ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 63 21 Number 1, 2015

http://dx.doi.org/10.11118/actaun201563010153

ANALYSIS OF THE HETEROGENEITY OF WEED INFESTATION IN CEREAL STANDS

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Abstract

WINKLER JAN, LUKAS VOJTĚCH, SMUTNÝ VLADIMÍR. 2015. Analysis of the Heterogeneity of Weed Infestation in Cereal Stands. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 63(1): 153–161.

The aim of this study was to evaluate the heterogeneity of the incidence of individual weed species on a selected experimental field. This field was situated in the cadastre of the village Žabčice (South Moravian Region, Czech Republic). To evaluate the intensity of weed infestation, a field experiment was established. In 2011, altogether 33 weed species were identified in a stand of spring barley. In the next year, the total number of weeds in a stand of winter wheat was 22. Basing on results of the evaluation of infestation heterogeneity it was possible to detect the following trends: The first one concerned the incidence of significantly dominant species *Chenopodium album* and *Veronica hederifolia* in stands of spring barley and winter wheat, respectively. The second one expressed the incidence of the so-called sub-dominant species. Regarding the character of the incidence of these weed species it would be suitable to kill them by means of a targeted application of herbicides. Finally, the third trend concerned the incidence of that group of weeds that occurred in the major part of the experimental plot but in low numbers only. The abundance of these species was minimal and the total number of weed plants did not exceed the limit of 100 specimens. This group of weeds involved also those species that were markedly more frequent on plots situated closer to the margin of the experimental field. The targeted application of herbicides can be performed on plots with a lower level of weed infestation; another possibility, however, seems to be a targeted intervention that helps to control the incidence of a certain weed species and/or that is performed along the margin of the field where the different weed species are more frequent.

Keywords: weeds, cereals, heterogeneity, weed infestation, mapping of weed incidence

INTRODUCTION

Weed management is an expensive affair. Every year, the losses caused by weeds represent more than 10% of the total plant production. Worldwide, the costs associated with the application of herbicides represent more than 60% of the total price of pesticides (Kohout, 1993). Mikulka and Chodová (2000) mentioned that more than 72% of total costs in the domain of plant protection were paid for weed control. Individual weed species differ in their competitive capabilities and in negative effects on yields. This is the reason why different crops are able to tolerate certain levels of weed infestation. According to Loux *et al.* (1998), the final goal of weed control and regulation is not to eradicate 100% of weed species.

The application of herbicides resulted both in acceleration and simplification of operations associated with weed management. Unfortunately, the use of these compounds is also often associated with their negative effects on the environment and health of living organisms (Smutný, Vondra, Kocurek, 2011).

A reduction of production costs, an increase in labour productivity, and the elimination of negative environmental effects can be reached by means of the application based on methods of precision farming and on a variable application of chemicals. This requires a good knowledge of the heterogeneity of individual fields and also of the level of weed infestation. The final result of these activities is a local specification of rules focused on weed control. The development of application technologies and machinery, a rapid progress in the field of electronics, and the possibility of use of the GPS signal for navigation of machines enable to apply herbicides locally in dependence on concrete conditions. A locally specific regulation of weed numbers expects that in locations with a zero and/or subliminal occurrence of weeds, the application of herbicides can be omitted while in those that are treated regularly it can be adapted to and modified in accordance with the degree of weed infestation (Sökefeld *et al.*, 2000).

When using this method of weed control, it is necessary to have well mapped data about the weed infestation of the plot. When mapping and grouping individual weed species, it is necessary to obtain results that are as similar to the real situation as possible and – at the same time – to keep the time consumption at a low level (Hamouz and Soukup, 2006).

The application map presents an area with the above-threshold incidence of a noxious factor on the plot. Using this map together with the navigation system, it is possible to determine points where the valves of a sprayer should be opened and/or closed (Gerhards *et al.*, 2000).

When using conventional methods of weed counting, it is not possible to characterise continually the whole area of larger plots so that it is necessary to use only samples collected in individual points of the developed sampling network. When optimizing the sampling strategy, it is important to remember that the time consumption must be acceptable, that the sampling network used must be sufficiently dense and that the size and the number of sampling points must be also representative. When using methods of discrete sampling, the size of the evaluated area is usually 0.0025 to 2.0000 sq. m· and the size of the sampling grid ranges from 1.8 × 1.8 to 50 × 50 meters (Colbach *et al.*, 2000).

