Original Paper

Weed control in sunflower (*Helianthus annuus* L.) on the interface of agro-climatic conditions of maize and sugar beet growing region

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In the experiment, we focused on the occurrence of weed density and weed diversity, in maize and sugar beet growing region and the effectiveness of herbicide treatments on field experiment performed on site Santovka and Plavé Vozokany in canopy of sunflower (*Helianthus annuus* L.) in 1998–2000. Plavé Vozokany site is located in the south-eastern part of the district Levice in maize growing production region. The average daily air temperature in the region is a 9.6 °C, and the annual amount of rainfall represents 604 mm and 330 mm during the growing season respectively. Santovka, the second experimental site, is located in the north-eastern part of the district of Levice in sugar beet growing region. The average daily air temperature in the region is 9.2 °C and the annual amount of rainfall represents 637 mm and the annual amount of rainfall during the growing season is a 354 mm. Actual weed infestation was carried out by the numerous method with a five replication on the control treatments (without herbicide application), as well as on the areas treated with herbicides. The occurrence of weeds in sunflower was assessed for 3 times per growing season. The evaluated sites were infested on the level of high weed infestation. The total abundance of weeds without herbicidal treatments ranged from 39.62 pcs to 63.50 per m^{-2}. Herbicides application effectively decreased the weed infestation in range from 3.13 pcs to 14.81 pcs per m^{-2}. The most dominant weed species were one year late spring weeds as follows: *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Persicaria lapathifolia* RAF. S. F. GRAY, *Persicaria maculata* RAF. S. F. GRAY, *Amaranthus retroflexus* L. and *Atriplex* spp. in the canopy of sunflower. Another most abundant weeds species designated as very dangerous species were *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., *Avena fatua* L., *Elytrigia repens* (L.) DESV, *Cirsium arvense* (L.) SCOP. and *Convolvulus arvensis* L. In pursuing the weed species diversity, we found medium relationship with air temperature during the year (r = 0.363427), and indirect relationship with rainfall pattern (r = -0.08196). The average weed density was in negative relationship with the air temperature (r = -0.98317), but strongly related to rainfall (r = 0.889926). 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. Differences in overall weed infestation, as well as the effectiveness of the used herbicides between experimental sites were at the same level of importance.

Keywords: sunflower, herbicides control, weed density, weed diversity

1. Introduction

All plants in the agrophytocenoses are strongly influenced by human activities and habitat factors, which includes primarily soil and weather conditions of particular year. Among these factors other factor is need to include, such as the relief of area, the exposure of field and structure of growing crops (Aldrich and Kremer, 1997; Stephenson, 2000).

Influence of weather conditions on yield and yield forming components of sunflower has been described precisely by Černý et al. (2011, 2012 a, 2012 b), they found a significant influence of year weather conditions to specific yield forming components of sunflower.

Weed control in sunflowers is one of the most critical elements in a management system that optimizes yield and quality. Sunflowers are planted at low densities and develop slowly during the initial weeks after planting. Weed competition with sunflowers during the first four weeks after crop emergence from species adapted to cool conditions, like wild mustard, kochia and wild oat, can reduce sunflower yield by 30 %. Once sunflowers become established they compete more effectively with weeds. Herbicide options for sunflowers have expanded, but there is a need for an integrated approach to maintain successful weed management strategies to preserve yield potential. Air temperature, rainfall, as well as wind can significantly effect the action of applied herbicides, e.g. some active ingredients of herbicides act poorly at low air temperatures (Pannacci et al., 2007). In addition to the air temperature the soil temperature is one of the factors that significantly influences the germination and emergence of seeds of sunflower, but also of the weeds

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because soil temperature (especially in the surface layers) is strongly dependent on the air temperature and is a periodic function of the time – daily and annual fluctuations (Aboudrare et al., 2006).

As reported by Mikulka et al. (1999), sunflower yield losses due to occurrence of weeds make up to 10 %. Gradually increasing the acreage of sunflower growing areas in the Slovak Republic tends to strongly weed infestation on lands where sunflower grown. Prevalent weeds occurred in sunflower canopy are from Asteraceae family. Weed as a harmful factor in canopy of sunflower have the possibility to grow from early spring until early autumn (Smatana et al., 2008).

