WEED INFESTATION IN WHEAT SOWINGS IN CENTRAL AND WESTERN PART OF LATVIA

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Abstract

A weed infestation monitoring was carried out annually at the end of July in stationary observed areas in the Jelgava, Dobele, Saldus, Talsi, Tukums and Kuldiga districts of Latvia during 1994—2002. The weed infestation of sowings was determined using quantitative currency method developed by A. Rasiņš and M. Tauriņa (1989). The occurrence index was calculated for characterizing separate weed species and groups of weeds. Shannon biological diversity index was used as a complex indicator for weed infestation of sowings. Evaluation of weed infestation monitoring results was done using data ranging and grouping. To characterize dynamics of separate weed species, the index of changes of the number of weed species was used. Fisher criterion was applied for evaluating the influence of herbicides and crop rotation. Dominant weeds (> 5 p. m^{-2}) in winter wheat sowings were *Elytrigia repens*, *Viola* spp., *Stellaria media*, *Matricaria perforata*, *Polygonum* spp., and in spring wheat sowings — *Elytrigia repens*, *Lamium purpureum*, *Stellaria media* and *Fallopia convolvulus*. The number of weed species varied from 13 to 18 during the 5 investigation years. The number of weed species with occurrence over 50% decreased in winter wheat sowings, but the number of species with occurrence up to 10—20% increased. Shannon index for annual and perennial weeds tended to increase in winter wheat sowings. Biological diversity index in spring wheat sowings was higher for annual weed species than for perennial weeds — in annual weed species it increased from 0.69 in 1998 to 0.80 in 2002. Periodicity of dominant of weed species was established for *Polygonum* spp., which reproduces with seeds, and for winter weeds *Matricaria perforata* and *Viola* spp. The amplitude of cyclical changes in winter weeds was greater when initial level of weed infestation was higher. Changes in the number of perennial weeds *Elytrigia repens* and *Cirsium* spp. were not cyclical. The weed infestation in repeated spring wheat sowings was significantly higher than in sowings with crop rotation, especially for perennial weeds *Circium* spp. and *Elytrigia repens*. Differences in the weed infestation in repeated winter wheat sowings were insignificant, compared to sowings with crop rotation. The effect of years as a factor was higher than that of the pre-crop. The influence of herbicides was significant for occurrence of *Cirsium* spp. in winter wheat and for the number of *Sonchus arvensis* and *Myosotis* spp. in spring wheat.

Key words: wheat, weed infestation, monitoring of weeds.

Introduction

The importance of monitoring of weed infestation in sowings has already been discussed in previous publications of D. Lapinsh, J. Korolova, A. Berzinsh (2000), D. Lapiņš, A. Bērziņš, J. Koroļova, A. Sprincina (2002), I. Vanaga, D. Lapiņš, A. Bērziņš, J. Koroļova, A. Sprincina (2002). This has also been confirmed by research results in Finland (Salonen et al., 2001), Lithuania (Kavoliunaite et al., 2000), Estonia (Тойво, 1997), Belarus (Протасов, 1995; Сорока, Романюк, 1997) and Russia (Ульянова, 1997; Кравченко, 1997). The analysis of long-term and annual observations of weed infestation of sowings weediness allows to determine the effect of crop rotation and chemical weed control compared to years as a factor of influence. Indexes are being more and more used for evaluating dynamics of weeds' biological diversity. The aim of the research was to analyze dynamics of weeds basing on the monitoring data in sowings in the Kurzeme and Zemgale regions of Latvia during 1998—2002.

Materials and Methods

The registration of weed infestation and data analysis methods

The weed infestation monitoring was carried out annually at the end of July in stationary observed areas in the Jelgava, Dobele, Saldus, Talsi, Tukums and Kuldiga districts starting from 1998. The observations were made on traditional and biological farms. Crop rotation and field areas were determined by the respective farmer. The weed infestation of sowings was determined using quantitative currency method developed by A. Rasiņš and M. Tauriņa (1989). The method is based on correlation between the occurrence of weed species in the field and the number of this weed species in 1 m^2 of field area. The invariability of the method allows to compare changes in weed infestation over a longer period of time (Лапиньш, 1999).