Horne and Schneider (1995) mentioned that the size of the sampling framework is rather dependent on concrete numbers of weed plants. In case that the sampling area is too large and the numbers of weeds too high, the resulting time consumption is also too high. If, however, the numbers of weeds are low, the variability of results is great and the number of zero values is often increased. The creation of full-area maps on the base of results of discrete mapping with a lower number (density) of sampling points can be improved by means of those ancillary data that are closely related to the variability of weed infestation. It is possible to use the method of co-kriging in combination with topographic parameters of terrain (Jurado-Expósito *et al.*, 2009), data about the soil type (Kalivas *et al.*, 2012) or results of measurements of electric conductivity of soil (Kroulik *et al.*, 2011).

The aim of this study was to evaluate the heterogeneity of the incidence of individual weed species on a selected field and – basing on obtained data – to assess possibilities of spot application of herbicides for control of identified weed species.

MATERIAL AND METHODS

The experimental field was situated in the cadastre of the village Žabčice (South Moravian Region, CR), which belongs to the geomorphological region of Dyje-Svratka Valley (Dyjsko-svratecký úval in Czech). This countryside is flat and its mean altitude is 184 metres above sea level. The Žabčice cadastre is classified as a maize-growing region with a very dry and hot climate. Within the period of the last three decades, the average annual temperature was +9.2 °C. The thirty-year average annual sum of precipitation was 483.3 mm (as far as this average was concerned, this locality is classified as dry). Data about precipitation and temperature were recorded in the meteorological station of Mendel University in Žabčice. Long-term averages of precipitations and temperatures are presented in Tab. I. In this locality, the water deficit results from a predominating north-west air circulation. Differences resulting from the predominance of evaporation over precipitations are more pronounced above all in the first half of the year (approximately from March to June). This means that in the major part of the growing season, the crop stands are more dependent on soil humidity and groundwater reserves.

The field experiment was established to evaluate the heterogeneity of weed infestation. In 2011, the incidence of weeds was evaluated in the stand of spring barley while in 2012 the weed infestation was assessed in the winter wheat crop. The total

I: *Long-term averages of precipitations and temperatures as recorded in individual months of the year (1961–1990) and the average monthly temperature and precipitation in the years 2011 and 2012*

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Precipitation (mm)	25	25	24	33	63	69	57	54	36	32	37	26
Temperature (°C)	–0.2	0.2	4.3	9.6	14.6	17.7	19.3	18.6	14.7	9.5	4.1	0.0
Precipitation (mm), (2011)	21.4	4.6	39.3	33.2	46.2	42.9	79.8	42.4	31.1	22.6	1.6	14.6
Temperature (°C), (2011)	–0.4	–0.9	5.4	12.4	15.3	19.4	19.2	20.5	17.1	9.3	2.5	2.2
Precipitation (mm), (2012)	27.4	7.4	2.4	19.8	21.4	101.2	64.6	43.0	40.2	49.2	19.4	35.6
Temperature (°C), (2012)	1.0	–3.4	7.0	10.8	16.9	19.9	21.4	21.2	16.2	9.4	6.5	–1.2

area of the experimental field (32,000 sq. m., i.e. 320 × 100 m) was divided to individual application plots of the size of 50 sq. m (i.e. 5 × 10 m). Their total number was 480 and they represented the smallest separately treated area (and also the area on which the occurrence of weeds was recorded).

These application plots were arranged in 48 bands of 10 plots each (A–I). These bands were further subdivided to establish 4 variants of the application of herbicides; this was done on the base of the noxiousness thresholds. Variant 1 (control) was treated uniformly in a standard manner (SO). In Variants 2, 3 and 4, the thresholds of noxiousness were defined as low (NP), medium (SP), and high (VP), respectively. Each variant involved 4 bands and the experiment had altogether three replications (I–III).