In Slovakia, economically important weeds are as follows: *Cirsium arvense* (L.) SCOP, *Elytrigia repens* (L.) DESV, *Chenopodium album* L., *Amaranthus retroflexus* L., *Chenopodium hybridum* L., *Sinapis arvensis* L., *Datura stramonium* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Persicaria lapathifolia* RAF. S. F. GRAY, *Persicaria maculata* RAF. S. F. GRAY, *Fallopia convolvulus* L. A. LOVE, *Avena fatua* L., *Convolvulus arvensis* L., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., *Iva xanthiifolia* (L.) NUTT., *Galinsoga parfiflora* CAV. and others (Kohout, 1993; Rapparini, 2006; Smatana et al., 2008).

A weed as harmful factors, however, occurs in crop plants every year at different species and density. Weed infestation of sunflower crops depends on seed bank of viable seeds and weed vegetative organs in soil, weather conditions during the winter, spring and summer, primary tillage, pre-sowing tillage, suitable forecrop, sowing dates and quality of seeding process, and crop condition etc. (Smatana, 2003).

Sunflower is sown at the time when the soil is already sufficiently heated up and the plants growths during the 9–12 days. Temperature conditions positively influences the emergence of weeds, what resulting to the necessity to maintain interrow area clean from emergence of sunflower up to canopy establishment (Líška et al. 2002; Elezovic et al., 2012). As reported Smatana (2003), sunflower as row crops, even at optimal density, good condition, good health and the favourable weather is unable compete against weeds and suppress its below the biological and economical threshold of harmfulness during this relatively long period.

Application of appropriate selective herbicides on weeds in the early growth stage of sunflower is globally important aspect of growing sunflower, both from an economic as well as ecological and environmental aspect (Černuško et al., 1994; Kavdir, 2004).

In terms of sustainable and ecologically sound approaches would be appropriate gradually subside use of herbicides and begin to fully implement by preventive measures (cleaning seeds and, suitably date of harvest and post-harvest treatment, management of farmyard manure, weed control outside the agricultural production area, care of birds, etc.). We can broadly use indirect measures (properly crop rotation and appropriate cropping patterns, balanced nutrition and fertilization of plants, selection and cultivation of suitable crops and local varieties. Direct action, of which is significant mechanical tillage (primary, pre-sowing and cultivation interventions in vegetation during the growing season), followed by physical (flame weeder, electric current, infrared and gamma radiation) and biological (use of bio agents – natural enemies of weeds) (Leather, 1987; Grace and Tilman, 1990; Rawat et al., 2013).

The aim of the research was to assess the density and species diversity of weeds in canopy of sunflower and evaluation of herbicide activity and protection in agro-climatic conditions in maize production region (locality Plavé Vozokany) and sugar beet production region (locality Santovka) during three production years of 1998–2000 and evaluation of the impact of different agro-climatic conditions of the occurrence of weeds in sunflower fields.

2. Material and methods

Spring and summer weather condition of main experimental plots at Plavé Vozokany site are shown in the Table 1.

The first location Plavé Vozokany is located in the south-eastern part of the district of Levice in maize production region. Altitude of area ranges from 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 average daily air temperature in the region (9.6 °C) classified the region as warm and very dry region. The annual amount of rainfall represents 604 mm and the annual amount of rainfall during the growing season reaches 330 mm. Santovka, the second location is located in the north-eastern part of the district of Levice in sugar beet production area. Altitude of the area ranges from 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 less (9.2 °C) than the Plavé Vozokany site, but 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 of the occurrence of individual weed species under rating scale of current weed infestation shown in Table 2. The occurrence of weeds in sunflower was assessed for 3 times per growing season in five replications, on the control plots (without herbicide treatment), as well as on the areas treated with herbicides. The first evaluation was conducted in the spring before application of herbicides on both sites equally. The second evaluation was carried

Table 1 Climatic conditions in the spring and summer months at Plavé Vozokany site, in the years 1998–2000

Months		1998		1999		2000	
		temperature in °C	rainfall in mm	temperature in °C	rainfall in mm	temperature in °C	rainfall in mmt
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 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

