WEED CONTROL IN ROW CROPS (*Helianthus annuus* L., *Beta vulgaris* L., *Zea mays* L.) ON THE INTERFACE OF AGRO-CLIMATIC CONDITIONS OF MAIZE AND SUGAR BEET GROWING REGION

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Abstract: *row crops are important part of Slovak agriculture. The main goal of the research was to evaluate the weed communities in row crops fields (sunflower – Helianthus annuus L., sugar beet – Beta vulgaris L. and maize - Zea mays L.) and evaluation of herbicide control and impact of different agro-climatic conditions on the occurrence of weeds in row crops fields. We have two experimental areas representing typical field in maize growing region and sugar beet growing region with total acreage of 1280 ha in western Slovakia. Weeds were evaluated three times for growing season in five replications, on the control plots (without herbicide treatment), as well as on the areas treated with herbicides as follows: T1 – presowing application (PPI); T2 – preemergent – during sowing or before crop and weed emergence (PRE); T3 – postemergent – after crop and weed emergence (POST). Weed pressure, expressed as a weed density on plots without herbicides application was counted as an average weed density across the location and terms of evaluation. In canopy of sunflower biggest pressure created Chenopodium album L., Echinochloa cruss-galli (L.) P. BEAUV., at sugar beet field Chenopodium album L., Echinochloa crus-galli (L.) P. BEAUV., Amaranthus retroflexus L., at maize field Echinochloa crus – galli (L.) P. BEAUV., Chenopodium album L. Not easily controllable species were determined according higher density under conventional herbicide control across the year and localities. In sunflower fields at maize growing region we determined Cirsium arvense (L.) SCOP., Chenopodium album L.; at sugar beet growing region Elytrigia repens (L.) DESV, Avena fatua L.. High density of Convolvulus arvensis L. was noted in both areas. At canopy of sugar beet the highest density of Echinochloa crus-galli (L.) P. BEAUV., Persicaria lapathifolia (RAF) S. F. GRAY., Cirsium arvense (L.) SCOP was noted in maize growing region; and Elytrigia repens (L.) DESV, Amaranthus retroflexus L., Avena fatua L. at sugar beet growing region. In maize field, dominant species at both localities were as follows: Cirsium arvense (L.) SCOP., Convolvulus arvensis L., Echinochloa crus – galli (L.) P. BEAUV. The highest weed infestation was in canopy of sunflower with average amount of 46.4 pcs of weed plants. The same level of weed infestation was counted in canopy of sugar beet and maize fields in range of 37.7- 38.0 pcs m^{-2}. Herbicides application effectively reduced the weed infestation to the 5.9 pcs m^{-2} in sugar beet fields up to 11.0 pcs m^{-2} in maize fields.*

Keywords: *sunflower, sugar beet, maize, herbicides control, weed density, weed diversity*

INTRODUCTION

Weed control is crucial factor of effective growing of row crops in Slovakia. Weed control strategy depends of deep knowledge of specific weed growing in canopy of cultivated crops. The most common tool for weed removal is blanket spraying of herbicides which raises environmental concerns. In order to reduce the amount of herbicides, knowledge of when and where to apply them is necessary. The priority to implement effective an integrated weed management is required first of all in canopy of row crops where there is large availability and application of herbicides (SMATANA AND TÝR, 2011). In Slovakia, the most important weed species are mainly *Cirsium arvense* (L.) SCOP, *Elytrigia repens* (L.) DESV, *Chenopodium album* L., *Amaranthus retroflexus* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Avena fatua* L., *Convolvulus arvensis* L. (SMATANA ET AL., 2008; TÝR AND VEREŠ, 2012). Creeping Thistle

(*Cirsium Arvensis* (L.) Scop.) is an invasive perennial weed species that causes major yield loss to sugar beet (KAZMI et al., 2015).

Weed control in row crops have specific features as long vegetative period and control of inter row weeds by mechanical inter row cultivation. Weeds that grow within the line of row crop plants (intra row weeds) have great impact on yield and chemical weed control is needed (PANACCI AND TEI, 2014)

The main goal of the research was to evaluate the weed communities in row crops fields (sunflower, sugar beet and maize) and evaluation of herbicide control and impact of different agro-climatic conditions in maize and sugar beet growing region on the occurrence of weeds in row crops fields.

MATERIAL AND METHODS

We have two experimental sites representing typical field in maize growing region - Plave Vozokany location and sugar beet growing region - Santovka location. Total acreage of farm fields was 1280 ha. The weather condition of experimental site at maize growing location during spring and summer period is documented in table 1.