The observations were made using 200 cm^{-2} frames at particular field points. Determination of weed species was done in 100 places and, if the field area was less than 20 ha, in 50 places. From these data, the occurrence of weed species (%) was calculated, and then the number of weed species in 1 m^2 was determined.

Table 1

Areas of crop sowings observed in 1998—2002

Crops	Area, ha				
	1998	1999	2000	2001	2002
Spring wheat	83	176	166	109	60
Winter wheat	205	191.5	190	329.5	144

Simultaneously with evaluation of weed infestation, data about herbicide use were collected. A precise list of herbicides was not obtained, because farmers quite often don't have their own plant protection technique.

The index (%) of occurrence of weed species or a group of weeds was calculated as weighted mean and was weighted against the total field area, where this species or group of weeds was observed:

$$Is_i^n = \frac{\sum_m^1 (Pl \times x_i)}{\sum_m^1 Pl}, \qquad (1)$$

where: Is_i^n — occurrence of weed species i in year n by A. Rasiņš's method;

i — symbol of weed species;

m — number of stationary observed areas for a particular crop in n year;

$\sum_m^1 Pl$ — total field area for a particular crop, ha.

Shannon biological diversity index was used as a complex indicator of weed infestation of sowings, which gives evaluation of total weed infestation of sowings according to all observed characteristics — number of weed species, number of weeds, and total number of weeds. A greater mathematical value of the index corresponds to greater total weed infestation of sowings (Magurran, 1988).

One of weed infestation's indicators is the index of change for the number of weeds, which shows the dynamics of weediness in one year compared to the previous year:

$$I'_{izm} = \frac{X_i^n - X_i^{n-1}}{X_i^{n-1}}, \qquad (2)$$

I'_{izm} — index of change for the number of weeds of a particular weed species i,

X_i^n — number of weeds of a particular weed species i in n year,

X_i^{n-1} — number of weeds of a particular weed species i in n-1 year.

Analysis of the weed infestation was carried out using data ranging and grouping. The index of change for the number of weeds of a particular weed species was used to characterize the dynamics of dominating weed species. Fisher criterion was applied to evaluate the influence of herbicides and crop rotation.

The number of determined weed species, changes in weed structure and weed occurrence were evaluated to analyze the dynamics of weeds in stationary observed areas. Species of weeds were grouped in clusters where the number of weeds is less than 1 p. m^{-2}, 1—5 p.m^{-2}, and > 5 p.m^{-2}. Analysis of occurrence of weed species during 5 inspection years was carried out by grouping the weed species into five clusters: 1) occurrence > 50; 2) 40—50; 3) 30—40; 4) 20—30, and 5) occurrence of 10—20% of the field area.

Meteorological conditions

The growth of weeds was dependent on meteorological conditions. Good meteorological conditions for weed growth were from April to June in all investigation years when daily temperature was higher than average long term norm.

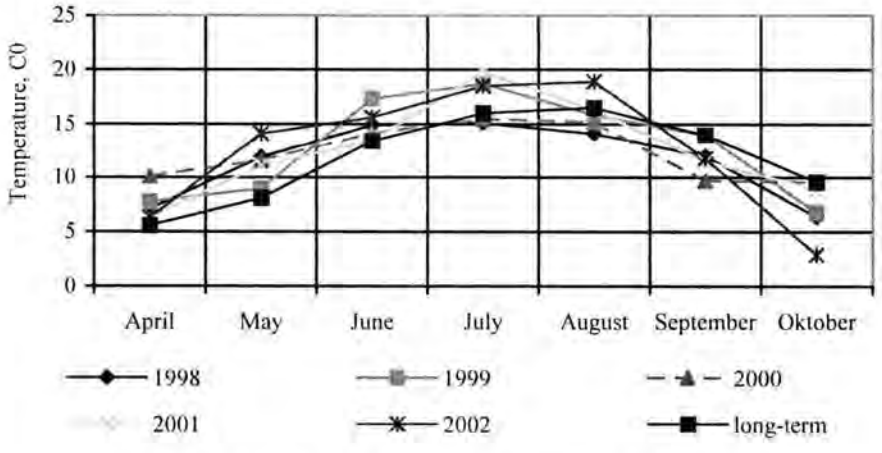

Fig. 1. The average daily temperature compared to long-term norm during 1998—2002

The precipitation was lower than norm in May and September in these years.