Table 2 Actual weeds density scoring system

Group of weeds	Actual weeds density description				
	no	unique	weak	medium	strong
	degree of weedy				
	0	1	2	3	4
	number of weeds plant (pcs 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

Table 3 Herbicides used and date of application expressed in active ingredients and commercial name of herbicides at Plavé Vozokany and Santovka experimental site

Year		Herbicides used	
		Plavé Vozokany site	Santovka site
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)

out during the growing phase of 4–8 leaves (BBCH 14–8). The third evaluation was carried out in the inflorescence emergence (BBCH 54–55) phase or full flowering phase (BBCH 61–65) of sunflower. In addition the number of weeds and the total effectiveness of applied herbicides were evaluated. Actual weed infestation was evaluated according Table 2.

Herbicides used (active ingredient – terms of applications (T1–T3) and the commercial name of the herbicide) are shown in Table 3.

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In the Plavé Vozokany site sunflower was grown annually on 42–60 % fields after cereal forecrop (winter wheat, spring barley), in location Santovka grown annually on 36–45 % fields after cereal forecrop (winter wheat, spring barley, maize) in one case sunflower was grown after legumes and alfalfa. The results were processed and evaluated by Stat graphic 5.0 software.

3. Results and discussion

In 1988, spring was dry and warm with comparison to LTA, autumn on the contrary was wet and cold. 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., *Capsella bursa-pastoris* (L.) MEDIC., *Echinochloa cruss-galli* (L.) P. BEAUV., *Atriplex* spp., *Stellaria media* (L.) VILL. and others. On the herbicides treatments, the high density of *Cirsium arvense* (L.) SCOP., *Convolvulus arvensis* L., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., *Galium aparine* L., *Chenopodium album* L. was noted.

In the locality Santovka on treatments without herbicides application the most abundance was noted by *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. BEAUV., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., *Persicaria maculata* (RAF) S. F. GRAY, *Amaranthus retroflexus* L.

On sprayed treatments the most abundant weed species were (in order of importance) *Elytrigia repens* (L.) DESV, *Convolvulus arvensis* L., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., *Chenopodium album* L., *Persicaria maculata* (RAF) S. F. GRAY.

The year 1999 was characterised by warm and moderately dry weather condition, summer was wet and warm, and autumn was cold and dry. The higher density of *Persicaria lapathifolia* (RAF) S. F. GRAY, *Echinochloa crus-galli* (L.) P. BEAUV., *Atriplex* spp., *Lamium purpureum* L., *Amaranthus retroflexus* L. was noted on control treatments at the locality Plavé Vozokany.

On the herbicide treatments the most abundant species were as follows: *Chenopodium album* L., *Lamium purpureum* L., *Convolvulus arvensis* L., *Amaranthus retroflexus* L., *Cirsium arvense* (L.) SCOP. and others. In the same year, the higher abundance of *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Persicaria maculata* (RAF) S. F. GRAY, *Capsella bursa-pastoris* (L.) MEDIC., *Tripleurospermum perforatum* (L.) SCHULTZ-BIP. was noted on control treatments without application of herbicides on the locality Santovka. On herbicides treatments the highest density of *Avena fatua* L., *Galium aparine* L., *Chenopodium album* L., *Persicaria maculata* (RAF) S. F. GRAY, *Capsella bursa-pastoris* (L.) MEDIC.) and others species was determined.

Year 2000 was characterised by wet and warm spring, and warm and dry summer and autumn. In this year, lack of precipitation creates very dry condition. In 2000, the most abundant weed species determined on control treatments were as follows: *Chenopodium album* L., *Atriplex* spp., *Amaranthus retroflexus* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Persicaria lapathifolia* (RAF) S. F. GRAY and other on the Plavé Vozokany site. Plots sprayed by herbicides were infested predominantly by *Chenopodium album* L., *Cirsium arvense* (L.) SCOP., *Amaranthus retroflexus* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Persicaria lapathifolia* (RAF) S. F. GRAY and others.