Table 1

Weather conditions of particular experimental site of maize growing region at locality Plavé Vozokany

Years		1998		1999		2000	
Months		Temperature (°C)	Rainfall (mm)	Temperature (°C)	Rainfall (mm)	Temperature (°C)	Rainfall (mm)
Spring	IV.	12.3	54.7	12.2	67	14.1	56.3
	V.	15.4	37	16.1	37.9	17.6	19.8
	VI.	20	122.8	19.1	142.2	21.7	3.5
Average IV. - VI.		15.9	71.5	15.8	82.4	17.8	26.5
Sum or average IV - VI.		47.7	214.5	47.4	247.1	53.4	79.6
Summer	VII.	20.8	83.3	21.4	159.1	21.4	77.4
	VIII.	20.5	23.4	19.2	71	22.3	6.1
	IX.	14.9	166.9	18.3	8.3	15.2	15.5
Average VII. - IX.		18.7	91.2	19.6	79.5	19.6	33.0
Sum VII. - IX.		56.2	273.6	58.9	238.4	58.9	99.0

The first location Plave Vozokany is situated in maize growing region in the south-eastern part of the district Levice -west part of Slovakia at 150 m to 164 m above sea level. Soil is loamy and soil type consists of black and brown soils on loess and alluvial deposits. The second location representing sugar beet growing region at locality Santovka, is located in the north-eastern part of the district of Levice in sugar beet production area at 170 m to 220 m above sea level. Soil is loamy and soil type consists of brown soil on loess and alluvial deposits. The average daily air temperature in the region is 9.2 °C and location is also classified as warm and very dry region with an average annual precipitation of 637 mm and 354 mm during growing season. Actual weed infestation was evaluated according standard scoring system (table 2).

The first evaluation was conducted in the spring before application of herbicides on both sites equally. The results were processed and evaluated by using Statgraphic 5.0 software.

Table 2

Scoring system and description of actual weeds density

Weeds group	Description				
	no	unique	weak	medium	strong
	Degree of weedy				
	0	1	2	3	4
	Number of weeds plant per square meter				
Very dangerous	-	≤ 2	3 - 5	6 - 15	≥16
Less dangerous	-	≤ 4	5 - 8	9 - 20	≥ 21
Minor significance	-	≤ 8	9 - 15	16 - 30	≥ 31

Weeds were evaluated three times for growing season in five replications, on the control plots (without herbicide treatment), as well as on the areas treated with herbicides as follows: T1 – presowing application (PPI); T2 – preemergent – during sowing or before crop and weed emergence (PRE); T3 – postemergent – after crop and weed emergence (POST).

Applied herbicides expressed in active ingredients in terms of particular applications (T1 - T3) and the commercial name of the herbicide are documented in Table 3, 4 and 5.

Table 3

Herbicide application expressed as active ingredients and applied amount of commercial brand of herbicides in canopy of sunflower at experimental sites of maize and sugar beet growing region

Year	Term	Maize growing region -Plavé Vozokany	Sugar beet growing region- Santovka
1998	**T1**	triflurazín (480 g ha^{-1}) - Triflurex 48 EC (2 l ha^{-1})	triflurazín (480 g ha^{-1}) - Triflurex 48 EC (2 l ha^{-1})
	T2	prometryn (500 g ha^{-1}) - Prometrex 50SC (1.1 l ha^{-1})	prometryn (500 g ha^{-1}) - Gesagard 500 FW (1.5 l ha^{-1})
	T3	haloxytop (108 g ha^{-1}) - Gallant Super (0.6 l ha^{-1})	-
1999	**T1**	triflurazín (480 g ha^{-1}) - Triflurex 48 EC (2 l ha^{-1})	triflurazín (480 g ha^{-1}) - Triflurex 48 EC (2 l ha^{-1})
	T2	prometryn (500 g ha^{-1}) - Prometrex 50SC (1.1 l ha^{-1})	prometryn (500 g ha^{-1}) - Gesagard 500 FW (1.5 l ha^{-1})
	T3	-	-
2000	**T1**	triflurazín (480 g ha^{-1}) - Triflurex 48 EC (2 l ha^{-1})	-
	T2	prometryn (500 g ha-1) - Prometrex 50SC (1.1 l ha^{-1})	prometryn (500 g.ha-1) - Gesagard 500 FW (1,5 l.ha^{-1})
	T3	-	S – metachlor - Dual Gold 960 EC (1 l.ha^{-1})

Term of evaluation: T1 – presowing application (PPI); T2 – preemergent – during sowing or before crop and weed emergence (PRE); T3 – postemergent – after crop and weed emergence (POST).