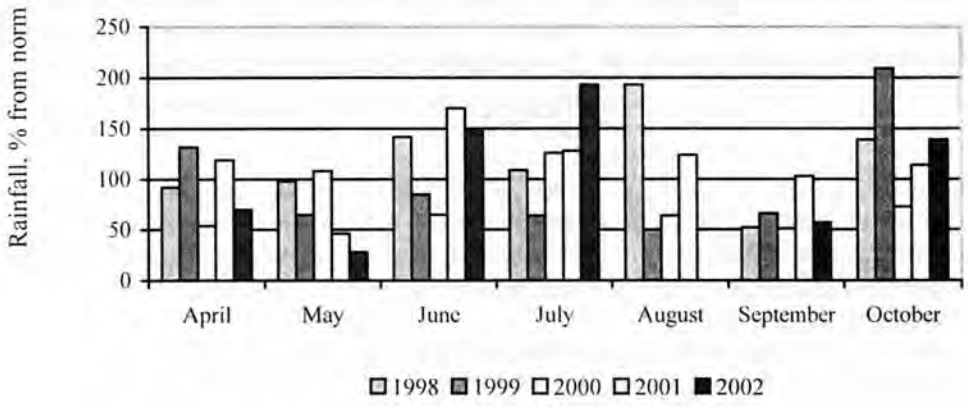

Fig. 2. The amount of precipitation, % from climatic norm, during the vegetation

Greatest deficit of precipitation was observed in August 2002 when average monthly rainfall was almost 0 mm. Greatest amounts of precipitation were observed in October 1999 — 209% above the norm. Much rainfall was also in July 2002, whereas April 2000 was the driest period. On the whole, the vegetation period of 1999 favored weed growth and development, as well as the effect of herbicides. The weather was cool with much precipitation throughout the second part of vegetation in 2000, which facilitated development of new weed shoots. Herbicides, sprayed at the end of May, had no effect on these weeds.

In 2001, the vegetation recovered on 3—5 April. Heavy rainfall in the second part of April delayed the field work, wheat was sown overdue, which might have effected occurrence of weeds. In May and June, the average air temperature was equal to average long-term indices. The amount of rainfall in these months: 72 mm in May and 99 mm in June, which makes 146% and 223% of the norm. Plants produced great vegetation mass that limited the growth of weeds. On the whole, the vegetation period in 2001 and 2002 favored weed growth and development.

Results and Discussion

The number and structure of weed species in wheat sowings

The number of weed species in winter wheat sowings varied within the range of 42—56 species in stationary observed areas during 1998—2002. Each second observation year demonstrated higher field pollution with different weed species (Table 2). The structure of weed species also varied – perennial weeds appeared to be more widespread. Higher variability of weed species was in 2001 — 56 weed species in winter wheat sowings. The lowest variability of weed species was observed in 2000 — in total 42 weed species. In 1998, 45 weed species were established in winter wheat sowings, three of which — *Elytrigia repens*, *Stellaria media* and *Viola* spp. — were of greatest occurrence > 15 p. m^{-2}. The structure of dominant weed species changed in 1999. The most widespread was *Elytrigia repens* — 107 pieces per 1 m^2. Then follow *Matricaria perforata* and *Apera spica-venti* – more than 15 p. m^2. The greatest quantity of weed species had the average number of weeds less than 1 piece per 1 m^2. Table 2 shows that the most significant was cluster with weed species > 5 p. m^2. The number of weed species decreased almost three times (from 8 to 3 weed species) during 1998—2002.

Table 2

The number of weed species in clusters by pieces in 1m^2 in winter wheat sowings, 1998—2002

Clusters by pieces in m^2	Number of weeds				
	1998	1999	2000	2001	2002
< 1	27	39	29	38	32
> 1	18	15	13	18	15
of which: 1—5	10	7	9	12	12
> 5	8	8	4	6	3

Table 3

The number of weed species in clusters by pieces in m^2 in spring wheat sowings, 1998—2002

Clusters by pieces in m^2	Number of weed species				
	1998	1999	2000	2001	2002
<1	33	30	22	32	19
1—5	9	10	9	11	10
>5	4	3	6	4	2
>1	13	13	15	15	12
Total	46	43	37	47	31

In spring wheat sowings in Kurzeme—Zemgale stationary observed areas, species with average number of weeds per 1 m^2 less than one had the greatest variety (Table 3). The number of weed species in the cluster >1 piece per 1 m^2 was 12 in 2002 and 15 — in previous years. The number of weed species in the cluster >1 piece per 1 m^2 was relatively constant — 9—11during 1998—2002. Highest variety of weed species was in 2001.