II: *Statistical characteristics of the heterogeneity of spring barley weed infestation*

Weed species	Statistical characteristics (plants per sq. m)						Numbers of registration plots and weed plants per sq.m.				
	Sum	Mean	Median	Modus	Minimum	Maximum	Less than 4 plants per sq.m.	5–9 plants per sq.m	10–19 plants per sq.m	20–29 plants per sq.m	More 30 plants per sq.m
Chenopodium album L.	17,890	37.27	35	25	4	109	1	4	44	121	310
Echinochloa crus-galli (L.) P. B.	9,255	19.28	15	0	0	119	49	76	123	97	98
Lamium purpureum L.	9,033	18.82	15,5	7	0	118	59	73	152	95	90
Stellaria media (L.) Vill.	8,053	16.78	16	17	0	68	39	81	184	130	43
Polygonum aviculare L.	2,678	5.58	3	0	0	55	201	122	58	16	7
Taraxacum scet. *Ruderalia* Kirschner, H. Øll-gaard et Štěpánek	2,151	4.48	3	1	0	20	223	133	57	2	0
Viola arvensis Murray	881	1.84	1	0	0	18	192	57	14	0	0
Thlaspi arvense L.	683	1.42	0,5	0	0	16	205	24	11	0	0
Capsella bursa-pastoris (L.) Med.	521	1.09	0	0	0	21	216	16	2	1	0
Fallopia convolvulus (L.) Á. Löve	272	0.57	0	0	0	7	144	5	0	0	0
Fumaria officinalis L.	138	0.29	0	0	0	10	70	3	1	0	0
Geranium pusillum Burm.	93	0.19	0	0	0	6	58	2	0	0	0
Veronica hederifolia L.	88	0.18	0	0	0	6	46	2	0	0	0
Atriplex patula L.	62	0.13	0	0	0	6	27	4	0	0	0
Anagallis arvensis L.	59	0.12	0	0	0	23	22	1	0	1	0
Trifolium pratense L.	54	0.11	0	0	0	14	23	1	1	0	0
Cirsium arvense (L.) Scop.	42	0.09	0	0	0	7	30	1	0	0	0
Amaranthus retroflexus L.	29	0.06	0	0	0	6	21	1	0	0	0
Papaver rhoeas L.	27	0.06	0	0	0	2	22	0	0	0	0
Elytrigia repens (L.) Nevski	12	0.03	0	0	0	6	3	1	0	0	0
Lapsana communis L.	10	0.02	0	0	0	5	3	1	0	0	0
Sonchus arvensis L.	9	0.02	0	0	0	2	7	0	0	0	0
Cardaria draba (L.) Desv.	7	0.01	0	0	0	1	7	0	0	0	0
Chenopodium hybridum L.	6	0.01	0	0	0	3	4	0	0	0	0
Carduus acanthoides L.	5	0.01	0	0	0	2	4	0	0	0	0
Tripleurospermum inodorum (L.) Schultz-Bip.	5	0.01	0	0	0	1	5	0	0	0	0
Avena fatua L.	5	0.01	0	0	0	2	4	0	0	0	0
Erodium cicutarium (L.) L´Hér.	2	0.00	0	0	0	1	2	0	0	0	0
Silene noctiflora L.	2	0.00	0	0	0	1	2	0	0	0	0
Galium aparine L.	1	0.00	0	0	0	1	1	0	0	0	0
Helianthus annuus L.	1	0.00	0	0	0	1	1	0	0	0	0
Convolvulus arvensis L.	1	0.00	0	0	0	1	1	0	0	0	0
Brassica napus L.	1	0.00	0	0	0	1	1	0	0	0	0

Weed infestation was evaluated on plots of the size of 0.25 sq. m. and there were four replications on each plot. In all cases, all weed species were identified and the numbers of specimens of each species were calculated. Czech and Latin names of individual weed species were published by Kubát (2002).

To define the spatial arrangement of individual species occurring within the framework of this field experiment, combinations of symbols of individual bands of plots (A–I) and of treatment variants (SOI, NPI, SPI, VPI SOII, NPII, SPII, VPII, SOIII, NPIII, SPIII, VPIII) were used. Obtained results were evaluated by means of a multidimensional analysis of ecological data using the Canoco 4.0 software (Ter Braak, 1998).