Table 4

Herbicide application expressed as active ingredients and applied amount of commercial brand of herbicides in canopy of sugar beet at experimental sites of maize and sugar beet growing region

Year		Maize growing region -Plavé Vozokany	Sugar beet growing region -Santovka
1998	**T1**	phenmedipham (184 g ha^{-1}) + desmedipham(144 g ha^{-1}) + ethofumesat (224 g ha^{-1}) - Betanal Progres OF (2 l ha^{-1})	chloridazon(2150 g ha^{-1}) – Burex 430 DKV + metolachlor (1000 g ha^{-1}) – Dual 500 EC
	T2	clopyralid (60 g ha^{-1}) – Lontrel 300 (0.2 l ha^{-1})	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})
	T3		phenmedipham (110 g ha^{-1}) + desmedipham(86 g ha^{-1}) + ethofumesat (134 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1}) + haloxytop (90 g ha^{-1}) - Gallant Super (0.5 l ha^{-1})
1999	**T1**	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1})) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})	chloridazon(2150 g ha^{-1}) – Burex 430 DKV
	T2	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1})) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})
	T3	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1})) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})	phenmedipham (138 g ha^{-1}) + desmedipham(108 g ha^{-1}) + ethofumesat (168 g ha^{-1}) - Betanal Progres OF (1,5 l ha^{-1}) + clopyralid (60 g ha^{-1}) – Lontrel 300 (0.2 l ha^{-1}) + haloxytop (90 g ha^{-1}) - Gallant Super (0.5 l ha^{-1})
2000	**T1**	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})	chloridazon(2150 g ha^{-1}) – Burex 430 DKV
	T2	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1}) + fluazifop – P – butyl (422 g ha^{-1}) – Fusilade Super (2,5 l ha^{-1})	phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})
	T3	- phenmedipham (92 g ha^{-1}) + desmedipham(72 g ha^{-1}) + ethofumesat (112 g ha^{-1}) - Betanal Progres OF (1,2 l ha^{-1}) + clopyralid (45 g ha^{-1}) – Lontrel 300 (0.15 l ha^{-1})	phenmedipham (138 g ha^{-1}) + desmedipham(108 g ha^{-1}) + ethofumesat (168 g ha^{-1}) - Betanal Progres OF (1,5 l ha^{-1}) + clopyralid (60 g ha^{-1}) – Lontrel 300 (0.2 l ha^{-1}) + haloxytop (90 g ha^{-1}) - Gallant Super (0.5 l ha^{-1})

Term of evaluation:; T1; T2; T3 – postemergent – after crop and weed emergence (POST) – Plavé Vozokany, T1 – preemergent – during sowing or before crop and weed emergence (PRE) T2; T3 – postemergent – after crop and weed emergence (POST) – Santovka.

Sunflower was grown after cereal forecrop (winter wheat and spring barley) annually from on 42 % - 60 % fields at Plavé Vozokany site in sugar beet region site Santovka grown annually on 36 % - 45 % fields after cereal forecrop (winter wheat, spring barley, maize) only in one case sunflower was grown after legumes and alfalfa. The both

experimental location have high share of maize for corn in range of 58% - 79% at Plavé Vozokany and 56% - 75% fields at Santovka was cover by maize too.

Table 5

Herbicide application expressed as active ingredients and applied amount of commercial brand of herbicides in canopy of maize at experimental sites of maize and sugar beet growing region

Year	Term	Maize growing region -Plavé Vozokany	Sugar beet growing region- Santovka
1998	T1	atrazin (750 g ha^{-1}) – Atranex 50 SC (1.5 L ha^{-1}) + acetochlor (1536 g ha^{-1}) + dichlormid (256 g ha^{-1}) – Trophy (2 L ha^{-1})	atrazin (750 g ha^{-1}) – Atranex 50 SC (1.5 L ha^{-1}) + acetochlor (1536 g ha^{-1}) + dichlormid (256 g ha^{-1}) – Trophy (2 L ha^{-1})
1999	T1	atrazin (750 g ha^{-1}) – Atranex 50 SC (1.5 L ha^{-1}) + acetochlor (1536 g ha^{-1}) + dichlormid (256 g ha^{-1}) – Trophy (2 L ha^{-1})	atrazin (750 ha^{-1}) – Atranex 50 SC (1.5 l ha^{-1}) + acetochlor (768 g ha^{-1}) + dichlormid (128g. ha^{-1}) – Trophy (1 l. . ha^{-1})
	T2	-	clopyralid (240 g .. ha^{-1}) – Lontrel 300 (0,4 l ha^{-1}).
2000	T1	atrazin (750 g ha^{-1}) – Atranex 50 SC (1.5 L ha^{-1}) + acetochlor (1536 g ha^{-1}) + dichlormid (256 g ha^{-1}) – Trophy (2 L ha^{-1})	atrazin (750 ha^{-1}) – Atranex 50 SC (1.5 L ha^{-1}) + propisochlor (1680 g ha^{-1}) – Proponit 840 EC (2 L ha^{-1})

Term of evaluation: T1 – preemergent – during sowing or before crop and weed emergence (PRE); T2 – postemergent – after crop and weed emergence (POST).

At both experimental sites maize was growing after cereal forecrop of winter wheat and spring barley. The weed species with high pressure to crops on untreated plots were determined according plant density of specific weed species per unit area across the years and growing area. The dominant or problematic species not easily controllable in row crops were determined according higher density under conventional herbicide control across the year and localities.