In all observation years in winter wheat sowings, dominating perennial weeds were *Elytrigia repens* and *Cirsium* spp., dominant annual weeds — *Galium aparine, Lamium purpureum, Veronica* spp., *Chenopodium* spp., *Matricaria perforata, Euphorbia helioscopia*, and *Polygonum covolvulus*. *Lamium purpureum* and *Galium aparine* dominated in the cluster >5 p. m^{-2} during 1998—2001. Whereas *Polygonum convolvulus* and *Viola* spp. dominated during 2000—2002. During the last two years, *Solanum nigrum, Galeopsis* spp., *Taraxacum officinale* have been observed among dominating weed species. On the whole, four weed species had the highest occurrence in winter wheat sowings during five inspection years: *Elytrigia repens* — 47 p.m^2, *Galium aparine* — 7,7 p.m^{-2}, *Laminum purpureum* — 7,4 p.m^2, and *Polygonum convolvulus* — 6,5 p.m^{-2}.

In spring wheat sowings, thirteen species of weeds with occurrence >1 p. m^{-2} were established. *Elytrigia repens* dominated also in spring wheat sowings during all five years. The number of *Polygonum convolvulus* increased from 4,9 p.m^{-2} in 1998 to 8,2 p.m^{-2} in 2002. *Galium aparine* decreased from 10,6 p.m^{-2} in 1998 to 1,8 p.m^{-2} in 2002. The number of fourth dominant weed species *Laminum purpureum* varied from 12 in 1998 to 7,7 p.m^{-2} in 2000 spring wheat sowings, and then decreased to 3 p.m^{-2} in 2001–2002.

The occurrence of weed species in wheat sowings

The greatest number of weed species in winter wheat sowings was established in the cluster with occurrence up to 10% of field area during 1998—2002. The number of these species was very variable by years — 15—26 species. The number of weed species in the cluster 10—20% was 8—13, which tended to grow. A similar number of weed species was in the cluster with occurrence more than 50%, which tended to decrease — from 13 in 1998 to 6 species in 2002.

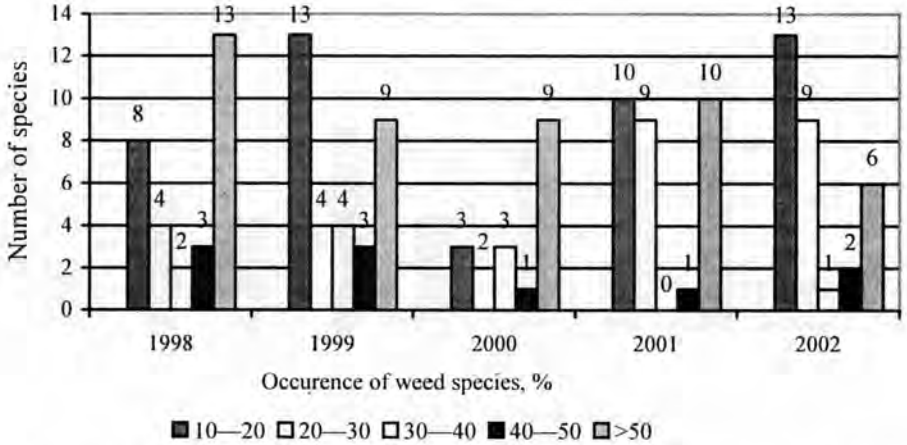

Fig. 3. The number of weed species compared to their occurrence in winter wheat sowings