RESULTS AND DISCUSSION

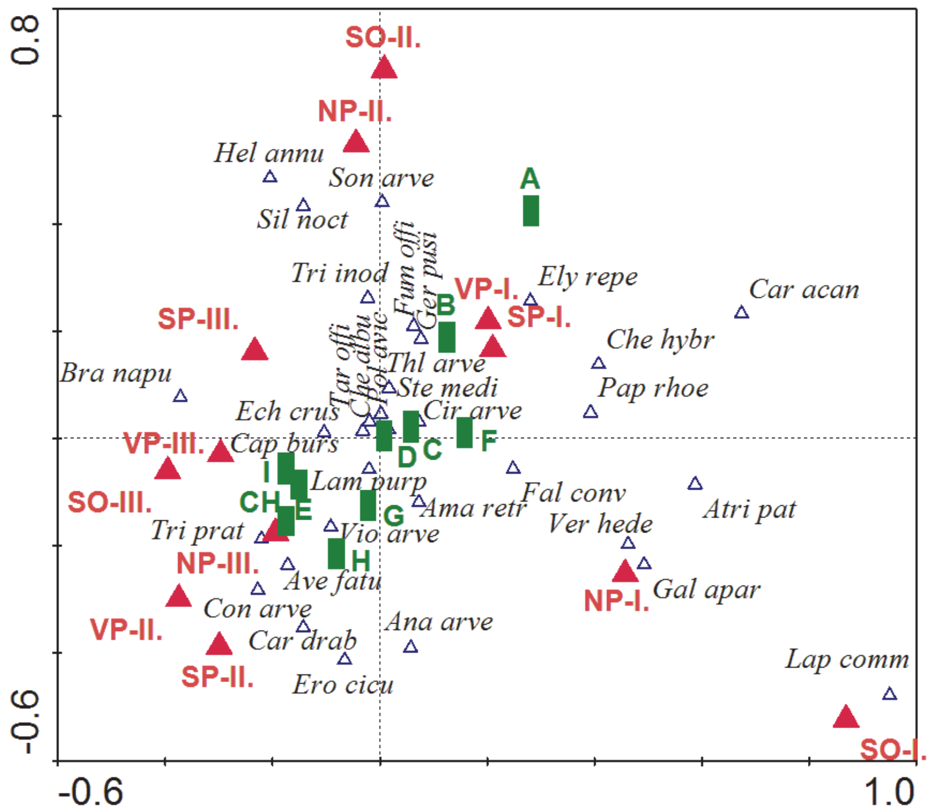
In 2011, altogether 33 weed species were identified in stands of spring barley. Statistic characteristics of the weed infestation heterogeneity are presented in Tab. II. In 2012, the total number of weed species found in stands of winter wheat was 22. Statistic characteristics of the weed infestation heterogeneity are presented in Tab. III.

At first, the evaluation of the heterogeneity of the incidence of individual weed species occurring in the stand of spring barley was performed by means of the Detrended Correspondence Analysis (DCA) and the gradient length estimate was 3.924. This value was thereafter used in the Canonical Correspondence Analysis (CCA). The significance of results was tested by means of the Monte-Carlo method and the total number of calculated permutations was 499.

Results of CCA are significant at the α level = 0.002 that evaluated the incidence of weeds in the stand of spring barley. This result if presented graphically as an ordination diagram (Fig. 1). Identified weed species can be classified into several groups. The first one occurred above all on plots situated nearer to the field margins (bends of plots „A“, and bends

III: *Statistical characteristics of the heterogeneity of winter wheat weed infestation*