RESULTS AND DISCUSSION

In canopy of sunflower at model locality of maize growing region at Plavé Vozokany site, the high density of *Chenopodium album* L., *Atriplex* spp. and *Echinochloa cruss-galli* (L.) P. BEAUV. were noted on control treatments. On the herbicides treatments the high density of *Cirsium arvense* (L.) SCOP., *Chenopodium album* (L) *Convolvulus arvensis* (L.), *Amaranthus retroflexus* (L.), *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., was also noted (table 6).

At sugar beet growing region of Santovka locality, the biggest pressure of *Echinochloa crus-galli* (L.) P. BEAUV., *Chenopodium album* (L.) and *Persicaria maculata* (RAF) was occurred on control treatments (table7).

Table 6

Weed density (pcs m^2) and species diversity at canopy of sunflower in the maize growing region - Plavé Vozokany site

Weed groups	Weed species	1998		1999		2000		Average density	
		no herbicides	treated	no herbicides	treated	no herbicides	treated	no herbicides	treated
Early-spring	*Avena fatua* L.	1.5	0.1	1.1	0.1	0.6	0.0	1.1	0.1
	Polygonum aviculare L.	1.2	0.1	0.5	0.2	2.7	0.3	1.5	0.2
	total	2.7	0.2	1.6	0.3	3.3	0.3	2.5	0.3
Late-spring	*Echinochloa crus-galli* (L.) P. BEAUV	5.2	0.3	5.5	0.2	3.2	1.5	4.6	0.7
	Chenopodium album L.	6.1	0.4	3.7	2.0	8.1	5.5	6.0	2.6
	Atriplex spp.	5.0	0.2	4.7	0.2	4.9	0.3	4.9	0.2
	Amaranthus retroflexus L.	2.7	0.2	3.9	1.0	3.6	2.0	3.4	1.1
	Persicaria lapathifolia (RAF) S. F. GRAY	2.8	0.2	8.3	0.4	3.1	1.0	4.7	0.5
	total	21.8	1.3	26.1	3.8	22.9	10.3	23.6	5.1
Overwinter weeds	*Tripleurospermum perforatum* (L.) SCHULTZ-BIP.	3.0	0.4	3.2	1.0	2.1	0.2	2.8	0.5
	Galium aparine L.	1.4	0.4	0.5	0.2	0.4	0.2	0.8	0.3
	Stellaria media (L.) Vill.	4.2	0.1	3.8	0.3	1.9	0.1	3.3	0.2
	Capsela bursa-pastoris (L.) Med.	6.0	0.3	2.4	0.4	2.1	0.1	3.5	0.3
	Lamium purpureum L.	2.8	1.0	4.4	2.0	3.1	0.3	3.4	1.1
	Thlaspi arvense L.	2.4	0.1	2.2	1.0	1.6	0.1	2.1	0.4

	total	19.8	2.3	16.5	4.9	11.2	1.0	15.8	2.7
Perennial weeds	*Cirsium arvense* (L.) SCOP.	2.5	3.1	0.7	1.0	2.0	2.8	1.7	2.3
	Convolvulus arvensis L.	1.2	1.6	1.2	1.5	0.8	0.4	1.1	1.2
	total	3.7	4.7	1.9	2.5	2.8	3.2	2.8	3.5
Total density		**48.0**	**8.5**	**46.1**	**11.5**	**40.2**	**14.81**	**44.8**	**11.6**

By herbicides control the most abundant weed species were ordered according of importance as follows: *Elytrigia repens* (L.) DESV, *Convolvulus arvensis* L.) *Avena fatua* L), *Cirsium arvense* (L.) SCOP., *Chenopodium album* L. (table 7). The our results correspond to the finding of SMATANA et al. (2008), that the most abundant weeds in canopy of sunflower are *Cirsium arvense* (L.) SCOP., *Persicaria* spp., *Echinochloa crus-galli* (L.) P. BEAUV., *Chenopodium* spp.

Table 7

Weed density (pcs m^2) and species diversity at canopy of sunflower in the sugar beet growing region - Santovka site