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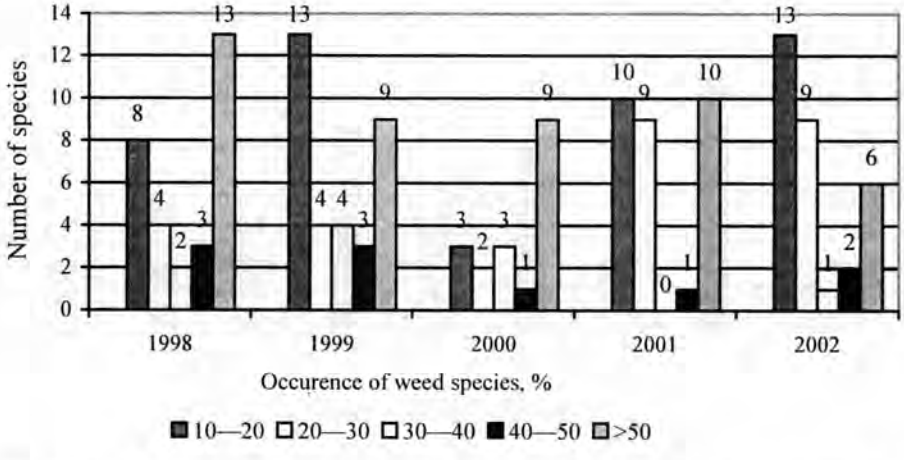

Fig. 3. The number of weed species compared to their occurrence in winter wheat sowings

The number of weed species in clusters with occurrence 20—30%, 30—40% and 40—50%, was not high. In winter wheat sowings, the number of weed species with occurrence greater than 50% decreased, while that of weeds with occurrence 10—20% — increased (Fig. 3).

Annual dominating weed species with occurrence >50% were *Viola* spp., *Matricaria perforata*, *Galium aparine*, *Stellaria media*, *Veronica* spp., *Polygonum covolvulus*, and *Polygonum* spp., perennial dominant weed species was *Elytrigia repens* and in some years also *Cirsium* spp. (Table 4).

The most common annual weeds with occurrence 20—30% in winter wheat sowings were *Consolida regalis*, *Capsella bursa- pastoris* and *Centaurea cyanus*, but the most common perennial weed – *Stachys palustris*. Other weed species had high variability of occurrence — within 10—50% during all five investigation years. In the cluster with

occurrence 10—20%, typical species were *Thlaspi arvense*, *Melandryum album*, and *Achillea millefolium*. The occurrence of *Consolida regalis*, *Myosotis* spp. and *Equisetum arvense* significantly decreased during 1999—2002.

Table 4

Occurrence of weed species in wheat sowings

Species of weeds	Occurrence, % from field area					On average, %
	1998	1999	2000	2001	2002	
Winter wheat						
Viola spp.	95.1	57.1	96	70	68.8	77.4
Polygonum spp.	66.3	86.3	54	90.7	73.6	74.1
Polygonum convulvolos	67.8	57	65	87.7	78.5	71.2
Elytrigia repens	75.1	82	82	72.5	39.1	70.1
Matricaria perforata	87.3	78	42	51.1	79.2	67.5
Galium aparine	82.9	57.6	67	69.9	42.4	64
Veronica spp.	75.6	52.1	78	54.6	51.4	62.3
Stellaria media	82.8	48.3	63	65.4	29.2	57.6
Cirsium spp.	82.4	87.8	31	53.3	28.5	56.6
Spring wheat						
Polygonum convulvolus	96.4	82.5	71	96.3	76.7	84.6
Galium aparine	80.7	75.8	74	98	45	74.6
Lamium purpureum	98.8	86	61	58.7	50	71
Veronica spp.	92.8	41.1	50	27.5	73.3	56.9
Euphorbia heloscopia	77.1	29.6	55	58.7	55	55
Polygonum spp.	78.3	88.2	50	28.4	25	54

Weed species with occurrence above 50% in spring wheat sowings decreased from 11 species in 1998 to 5 in 2002 (Fig. 4).

Annual weeds *Lamium purpureum*, *Polygonum convolvulus*, *Veronica* spp., *Galium aparine*, *Euphorbia helioscopi* were the most frequent species with occurrence > 50% in the observed spring wheat sowings. Perennial weed *Elytrigia repens* showed invariable occurrence (more than 50%) throughout all the investigation years.

Chenopodium spp. and *Polygonum* spp. were most dominating weed species in 1998, 1999 and 2000, with occurrence > 50% that decreased to 30—40% during the last investigation years. *Avena fatua*, *Capsella bursa — pastoris* and *Taraxacum officinale* exhibited high occurrence only in 1998.