In the same year, sunflower fields at Santovka location were infested mainly by *Elytrigia repens* (L.) DESV, *Echinochloa crus-galli* (L.) P. BEAUV, *Amaranthus retroflexus* L., *Avena fatua* L., *Capsella bursa-pastoris* (L.) MEDIC.) on control treatment. Herbicides treatments were infested mainly by *Elytrigia repens* (L.) DESV, *Cirsium arvense* (L.) SCOP., *Avena fatua* L., *Convolvulus arvensis* L., *Chenopodium album* L. and others. According result of weed density and weed diversity the perennial weed were dominant group of weeds in 2000. Due to the deeper root system perennial weeds had better potential for growing in this dry period.

In case of warm and wet condition during summer, the follow-up weedness of *Amaranthus retroflexus* L., *Echinochloa crus-galli* (L.) P. BEAUV was noted. In this favourable condition regeneration capability of *Elytrigia repens* (L.) DESV was also increased. Warm and early spring of 1999 with lack of precipitation stimulate germination of seeds and sprouting of vegetative reproductive organs from deeper soil layer such as *Avena fatua* L., *Cirsium arvense* (L.) SCOP. and *Convolvulus arvensis* L.

In pursuing the total number of weed species we found the medium relationship on air temperature during the year (r = 0.363427), with rainfall indirect dependence (r = -0.08196). The average weed abundance was in the indirect dependence of the air temperature (r = -0.98317), but strongly dependent on rainfall (r = 0.889926) at Plavé Vozokany site.

Weed infestation was higher in the growing years when early spring to early summer was warm and humid. When this period was dry lower weed infestation was noted. The results we obtained correspond to the results reported by Smatana et al. (2008), that in canopy of sunflower the most abundant weeds are: *Cirsium arvense* (L.) SCOP., *Persicaria* sp., *Echinochloa crus-galli* (L.) P. BEAUV, *Chenopodium* spp. and *Elytrigia repens* (L.) DESV.

Our results are with concordance to Cigľar et al. (2000), who claims that in canopy of sunflower most frequently occurred weeds are *Chenopodium* spp., *Echinochloa crus-galli* (L.), *Persicaria* spp. and *Amaranthus retroflexus* L. On spite of Cigľar et al. (2000) finding we have no evidence about occurrence *Datura stramonium* L., in sunflower fields. According results of Smatana (2003) in maize and sugar beet grooving region, the dominant

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weed species in canopy of sunflowers were *Cirsium arvense* (L.) SCOP., *Persicaria* sp., *Elytrigia repens* (L.) DESV and *Echinochloa crus-galli* L. As reported Kavdir (2004), the most represented weed in crops of sunflower studied in the territory of Turkey was common cocklebur (*Xanthium strumarium* L.), belonging to the same family as the sunflower. In our experimental site in Slovakia this weed species does not occur. Khan et al. (1988), who focused on occurrence of monocot weeds in agro-climatic conditions of Pakistan claims that most species were represented by bermudagrass (*Cynodon dactylon* L.), johnsongrass (*Sorghum halapense* L. Pers.), junglerice (*Echinochloa colonum* L.), and crowfootgrass (*Dactyloctenium aegyptium* L.). The results obtained by mentioned author come from another climatic zone, and thus are significantly different from our results.

On the experimental plots treated with herbicides, later occurred mainly perennial weeds and annuals late spring weeds which emerged after the expiry of applied herbicides, in all studied years in both locations. The effectiveness of the applied herbicides was very good even excellent (with respect for their ineffectiveness on perennial weeds). Differences in overall weed infestation, as well as the effectiveness of the herbicide between monitored sites were not evident.

When studying of short-term changes in plant communities, it is necessary to respect the fact that plant communities at every moment of its existence are going through various phases of seasonal development, as also mentioned Líška et al. (2008). Knowledge of interactions between weeds and influences affecting its species and numerous representation on a plot, can significantly contribute to better decision-making process in a rational regulation of weeds (Kohout, 1993).