Statistical characteristics (plants per sq. m)	Numbers of registration plots and weed plants per sq.m.						Statistical characteristics T(plants per sq. m)				
	Sum	Mean	Median	Modus	Minimum	Maximum	Less than 4 plants per sq.m.	5–9 plants per sq.m	10–19 plants per sq.m	20–29 plants per sq.m	More 30 plants per sq.m
Veronica hederifolia L.	12,925	26.93	27	30	2	67	5	23	101	15	96
Stellaria media (L.) Vill.	4,583	9.55	9	9	0	28	75	166	214	17	0
Lamium amplexicaule L.	4,326	9.01	8	6	0	31	122	121	172	34	4
Polygonum aviculare L.	978	2.04	1	0	0	32	264	32	15	1	1
Viola arvensis Murray	919	1.91	1	0	0	13	270	54	4	0	0
Holosteum umbellatum L.	773	1.61	1	0	0	15	209	48	9	0	0
Chenopodium album L.	520	1.08	1	0	0	10	242	15	1	0	0
Lamium purpureum L.	410	0.85	0	0	0	19	111	22	5	0	0
Capsella bursa-pastoris (L.) Med.	269	0.56	0	0	0	8	178	3	0	0	0
Thlaspi arvense L.	173	0.36	0	0	0	5	127	1	0	0	0
Consolida orientalis (Gr. Et Godr.) Schrödiger	155	0.32	0	0	0	5	99	1	0	0	0
Veronica triphyllos L.	107	0.22	0	0	0	15	50	2	1	0	0
Geranium pusillum Burm.	43	0,09	0	0	0	7	30	1	0	0	0
Papaver rhoeas L.	41	0.09	0	0	0	4	35	0	0	0	0
Apera spica-venti (L.) P. B.	24	0.05	0	0	0	3	19	0	0	0	0
Taraxacum scet. *Ruderalia* Kirschner, H. Øll-gaard et Štěpánek	21	0.04	0	0	0	3	17	0	0	0	0
Descurainia Sophia (L.) Prantl	17	0.04	0	0	0	2	15	0	0	0	0
Tripleurospermum inodorum (L.) Schultz-Bip.	14	0.03	0	0	0	2	12	0	0	0	0
Fallopia convolvulus (L.) Á. Löve	8	0.02	0	0	0	2	7	0	0	0	0
Myosotis arvensis (L.) Hill	2	0.00	0	0	0	1	2	0	0	0	0
Conyza canadensis (L.) Cronquist	1	0.00	0	0	0	1	1	0	0	0	0
Galium aparine L.	1	0.00	0	0	0	1	1	0	0	0	0



1: *Ordination diagram expressing the spatial incidence of identified species and rows of plots in the stand of spring barley*

Explanations: ■ A – I, variants of treatment; ▲SO-I., NP-I., SP-I., VP-I, SO-II., NP-II., SP-II., VP-II, SO-III., NP-III., SP-III., VP-III.

Weed species abbreviations: Ama retr – Amaranthus retroflexus, Ana arve – Anagallis arvensis, Atri patu – Atriplex patula, Ave fatu – Avena fatua, Bra napu – Brassica napus, Cap burs – Capsella bursa-pastoris, Car acan – Carduus acanthoides, Car drab – Cardaria draba, Cir arve – Cirsium arvense, Con arve – Convolvulus arvensis, Ech crus – Echinochloa crus-galli, Ely repe – Elytrigia repens, Ero cicu – Erodium cicutarium, Fal conv – Fallopia convolvulus, Fum offi – Fumaria officinalis, Gal apar – Galium aparine, Ger pusi – Geranium pusillum, Hel annu – Helianthus annuus, Che albu – Chenopodium album, Che hybr – Chenopodium hybridum, Lam purp – Lamium purpureum, Lap comm – Lapsana communis, Pap rhoe – Papaver rhoeas, Pol avic – Polygonum aviculare, Sil noct – Silene noctiflora, Son arve – Sonchus arvensis, Ste medi – Stellaria media, Tar offi – Taraxacum scet. Ruderalia, Thl arve – Thlaspi arvense, Tri inod – Tripleurospermum inodorum, Tri prat – Trifolium pratense, Ver hede – Veronica hederifolia, Vio arve – Viola arvensis.

with the variation SO-I.) and involved the following species: *Atriplex patula, Carduus acanthoides, Elytrigia repens, Galium aparine, Chenopodium hybridum, Lapsana communis, Papaver rhoeas, Veronica hederifolia.*

The second group of weeds occurred more likely on the whole surface of the experimental field; these weed species are presented in the middle of the ordination diagram and are as follows: *Amaranthus retroflexus, Capsella bursa-pastoris, Cirsium arvense, Echinochloa crus-galli, Fallopia convolvulus, Fumaria officinalis, Geranium pusillum, Chenopodium album, Lamium purpureum, Polygonum aviculare, Stellaria media, Taraxacum* scet. *Ruderalia, Thlaspi arvense.*

