	1,84	7,58	1,89	6,31	0,84	2,95	1,29	5,84
30	1,73	7,15	1,57	6,16	0,93	2,99	1,34	5,80

Results on the contamination of drainage water with atrazine, in dependence on different drainpipe spacing, are in agreement with the results Accinelli et al. (2002). These authors point to the fact that the quantity of atrazine leached in these parts is strongly influenced by the distribution of precipitation (drainage discharge), time of herbicide application, their quantities added, and the phenological stage of maize. In the case of the mentioned atrazine rate (1200 g/ha) applied to hydroameliorated soil and the recorded quantities of precipitation drainage discharge, atrazine concentrations were higher than the tolerated limit in 10 months in all years.

Table 5: Quantity of of atrazine leached in pipe drainage variants(g ha^{-1}) and percentage of atrazine leached relative to its total quantity added with aplication

Spacing variants (m)	1991/92		1993/94		1996/97		1999/2000	
	g ha^{-1}	%	g ha^{-1}	%	g ha^{-1}	%	g ha^{-1}	%
15	3,99	0,33	4,12	0,34	1,86	0,16	2,00	0,17
20	3,92	0,33	4,63	0,39	1,98	0,17	2,29	0,19
25	3,92	0,33	5,07	0,42	1,71	0,14	2,14	0,18
30	3,96	0,33	4,35	0,36	1,85	0,15	2,29	0,19

Atrazine was mostly lost during the growing season. Larger quantity of total atrazine leached was recorded in the first two years (higher total drainage discharge and higher concentrations) and vice verse. Atrazine losses ranged from 0.14% to 0.42%. Albanis et al. (1988) reported different quantities of leached atrazine with respect to soil texture (0.54% in clay, 0.66% in loam and 0.47% in silt-loam) and Accinelli et al. (2002) reported about 0.61% atrazine losses in silty loam.

Conclusions

In 10 months in all years and all variants concentrations of atrazine were higher from the tolerated limit.

Quantity of atrazine leached is depended on the total drainage discharge and its concentrations in drainage water.

ANOVA showed that there were no statistically significant differences between the tested variants in particular years either in atrazine concentrations or in the quantity of atrazine leached, at LSD=0.05.

References

Accineli C. – Vicari A. – Rossi P. – Catizone P.: 2002: Losses of atrazine, metolachlor, prosulfuron and triasulfuron in subsurface drain water. Agronomie **22:** 399-411.

Albanis T.A. – pomonis P.J. – Sdoukos A.T.: 1998: Movement of methyl parathion, lindane and atrazine through lysimeters in field conditions. Toxicological and Environmental Chemistry **17:** 35-45.

Buhler D.D. - Randall G.W. - Koskinen W.C. - Wyse D.L.: 1993. Atrazine and alachlor losses from subsurface tile drainage of a clay loam soil, *J. Environ. Qual.* **22**: 583–588.

Cooper R.L. – Stoker T.E. – Tyrey L. – Goldman J.M. – Quinn T. – Clark J.M.: 2000. Atrazine disrupts the hypothalamic control of pituitary-ovarian function. Toxicol. Sci. **53:** 297-307.

Gojmerac T. – Ostojic Z. – Paukovic D. - Pleadin J. –Zuric M.: 2006. Evaluation of Surface Water Pollution with Atrazine, an Endocrine Disruptor Chemical, in Agricultural Areas of Turopolje, Croatia. Bull. Environ. Contam. Toxicol. **76:** 490-496.

Jolánkai M. – Szentpétery Z. – Hegedűs Z.: 2006. Pesticide residue discharge dynamics in wheat grain. Cereal Research Communications, **34,** 1. 505-508.

Krisch J. – Horváth E. – Vágvölgyi C. – Tanács L.: 2007. Mobility of herbicides and fungicides in soil and their effects on soil microorganisms. Cereal Research Communications, **35,** 1. 673-676.

Sraka M. – Vidacek Z. – Smit Z. – Bensa A. – Vrhovec D.: 2007. Herbicides in the soil and waters of river Drava catchment area. Cereal Research Communications, **35,** 2. 1089-1092.

Varga B. – Svecnjak Z. – Jurkovic Z. – Pospisil M.: 2007. Quality responses of winter wheat cultivars to nitrogen and fungicide applications in Croatia. Acta Agronomica Hungarica, **55,** 1. 37-48.

Vargha M. – Somlai Z. – Takáts Z. – Márialigeti K.: 2004. Microbiological impact of atrazine pollution in river sediment and soil. Acta Agronomica Hungarica, **52,** 3. 297-307.

Varró P. – Tarnawa A. – Világi I. – Banczerowski-Pelyhe I.: 2007. Tolerable pesticide contamination in food – motility changes of rat ileum as a new biomarker of toxicity testing. Cereal Research Communications, **35,** 2. 1281-1284.

Velisková Y.: 2006. Problem of water pollution and ways of solution. Cereal Research Communications, **34,** 1. 101-103.