Effective weed control system must be created, based on deep knowledge of the cause of reproduction of certain weed species and knowledge of its biological properties. We confirmed also the contentions

Table 4 Occurrence of weeds in the site Plavé Vozokany during 1998–2000 in pcs m^{-2}

Group of weeds	Weeds	1998		1999		2000		Average 1998–2000	
		without spraying	treated	without spraying	treated	without spraying	treated	without spraying	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 sp.	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
	Capsella 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

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Table 5 Occurrence of weeds in the site Santovka during 1998 – 2000 in pcs m^{-2}

Weeds		1998		1999		2000		Average 1998–2000	
		without spraying	treated	without spraying	treated	without spraying	treated	without spraying	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
	Capsella 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

mentioned by Pannaci et al., (2007), that it is necessary to use herbicides rationally and economically. Therefore it is necessary to precisely determine the prognosis of weed infestation, choose the most suitable herbicide, respectively combination of active substances and select the properly method of its application. The crops sown into wide rows, including the sunflower are very sensitive to weed infestation and generally cannot be successfully grown without chemical or mechanical intervention (Stephenson, 2000). Regulation and use of biological rules seeking to increase the performance of organisms, the method of operation of agricultural systems in terms of creation and protection of landscape space, such as parts of the environment have necessitated the creation and development of new sustainable, ecological, systemic approaches, which represents the understanding of the problems mentioned in the mutual and interactive relationship with harmful organisms, including weeds (Colquhoun, 2006; Líška et al., 2008; Bhadoria, 2011).

Occurrence of weed species on control plots and plots treated with herbicides over the period examined (1998–2000) are shown in Table 4 – Plavé Vozokany location and Table 5 – Santovka location.

4. Conclusions

The evaluated sites were infested on the level of high weed infestation. The total abundance of weeds without herbicidal treatments ranged from 39.62 to 63.50 pcs m^{-2}. Herbicides application effectively reduced the weed infestation to the range from 3.13 pcs m^{-2} to 14.81 pcs m^{-2}. In the canopy of sunflower, the most dominant weed species, belongs to the group of one year late spring weeds, were as follows: *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. BEAUV, *Persicaria lapathifolia* RAF. S. F. GRAY, *Persicaria maculata* RAF. S. F.

GRAY, *Amaranthus retroflexus* L. and *Atriplex* spp. Another most abundant weeds species designated as very dangerous species were *Tripleurospermum perforatum* (L.) SCHULTZ-BIP., *Avena fatua* L., *Elytrigia repens* (L.) DESV, *Cirsium arvense* (L.) SCOP. and *Convolvulus arvensis* L. Concerning to total range of diversity of weed species, the median dependence on air temperature of year (r = 0.363427), and strong indirect relationship with rainfall (r = -0.08196) was found. The average weed density was in the indirect relationship with the average year temperature (r = -0.98317), but strongly dependent on rainfall (r = 0.889926). Infestation of weeds was higher in the growing years when early spring to early summer was warm and humid. Minor weed infestation was recorded when that period was dry. Variations in overall weed infestation, as well as the effectiveness of the herbicides used between evaluated sites were at the same level of significance.

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6. References

ABOUDRARE, A. et al. (2006) Effects of soil tillage and fallow management on soil water storage and sunflower production in semi-arid Mediterranean climate. In *Agricultural Water management*, vol. 83, no. 3, pp. 183–196.
DOI: http://dx.doi.org/10.1016/j.agwat.2005.12.001.

ALDRICH, R. J. and KREMER, R. J. (1997) *Principles in Weed management*. 2nd ed. Iowa : Iowa State University Press, 455 pp.

BHADORIA, P. B. S. (2011) Allelopathy: A Natural Way towards Weed Management. In *American Journal of Experimental Agriculture*, vol. 1, no. 1, pp. 7–20.

COLQUHOUN, J. B. (2006) Allelopathy in weeds and crops: Myths and facts. In *Proc. of the 2006 Wisconsin Fertilizer – Aglime & Pest Management Conference,* vol. 45, pp. 318–320.

CIGĽAR, J. et al. (2000) General Crop Production. 2nd ed. Nitra: SPU (in Slovak).

ČERNUŠKO, K., LÍŠKA, E. and BORECKÝ, V. (1994) *Weeds and Protection Agains Weeds*. Nitra: SPU (in Slovak).