Species of the third group were found out more frequently on plots situated in the centre of the experimental field and/or in central plots and were as follows: *Anagallis arvensis, Avena fatua, Brassica napus, Cardaria draba, Convolvulus arvensis, Erodium cicutarium, Helianthus annuus, Silene noctiflora, Sonchus arvensis, Trifolium pratense, Tripleurospermum inodorum, Viola arvensis.*

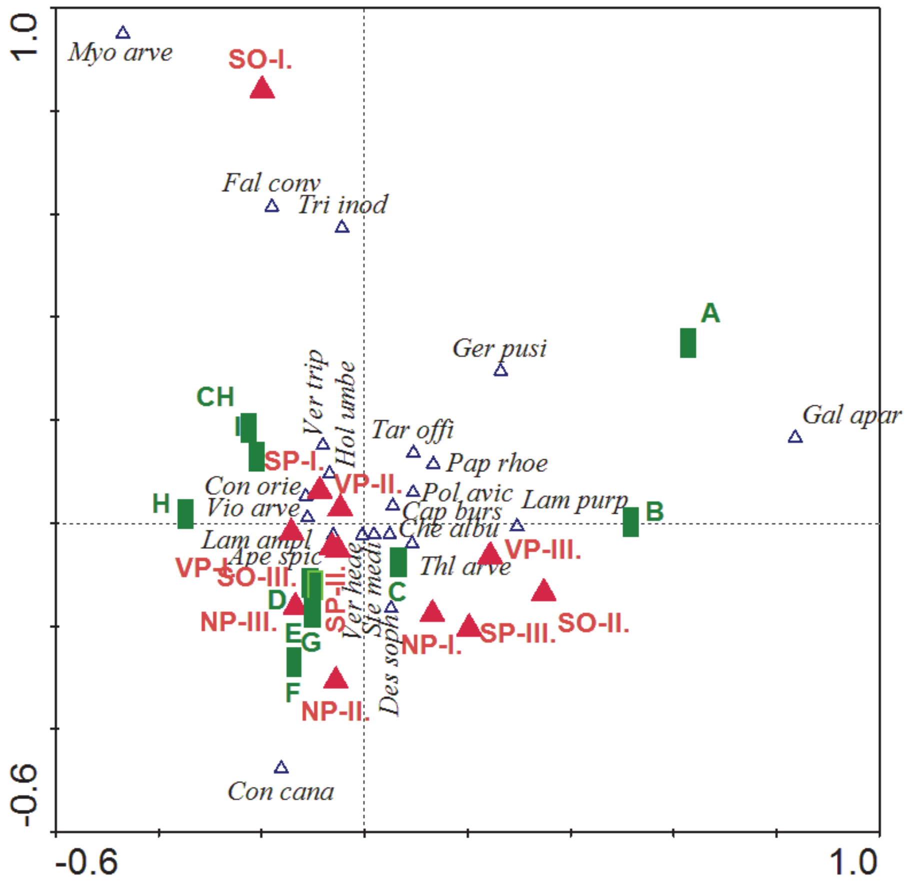
In case of the experiment with the winter wheat crop, the evaluation of the incidence of individual weed species was performed by means of the Detrended Correspondence Analysis (DCA) and the calculated gradient length estimate was 4.546. This value was thereafter used in the Canonical Correspondence Analysis (CCA). The significance of results was tested by means of the Monte-Carlo method and the total number of calculated permutations was 499.

Results of CCA were significant at the level of $\alpha = 0.002$; this value expressed the rate of weed infestation in the winter wheat stand and is presented graphically in Fig. 2. Identified weed species can be classified into several groups. The first one involves above all species growing on plots situated nearer to the field margins (i.e. bands of A and SOL plots, respectively). Individual identified species were as follows: *Fallopia convolvulus, Galium aparine, Geranium pusillum, Tripleurospermum inodorum, Myosotis arvensis.*

Weeds of the second group occurred throughout the experimental field and are presented in the centre of the ordination diagram; this group involved the following weed species: *Apera spica-venti, Capsella bursa-pastoris, Descurainia sophia, Chenopodium album, Lamium amplexicaule, Lamium purpureum, Papaver rhoeas, Polygonum aviculare, Stellaria media, Taraxacum* scet. *Ruderalia, Thlaspi arvense, Veronica hederifolia.*