Weed groups	**Weed species**	**1998**		**1999**		**2000**		**Average 1998 - 2000**	
		no herbicides	**treated**	**no herbicides**	**treated**	**no herbicides**	**treated**	**no herbicides**	**treated**
Early-spring	*Avena fatua* L.	2.0	0.1	3.1	0.6	6.3	1.3	3.8	0.7
	total	2.0	0.1	3.1	0.6	6.3	1.3	3.8	0.7
Late-spring	*Echinochloa crus-galli* (L.) P. BEAUV	6.6	0.2	6.9	0.2	8.1	0.3	7.2	0.2
	Chenopodium album L.	9.2	0.3	7.7	0.4	4.6	0.7	7.2	0.5
	Atriplex sp.	2.9	0.1	3.3	0.2	1.6	0.2	2.6	0.2
	Amaranthus retroflexus L.	3.4	0.1	3.1	0.2	7.2	0.3	4.6	0.2
	Persicaria maculata RAF. S. F. GRAY	4.1	0.2	4.7	0.3	5.1	0.4	4.6	0.3
	Tithymalus helioscopia (L.) Scop.	2.3	0.1	1.4	0.1	4.2	0.3	2.6	0.2
	total	28.5	1.0	27.1	1.4	30.8	2.2	28.8	1.5
Overwinter	*Tripleurospermum perforatum* (L.) SCHULTZ-BIP.)	5.8	0.3	3.4	0.2	2.7	0.1	4.0	0.2
	Galium aparine L.	0.0	0.0	0.7	0.5	0.5	0.4	0.4	0.3
	Stellaria media (L.) Vill.	0.2	0.0	1.3	0.1	2.4	0.1	1.3	0.1
	Capsela bursa-pastoris (L.) Med.	0.4	0.0	3.5	0.2	5.3	0.3	3.1	0.2
	Thlaspi arvense L.	0.7	0.0	1.5	0.1	2.8	0.1	1.7	0.1
	total	7.1	0.4	10.4	1.1	13,7	1.0	10.4	0.8
Perennial	*Elytrigia repens* (L.) DESV	1.0	1.0	0.0	0.0	9,1	3.7	3.4	1.6
	Cirsium arvense (L.) SCOP.	0.0	0.0	0.0	0.0	1,5	1.7	0.5	0.6
	Convolvulus arvensis L.	1.0	1.0	0.0	0.0	2,1	1.3	1.1	0.8
	total	2.0	2,0	0.1	0.0	12,7	6.7	4.9	2.9
Total density		**39.6**	**3.5**	**40.6**	**3.1**	**63.5**	**11.2**	**47.9**	**5.9**

In canopy of sugar beet at the Plavé Vozokany site, the most abundant weed species occurred on treatment without herbicide application listed in decreasing order of abundance were as follows: *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. BEAUV., *Amaranthus retroflexus* L., *Persicaria lapathifolia* (RAF) S. F. GRAY., *Atriplex* spp. (table 8).

Table 8

Weed density (pcs m^2) and species diversity at canopy of sugar beet in the maize growing region - Plavé Vozokany site

Group of weeds	**Weeds**	**1998**		**1999**		**2000**		**Average 1998 - 2000**	
		no herbicides	**treated**	**no herbicides**	**treated**	**no herbicides**	**treated**	**no herbicides**	**treated**
Early-spring	*Avena fatua* L.	1.7	0.3	0,8	0.2	1.6	0.5	1.3	0.3
	Polygonum aviculare L.	2.2	0.2	2,7	0.4	3,4	0.3	2,8	0,3
	total	3,9	0.5	3,5	063	5.0	0.8	4,1	0.6
Late-spring	*Echinochloa crus-galli* (L.) P. BEAUV	5.6	0.3	5.3	0.5	5,8	0,6	5.6	0.5
	Chenopodium album L.	5,3	0.1	4,1	0,2	7,3	0,2	5,6	0,2
	Atriplex spp.	4,1	0.2	3,6	0.1	3,3	0.2	3,7	0.2
	Amaranthus retroflexus L.	4,5	0.3	4,8	0,4	5,4	0,4	4,9	0,4
	Persicaria lapathifolia (RAF) S. F. GRAY	2.3	0.4	3,5	0.6	6.1	0,5	4.0	0.5
	total	21.8	1.3	21.3	1.8	25.9	1.9	23.8	1,8
Overwinter weeds	*Tripleurospermum perforatum* (L.) SCHULTZ-BIP.)	2,6	0.3	2,6	0.6	2.4	0.4	2,5	0.4
	Galium aparine L.	2,4	0.6	0,4	0.1	0,3	0.1	1,0	0.3

	total	5.0	0,9	3.0	0,7	2,7	0,5	3,5	0.7
Perennial weeds	*Cirsium arvense* (L.) SCOP.	2.4	0,7	0.8	0,3	2.0	0,6	1.7	0,5
	Convolvulus arvensis L.	1.1	0,2	1.3	0,3	1.0	0.2	1.1	0,2
	total	3.5	0,9	2,1	0,6	3,0	0,8	2.8	0,7
Total density		**34,7**	**3,8**	**30,0**	**3,7**	**39,0**	**4.1**	**34,2**	**3,8**

Under herbicide control the high density of *Echinochloa crus-galli* (L.) P. BEAUV., *Persicaria lapathifolia* (RAF) S. F. GRAY., *Cirsium arvense* (L.) SCOP., *Amaranthus retroflexus* L., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., was noted.