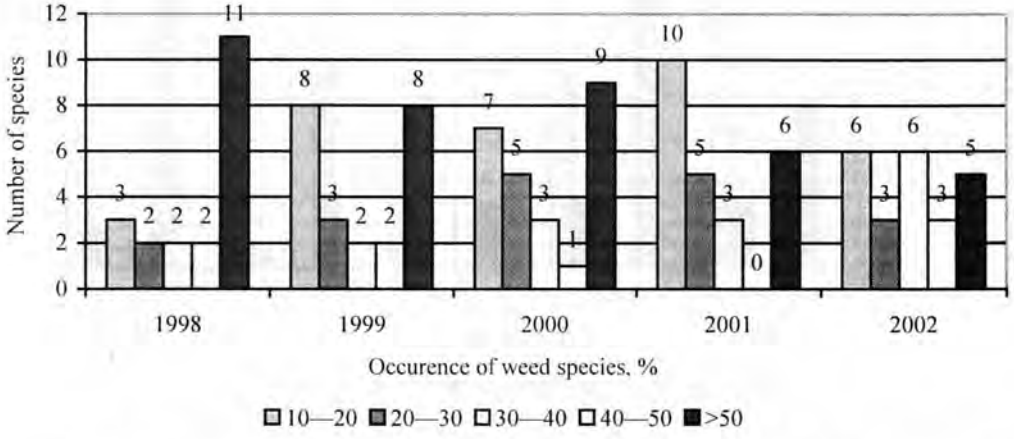

Fig. 4. The number of weed species compared to their occurrence in spring wheat sowings

The occurrence of *Stellaria media* and *Equisetum arvense* varied within the range of 20—40%, occurrence of *Galeopsis* spp., *Sonchus arvense* and *Convolvulus arvensis* within 10—30%, *Stachys palustris* and *Plantago* spp. — 10—20%. In 1998, annual weeds *Lamium purpureum*, *Polygonum convolvulus*, *Veronica* spp., *Galium aparine*, *Polygonum* spp., *Euphorbia helioscopia*, *Avena fatua*, *Capsella bursa — pastoris* and *Chenopodium* spp. demonstrated high occurrence (more than 50% of field area).

Complex evaluation of weed infestation variety

The highest Shannon index (0.72—0.79 on average) was established for annual weed species in winter wheat sowings during 1998–2002. The lowest Shannon index (0.68) was in 1999, but the highest (0.79) was in 2002, which shows that the index of annual weeds in winter wheat sowings tends to grow (Fig. 5).

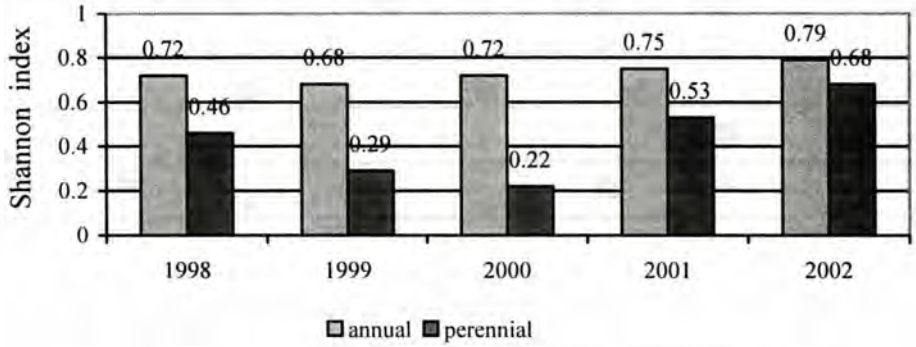

Fig. 5. Evaluation of winter wheat sowings with Shannon index

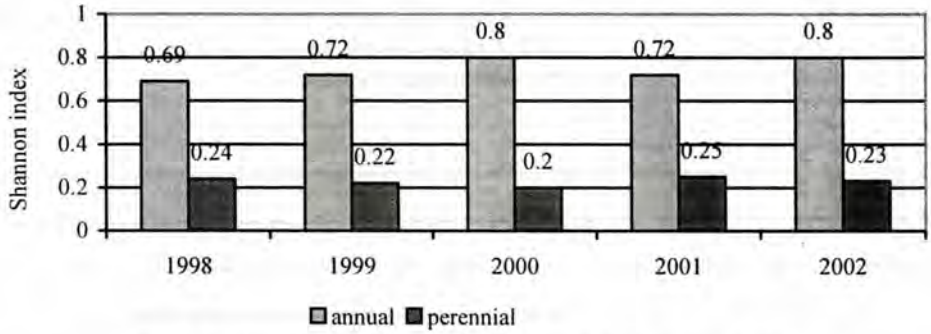

Fig. 6. Evaluation of spring wheat sowings with Shannon index

Shannon index for perennial weeds in winter wheat sowings ranged from 0.22 to 0.68 — it was very low in 1999 and 2000 (0.29 and 0.22, respectively), but the highest (0.68) in 2002.