Weeds of the third group were found out more frequently on plots situated in the centre of the experimental field (or in central plots in the middle of the stand) and were as follows: *Conyza canadensis, Consolida orientalis, Holosteum umbellatum, Veronica triphyllos, Viola arvensis.*

The evaluation of heterogeneity of weed infestation revealed some trends that were common for stands of both winter wheat and spring barley crops. The first one was represented by the incidence of a single, markedly dominant weed species. In stands of spring barley and winter wheat, these were *Chenopodium album* and *Veronica hederifolia,* respectively. The shares of these species in total numbers (abundance) of all plants were 34% and even 49% (*Chenopodium album* and *Veronica hederifolia*, respectively). On individual sampling



2: *Ordination diagram expressing the spatial incidence of identified species and rows of plots in the stand of winter wheat*

Explanations: ■ A – I, variants of treatment; ▲SO-I., NP-I., SP-I., VP-I, SO-II., NP-II., SP-II., VP-II, SO-III., NP-III., SP-III., VP-III.

Weed species abbreviations: Ape spic – Apera spica-venti, Cap burs – Capsella bursa-pastoris, Con cana – Conyza canadensis, Con orie – Consolida orientalis, Des soph – Descurainia sophia, Fal conv – Fallopia convolvulus, Gal apar – Galium aparine, Ger pusi – Geranium pusillum, Hol umbe – Holosteum umbellatum, Che albu – Chenopodium album, Lam ampl – Lamium amplexicaule, Lam purp – Lamium purpureum, Myo arve – Myosotis arvensis, Pap rhoe – Papaver rhoeas, Pol avic – Polygonum aviculare, Ste medi – Stellaria media, Tar offi – Taraxacum scet. Ruderalia, Thl arve – Thlaspi arvense, Tri inod – Tripleurospermum inodorum, Ver hede – Veronica hederifolia, Ver trip – Veronica triphyllos, Vio arve – Viola arvensis.

plots, the intensity of their incidence was high and mostly exceeded the limit of 30 specimens per square meter. This means that the harmfulness of both is high. The intensity of infestation was so high that the area-wide spraying of herbicides seemed to be more necessary.

The second trend concerned the incidence of species that could be defined as subdominant. Their shares in total numbers of weeds were higher than 10% and they usually occurred in individual focal points (their numbers ranged mostly from 10 to 19 plants per sq. m). In the majority of sampling points under study, the incidence of these species was markedly high and for that reason they could be classified as harmful. In the stand of spring barley, this group involved species *Echinochloa crus-galli, Lamium purpureum,* and *Stellaria media* while in the winter wheat crop *Stellaria media* and *Lamium amplexicaule* were the most frequent weed species. Regarding the character of these weed species, a targeted application of herbicides seemed to be the most suitable.

The third trend concerned the incidence of that group of weeds that occurred in the major part of the experimental plot but in reduced numbers only. In this case, a higher intensity of infestation was observed only marginally, their harmfulness was more or less disputable, and it was manifested only in some parts of the experimental field. In the stand of spring barley, this group involved *Polygonum aviculare, Taraxacum* scet. *Ruderalia, Viola arvensis, Thlaspi arvense, Capsella bursa-pastoris, Fallopia convolvulus,* and *Fumaria officinalis*. In the stand of winter wheat, the following weed species belonged to this group: *Polygonum aviculare, Viola arvensis, Holosteum umbellatum, Chenopodium album, Lamium purpureum, Capsella bursa-pastoris, Thlaspi arvense, Consolida orientalis,* and *Veronica triphyllos*.

However, a significant group of species were represented only minimally and their total numbers did not exceed the limit of 100 plants. This group involved also those weed species that occurred much more frequently on plots situated nearer to the margin of the experimental field.

The mapping of weed infestation of individual crops represented the crucial problem within the framework of this research. Today, this mapping is performed most frequently on the base of a direct assessment of the stand but this is very laborious and time consuming method. It can be therefore said that, on larger areas, manual methods of mapping do not allow to perform the sampling with an adequate intensity and efficiency just because of their high laboriousness and time consumption. For that reason there are nowadays efforts how to find new ways and methods of an easier data collection (Hamouz and Soukup, 2006). For species with a high threshold of harmfulness (e.g. *Viola arvensis*), a smaller size of the sampling area (2 × 0.25 sq. m) seems to be sufficient for each point of the sampling network while for species with a lower threshold of harmfulness and a lower incidence (e.g. *Galium aparine)* the sampling area should be larger, at least 2 × 1 sq. m (Hamouz, 2005).