In the sugar beet growing region (table 9) at locality Santovka on control treatments the high abundance have *Echinochloa crus-galli* (L.) P. BEAUV., *Chenopodium album* L., *Amaranthus retroflexus* L.) *Atriplex* spp., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP. On chemically control treatments the most abundant weed species were in order of importance *Elytrigia repens* (L.) DESV, *Amaranthus retroflexus* L., *Avena fatua* L., *Cirsium arvense* (L.) SCOP. and *Convolvulus arvensis* L. Total weed density in canopy of sugar beet vary from 30 to 39 at Plavé Vozokany fields and from 36.7 to 45.6 plants at Santovka fields, with the highest density in dry year condition in 1999. Herbicides application effectively decreased the weed infestation in an average up to 3.8 at Plavé Vozokany fields and 4.1 plants per m^2 at Santovka fields. During dry year condition the effectiveness of herbicides application was substantially less in Santovka fields with total weed density of 14.3 weeds per m^2. According result of TÝR et al. (2011) the most dangerous weed species are *Persicaria* spp., *Amaranthus* spp., *Atriplex* spp., *Chenopodium* spp., and *Echinochloa crus-galli* (L.) P. BEAUV., which infested more than 90% of sugar beet fields in maize and sugar beet production region.

Table 9

Weed density (pcs m^2) and species diversity at canopy of sugar beet in the sugar beet growing region - Santovka site

Group of weeds	**Weeds**	**1998**		**1999**		**2000**		**Average 1998 - 2000**	
		no herbicides	**treated**	**no herbicides**	**treated**	**no herbicides**	**treated**	**no herbicides**	**treated**
Early-spring	*Avena fatua*	1.1	1,2	1,6	07	6,0	0,3	2,9	0.7
	Fallopia convolvulus	1,3	0.3	0,8	0.1	0,6	0.1	0,9	0,2
	total	2,4	1.5	2,4	0,8	6,6	0.4	3,8	0.9
Late-spring	*Echinochloa crus-galli*	12.0	0.2	11,0	0.9	12,0	0,5	11,3	0.5
	Chenopodium album	8,0	0.,3	7,0	0,2	6,0	0,1	7,0	0,2
	Atriplex spp.	3,3	0,1	3,7	0.2	3,3	0.1	3,4	0.1
	Amaranthus retroflexus.	4,5	0.6	4,3	0,7	4,4	0,9	4,4	0,7
	Persicaria lapathifolia	2.1	0.7	2,4	1,2	2,6	0,7	2,4	0.3
	total	29.9	1.9	28.4	3,2	28.3	2,3	28.5	1,8
Overwinter weeds	*Tripleurospermum perforatum*	3,0	0.3	4,2	0.1	2.1	0.8	3,1	0.4
	Galium aparine	0,01	0.01	0,6	0.5	0,4	0.2	0,3	0.2
	total	3.0	0,3	4,8	0,6	2,5	1,0	3,4	0.6
Perennial weeds	*Cirsium arvense*	0,3	0,9	2,5	0,9	0,4	1,2	1.2	0,7
	Convolvulus arvensis	0,5	0,9	1.1	0,3	4.0	0.9	1.9	0,7
	Elytrigia repens	0,5	1,1	6,4	8,5	0,01	0,01	2,3	3,2
	total	1,3	2,9	10,0	9,7	4,4	2,1	5,4	4,6
Total density		**36,7**	**6,5**	**45,6**	**14,3**	**42,0**	**5,0**	**41,1**	**7,9**

The most abundant weed species in canopy of maize cropping at maize growing region (table 10) on control treatment without herbicide application listed in decreasing order of abundance as follows: *Chenopodium album* L., *Setaria viridis* (L.) P. BEAUV, *Echinochloa crus – galli* (L.) P. BEAUV. *Persicaria lapathifolia* (RAF) S. F. GRAY and, *Atriplex* spp. All mentioned species belong to late spring group of weeds. On herbicide control fields perennial weed *Cirsium arvense* (L.) SCOP., with average number of 2.9 plants per square meter was determined, followed by *Convolvulus arvensis* L., *Echinochloa crus – galli* (L.) P. BEAUV. and *Persicaria lapathifolia* (RAF) S. F. GRAY (table 10). The late-spring weeds created the largest pressure also at locality Santovka. The most abundant weeds were *Echinochloa crus –*

galli (L.) P. BEAUV, *Chenopodium album* L., *Atriplex* spp., *Convolvulus arvensis* L *Amaranthus retroflexus* L., *Fallopia* convolvulus (L.) A. LOVE *Avena fatua* L. On sprayed treatments the most abundant weed species were *Echinochloa crus – galli* (L.) P. BEAUV., *Convolvulus arvensis* L., *Cirsium arvense* (L.) SCOP., *Fallopia* convolvulus (L.) A. LOVE, *Elytrigia repens* (L.) DESV., *Avena fatua* L. (table 11). Total weed density in canopy of maize vary from 33.8 to 44.3 at Plavé Vozokany fields and from 26.6 to 40 plants at Santovka fields with the highest density in dry year condition in 2000. Herbicides application effectively decreased the weed infestation in an average from 7.2 at Plave Vozokany fields to 14.7 plants per m^2 at Santovka fields. During dry year condition the effectiveness of herbicides application was substantially less in Santovka fields with total weed density of 21 weeds per m^2. According results of TÝR and VEREŠ (2012) one of the most dangerous weed species in canopy of maize are *Chenopodium* spp., *Amaranthus* spp., and *Echinochloa crus-galli* (L.) P. BEAUV in maize growing region and *Persicaria* spp., *Atriplex* spp., and *Echinochloa crus-galli* (L.) P. BEAUV at sugar beet growing region of Slovak Republic. The total abundance of weeds in row crops without herbicidal treatments ranged from 26.60 pcs to 63.50 per m^2. Herbicides application effectively decreased the weed infestation in range from 3.13 pcs to 21.10 pcs per m^2.