Biological diversity index for annual weeds in spring wheat sowings was higher than for perennial weeds. Annual weed index increased from 0.69 in 1998 to 0.80 in 2002. Variance of Shannon index for annual weeds was 0.8 each year, but for perennial weeds it varied within 0.2—0.25.

Indexes of changes for dominant weeds in wheat sowings

It is possible to analyze indexes of changes in weed infestation more precisely in a longer time period, therefore additionally investigation results of the Department of Soil Management from earlier years (1994—1997) were used. The periodicity of change for the number of weeds was established for dominant weeds that reproduce with seeds — *Polygonum* spp., and for winter weeds *Matricaria perforate* and *Viola* spp. (Fig. 7). The amplitude of cyclic changes was higher when higher was the initial weed infestation in 1994, which is best demonstrated by the change in the number of two dominant weeds *Matricaria perforata* and *Viola* spp.

Changes in the indexes of perennial dominants *Elytrigia repens* and *Cirsium* spp. were not cyclic. The increase in these indexes during some years was dependent not only on soil tillage, but also on other meteorological and biological conditions.

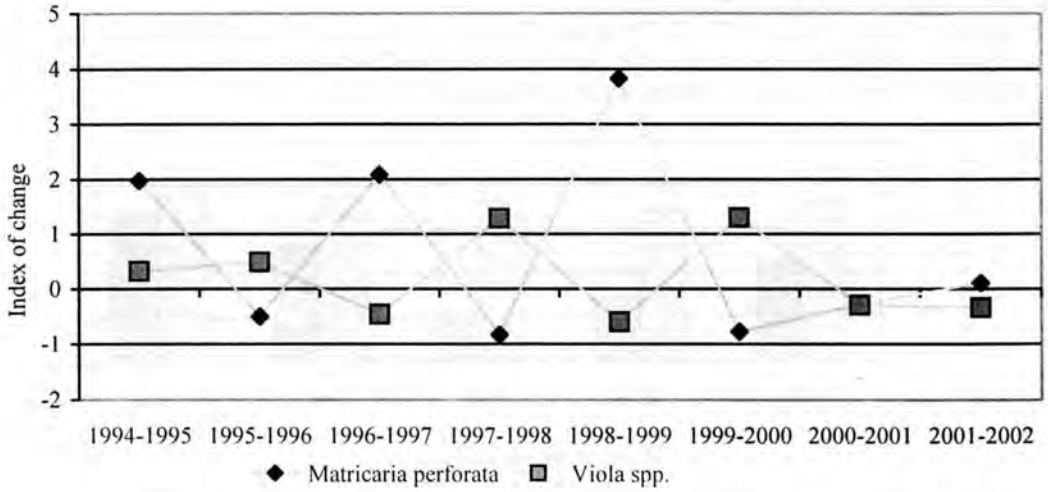

Fig. 7. Indexes of change for dominant winter weeds in winter wheat sowings

The periodicity of change for the number of weeds that reproduce with seeds in spring wheat sowings was not pronounced compared to winter wheat sowings. Dominant weed species were *Galium aparine* and *Lamium purpureum*, and also winter weeds *Matricaria perforata* and *Viola* spp. (Fig. 8). Low cyclic changes were established for *Galium aparine* and *Lamium purpureum* during 1996—2002. Changes in the number of perennial weeds *Elytrigia repens* and *Cirsium* spp. in spring wheat sowings don't have any agronomical explanation.