An alternative to the manual assessment of the rate of weed infestation represent the so-called sensor methods that most frequently function on the principle of measuring the spectral reflectance. In individual bands of electromagnetic radiation, plants show differences in their spectral reflectance (Lukas *et al.*, 2011). Soille (2000) mentioned that the most suitable wavelengths enabling to differentiate plants from the neighbouring terrain can be found in the region of the near-infrared spectrum. When using them, the crop canopy reflects more impacting solar radiation than the soil surface. According to Kroulík (2012) methods of remote sensing represent another possibility how to assess the degree of weed infestation of individual crops. In this case, sensors are installed on satellites and/or planes and serve as receptors of intensity of electromagnetic waves reflected by the vegetation. In studies on plant stands, the visible part of the light spectrum (wavelengths of 400–700 nm and of 700–2500 nm) is used most frequently.

A survey of available mapping techniques (based on a combination of remote sensing and terrestrial scanning) was published by López-Granados (2011). Peréz *et al.* (2000) emphasised that the mapping of large areas of various stands was a great advantage of this method but that the reduced accuracy of results was a certain disadvantage so that is was possible to identify only a limited number of weed species (above all those that were higher than the crop canopy).

At present, the importance of remote sensing for local specific weed management is limited. The resolution of satellite pictures is not sufficient for mapping of young weeds in early stages of growth. Monitoring from helicopters or planes is more suitable, above all because of relatively lower costs and a better degree of resolution. However, there are no algorithms available that would enable to evaluate recorded data and to specify doses and methods of herbicide application (Kunisch, 2002).

It is also possible to use fluorescent radiation; this method can be used not only for detection of weed infestation in wide-row cultures and/or of inter-rows in densely sown crops but also for diagnostics of resistant weed populations. It can be also used in studies on effects of application machinery and conditions of application (Klem, 2006). Until now, however, methods of automatic detection are based on an assumption that weed plants are not overlapped by the canopy of the infested crop. For that reason they can be used only in wide row crops (and in early stages of their growth and development). In cereals, however, these methods can be used only with difficulties (Gerhards *et al.*, 1998).

Trends to the occurrence of one dominant weed species in crops reduce the value of a targeted application of herbicides. On the other hand, however, there is also a significant group of species that show a marked mosaic incidence in stands of cultural plants and this fact enables a targeted application of herbicides. As emphasised by Gerhards *et al.* (1996), it is not possible to formulate any general recommendations without a good knowledge of a concrete situation and the degree of weed infestation.

CONCLUSION

The obtained results indicate that there are several trends that play an important role when deciding about a targeted application of herbicides. A trend to the incidence of one dominant weed species was observed in both cereal species under study. The degree of incidence of this weed species was so high that its control could be possible only by means of an area-wide application of herbicides on the experimental field.

As far as the other weed species were concerned, a trend to their non-uniform incidence and a different intensity of infestation of experimental crops were observed. This means that it can be useful and prospective to think on their targeted application. Besides it was also observed that the effect of field margins was also important, this trend was manifested above all through the occurrence of rather specific weed species.

Methods of a targeted application of herbicides can be used either on fields with a lower level of weed infestation or as a means how to control a certain, weed species and/or for the treatment of field margins where these specific weed species can occur more frequently. On heavily weed-infested plots, a targeted application of herbicides would not be efficient enough. The laboriousness and a high consumption of time necessary for the evaluation of the degree of weed infestation represent a great problem and obstacle of the targeted application of herbicides. It can be therefore concluded that an efficient application of herbicides is not possible without a good knowledge of the degree and species composition of the weed infestation.

Acknowledgement

This study was performed within the framework of the project NAZV QI111A184 "Optimization of methods of weed control within the system of precision farming" and also as an output of the Internal Grant Agency of the Faculty of Agronomy, MENDELU BRNO, No. TP 10/2013 "Studies on selected factors influencing the manifestation of the biological potential of agricultural cultures".

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