Table 10

Weed density (pcs m^2) and species diversity at canopy of maize in the maize growing region - Plavé Vozokany site

Weeds		1998		1999		2000		Average 1998 - 2000	
		no herbicides	treated	no herbicides	treated	no herbicides	treated	no herbicides	treated
Early-spring	*Avena fatua*	2.2	0.2	0,01	0.01	0.01	0.01	0.73	0.07
	Fallopia convolvulus	0.5	0.1	1.4	0.4	0.5	0.1	0.80	0,20
	total	2.7	0.3	1.4	0.4	0.5	0.1	1.53	0.27
Late-spring	*Echinochloa crus – galli*	6.1	0.4	5.8	0.3	8.2	1.2	6.70	0.63
	Chenopodium album	4.2	0,2	3,4	0.1	5.4	0.6	4.66	0.33
	Atriplex spp.	3.2	0.3	4,5	0.3	2.6	0.1	3.43	0.23
	Setaria viridis	7,3	0,5	2,7	0,2	4,5	0,2	4,83	0,3
	Persicaria lapathifolia	1.5	0.1	2.5	0.1	9.1	1.2	4.36	0.45
	total	22.3	1.5	18.9	1.0	29.8	3.3	26,37	1.94
Overwinter weeds	*Tripleurospermum perforatum*	1.6	0.1	1.9	0.1	2.6	0.3	1.90	0.16
	Galium aparine	2.2	0.6	3.7	0.8	3.2	0.7	3.03	0.70
	Capsela bursa-pastoris	2.3	0.2	4.7	0.9	2.2	0.3	3.06	0.27
	total	6.1	0.9	10.3	1.8	8.0	1.3	8.99	1.13
Perennial	*Cirsium arvense*	2.2	2.9	0.8	1.1	1.9	2.4	1.63	2.13
	Convolvulus arvensis	1.0	1.2	1.4	1.8	1.1	1.4	1.23	1.47
	total	3.2	4.1	2.2	2.9	3.0	3.8	2.86	3.47
Total		**34.3**	**6.8**	**33.8**	**6.3**	**44.3**	**8.5**	**36.69**	**7.20**

Table 11

Weed density (pcs m^2) and species diversity at canopy of maize in the sugar beet growing region - Santovka site

Weeds		1998		1999		2000		Average 1998 - 2000	
		no herbicides	treated	no herbicides	treated	no herbicides	treated	no herbicides	treated
Early-spring	*Avena fatua*	0.01	0.01	0.01	0.01	5.7	2.0	1.90	0.66
	Fallopia convolvulus	2.5	0.2	1.5	1.0	1.0	1.0	2.00	1.33
	Polygonum aviculare	0.01	0.01	0.01	0.01	3.0	1.0	1.00	0.33
	total	2.5	2.0	1.5	1.0	9.7	4.0	4.90	2.32
Late-spring	*Echinochloa crus – galli*	17.0	8.0	15.0	0.3	16.0	5.0	16.0	4.43
	Chenopodium album	7.1	0.4	5.5	0.3	6.6	1.0	6.46	0.56
	Atriplex spp.	3.6	0.1	4.0	0.2	5.0	0.4	4.20	0.23
	Amaranthus retroflexus	1.5	0.1	1.5	0.1	3.0	1.0	2.00	0.40
	Setaria viridis	0.01	0.01	0.01	0.01	5.0	1.0	1.66	0.33
	total	29,2	8.4	26.0	0.9	35.6	8,4	30.32	5.95
Overwinter	*Tripleurospermum*	0.01	0,01	5.0	1.0	0.01	0.01	1.66	0.33

	perforatum								
	total	0.01	0.01	5.0	1,0	0,01	0.01	1.66	0.33
Perennial	*Elytrigia repens*	0.01	0.01	0.01	0.01	2,0	2.7	0.66	0.90
	Cirsium arvense	0.3	0.7	5.0	8.0	0,01	0.01	1.76	2.90
	Convolvulus arvensis	0.01	0.01	2.0	3.0	6,0	6.0	2.66	3.00
	total	0.32	0.72	7.01	11.01	8.01	8.71	5.08	5.80
Total		**32.00**	**11.30**	**26.60**	**14.90**	**40.00**	**21.10**	**39.96**	**14.76**