ČERNÝ, I., MÁTYÁS, M. and VEVERKOVÁ, A. (2012a) The Influence of Weather Condition and Biological Material on Yield of Achenes and Fatty Content of Sunflower (*Heliathus annuus* L.). In *Cropping Technologies and Their Importance for Praxis.* Piešťany: Centrum výskumu rastlinnej výroby Piešťany, p. 88–91 (in Slovak).

ČERNÝ, I., PAČUTA, V. and MÁTYÁS, M. (2012 b) Analysis of the impact of weather conditions and biological material for the formation of selected yield forming components and yields of sunflower (*Helianthus annuus* L.). In *Prosperous oil seed crops 2012*. Praha: ČZU in Prague (in Slovak).

ČERNÝ, I. et al. (2011) Yield formation of sunflower due to temperature and moisture conditions of the growing sites. In *Acta fytotechnica et zootechnica*, vol. 54, no. 1, pp. 17–21.

ELEZOVIC, I. et al. (2012) Yield and yield components of imidazolinone-resistant sunflower (*Helianthus annuus* L.) by pre-emergence herbicide and time of post-emergence weed removal. In *Field Crops Research*, vol. 128, no. 3, pp. 137–146.
DOI: http://dx.doi.org/10.1016/j.fcr.2011.12.020.

GRACE, J. B. and TILMAN, D. (1990) *Perspectives on Plant Competition.* San Diego: Academic Press, Inc., 1990.

KAVDIR, I. (2004) Discrimination of sunflower, weed and soil by artificial neural networks. In *Computers and Electronics in Agriculture*, vol. 44, no. 2, pp. 153–160.
DOI: http://dx.doi.org/10.1016/j.compag.2004.03.006.

KHAN, R.U., MORRISON, I.N. and RASHID, A. (1988) Grass weed control in sunflower in the spring and kharif (summer) season under barani (rainfed) conditions in Pakistan. In *Crop protection,* vol. 7, no. 1, pp. 9–15.
DOI: http://dx.doi.org/10.1016/0261-2194(88)90030-0.

KOHOUT, V. (1993) *Weed Control of Field*. Praha: Ministry of Agriculture (in Czech).

LEATHER, G. R. (1987) Weed control using allelopathic sunflowers and herbicide. In *Plant and Soil*, vol. 98, no. 1, pp. 17–23.

LÍŠKA, E. et al. (2002) *Weed Biology*. Nitra: SPU in Nitra (in Slovak).

LÍŠKA, E. et al. (2008) *General Crop Production*. Nitra: SPU in Nitra (in Slovak).

MIKULKA J. et al. (1999) *Weeds of Field, Meadows and Gardens*. Praha: ČZU Praha (in Czech).

PANNACI, E., GRAZIANI, F. and COVARELLI, G. (2007) Use of herbicide mixtures for pre and post-emergence weed control in sunflower (*Helianthus annuus* L.). In *Crop Protection*, vol. 26, no. 8, pp. 1150–1157.
DOI: http://dx.doi.org/10.1016/j.cropro.2006.10.008.

RAPPARINI, G. (2006) Preventive weed control in sunflower. In *L´Informatore Agrario*, vol. 62, no. 10, pp. 44–49.

RAWAT, L. S., MAIKHURI, R. K. and NEGI, V. S. (2013) Inhibitory effect of leachate from *Helianthus annuus* on germination and growth of *Kharif* crops and weeds. In *Acta Ecologica Sinica*, vol. 33, no. 5, pp. 245–252.
DOI: http://dx.doi.org/10.1016/j.chnaes.2013.07.003.

SMATANA, J., MACÁK, M. and VEREŠ, T. (2008) Effect od forecrop on weed infestation of *Helianthus annuus* in the Slovak Republic. In *Lucrari Stiintifice*, vol. 40, no. 1, pp. 489–492.

SMATANA, J. (2003). Actual weed infestation of sunflower in Slovak Republic and their influence by forecrops. In *Sustainable agriculture and rural development*. Nitra: SPU in Nitra, pp. 276–278.

STEPHENSON, G. R. (2000) Herbicide use and world food production: Risk and Benefits. In *Abstract of 3rd International Weed Science Congress, 6–11 June 2000. Foz Do Iguassu, Brazil*. Corvallis: International Weed Science Society, pp. 240.