The most dominant weed species were one year late spring weeds *Echinochloa crus – galli* (L.) P. BEAUV, *Chenopodium album* L., *Amaranthus retroflexus* L., *Atriplex* spp., and *Persicaria lapathifolia* (RAF) S.F.GRAY in the canopy of row crops. Another most abundant weeds species designated as very dangerous species were *Tripleurospermum perforatum* (L. SCHULTZ-BIP), *Cirsium arvense* (L.) SCOP., *Convolvulus arvensis* (L.), *Avena fatua* (L.), and *Elytrigia repens* (L.) DESV). Higher weed infestation was noted in the growing years when early spring to early summer was warm and humid. Lower weed infestation was observed when this period was dry. Herbicides application effectively reduced the weed infestation to the 5.9 pcs m^{-2} in sugar beet fields up to 11.0 pcs m^{-2} in maize fields.

CONCLUSIONS

According field evaluation of weed diversity and weed density at canopy of sunflower, maize and sugar beet we determined the most dominant and problematic weed species at the most productive agricultural areas – maize and sugar beet growing region of Slovakia. Weed pressure was evaluated according higher weed density on zero treatments.

Weed infestation in sunflower field. The higher weed infestation in sunflower on zero treatments cropping in maize growing region we determined as follows: *Chenopodium album* L., *Atriplex* spp. and *Echinochloa cruss-galli* (L.) P. BEAUV. At sugar beet growing region site we determined high density of *E. crus-galli* (L.) P. BEAUV. and *Ch. album* (L.).

Under herbicides control, in field located at maize growing region we determined high density of: *Cirsium arvense* (L.) SCOP., *Chenopodium album* (L) *Convolvulus arvensis* (L.), *Amaranthus retroflexus* (L.), *Tripleurospermum perforatum* (L.) SCHULTZ-BIP and in sugar beet growing region site *Elytrigia repens* (L.) DESV, *Convolvulus arvensis* (L.), *Avena fatua* (L.), *Cirsium arvense* (L.) SCOP., *Chenopodium album* (L.)

Weed infestation in sugar beet field. The high density of weed infestation in canopy of sugar beet on zero treatment in maize growing region site listed in decreasing order of abundance are as follows: *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. BEAUV., *Amaranthus retroflexus* L, *Persicaria lapathifolia* (RAF) S. F. GRAY., *Atriplex* spp. At the sugar beet growing region *Echinochloa crus-galli* (L.) P. BEAUV., *Chenopodium album* (L.), *Amaranthus retroflexus* (L.), *Atriplex* spp., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP.

Under herbicide treatments in maize growing region the high density of *Echinochloa crus-galli* (L.) P. BEAUV., *Persicaria lapathifolia* (RAF) S. F. GRAY., *Cirsium arvense* (L.) SCOP., *Amaranthus retroflexus* (L.), *Tripleurospermum perforatum* (L.) SCHULTZ-BIP. was noted, and at sugar beet growing region the most abundant weed species were in order of importance *Elytrigia repens* (L.) DESV, *Amaranthus retroflexus* (L), *Avena fatua* (L.), *Cirsium arvense* (L.) SCOP. and *Convolvulus arvensis* (L.)

Weed infestation in maize field. The high density of weed infestation in canopy of maize cropping in maize growing region on zero treatment listed in decreasing order of abundance as follows: *Chenopodium album* L. *Setaria viridis* (L.) P. BEAUV, *Echinochloa crus – galli* (L.) P. BEAUV. *Persicaria lapathifolia* (RAF) S. F. GRAY and *Atriplex* spp. In sugar beet growing region the most abundant weeds were *Echinochloa crus – galli* (L.) P.

BEAUV, *Chenopodium album* L., *Atriplex* spp., *Convolvulus arvensis* L *Amaranthus retroflexus* L., *Fallopia convolvulus* (L.) A. LOVE *Avena fatua* L.

On herbicide control fields in maize growing region dominated *Cirsium arvense* (L.) SCOP., followed by *Convolvulus arvensis* L., *Echinochloa crus – galli* (L.) P. BEAUV. and *Persicaria lapathifolia* (RAF) S. F. GRAY and in sugar beet growing region on sprayed treatments the most abundant weed species were *Echinochloa crus – galli* (L.) P. BEAUV., *Convolvulus arvensis* L., *Cirsium arvense* (L.) SCOP., *Fallopia convolvulus* (L.) A. LOVE, *Elytrigia repens* (L.) DESV., *Avena fatua* L.

The highest weed infestation was in canopy of sunflower with average amount of 46.4 pcs m^{-2} of weed plants. The same level of weed infestation was counted in canopy of sugar beet and maize fields in range of 37.7 pcs m^{-2}- 38.0 pcs m^{-2}. Herbicides application effectively reduced weed infestation.

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