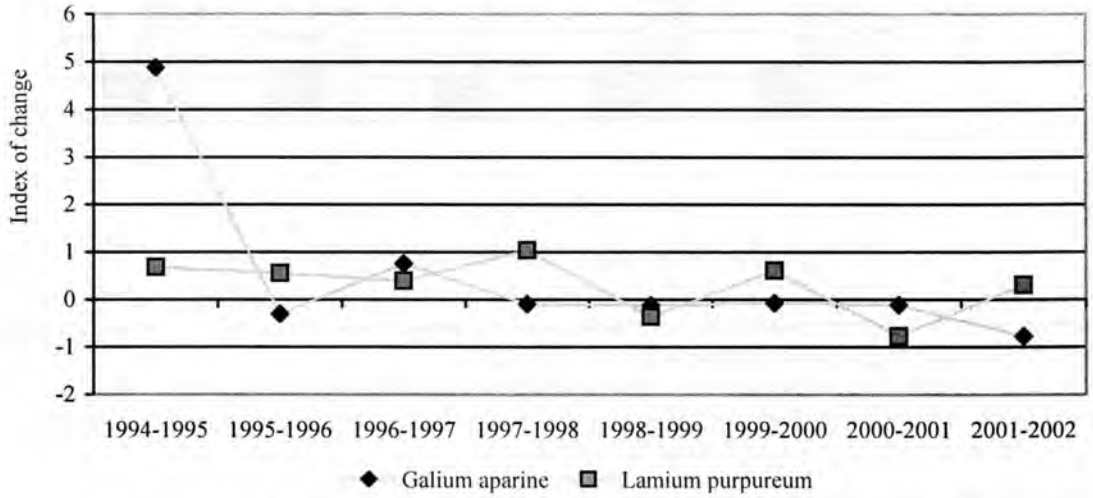

Fig. 8. Indexes of change for dominant weeds in spring wheat sowings

The effect of pre-crop on weed infestation in of wheat

The investigation results show that not always repeated sowings were the reason for a high level of weed infestation, especially in 2001 and 2002. The difference between the number of weeds in repeated winter wheat sowings and sowings with crop rotation was insignificant for all weeds.

Table 5

Weed infestation in of spring wheat in 2001 compared to crop rotation, $p.m^{-2}$

Species of weeds	Number of weeds, $p.m^{-2}$			Confidence, P%
	repeated sowings	crop rotation	±	
Cirsium spp.	9.33	0.83	8.5	96.4
Chenopodium spp.	8.33	0.33	8	91.8
Elytrigia repens	128	14	114	98.1
Polygonum convolvulus	2.33	10.17	–7.8	87.9
Matricaria perforata	3.00	1.00	2	70.6
Veronica spp.	2.67	1.5	1.2	39.7
Galium aparine	8.67	6.83	1.8	33.0
Polygonum spp.	2.33	1.33	1	19.1

In spring wheat sowings, the negative effect of repeated sowings was typical, also the number of weeds per 1 m^2 was greater than in sowings with crop rotation. A significant difference was established for *Cirsium* spp. and *Elytrigia repens*. The preplant as a factor of influence on weed infestation had low confidence probability (P%>90). Higher but insignificant levels of probability were established for *Galium aparine* and *Lamium purpureum*, but the lowest for *Veronica* spp.

The effect of herbicides

The weed infestation of wheat sowings was analyzed by comparing use of herbicides. High confidence probability (> 90%) was established to *Cirsium* spp., *Matricaria perforata*, and *Chenopodium* spp. Use of herbicides might be one of factors influencing occurrence of these weeds (Table 6). The confidence of difference for other dominant weeds *Veronica* spp., *Polygonum* spp., *Fallopia convolvulus*, *Viola* spp., *Stellaria media* was low.

Table 6

Weed infestation of winter wheat compared to use of herbicides, on average during 1995—2002

Species of weeds	Number of weeds, p. m^{-2}		±difference	Confidence, P%
	without herbicides	with herbicides		
Cirsium spp.	8	2.5	–5.5	97.1
Matricaria perforata	26.3	6.6	–19.7	90.5
Chenopodium spp.	4.5	1.2	–3.5	93.0
Sonchus arvensis	5.9	0.8	–5.2	83.4
Galium aparine	10.1	5.0	–5.1	84.2
Polygonum spp.	6.6	3.8	–2.8	84.1

Table 7

Weed infestation of spring wheat compared to use of herbicides, on average during 1995—2002

Species of weeds	Number of weeds, p. m^{-2}		±difference	Confidence, P%
	without herbicides	with herbicides		
Sonchus arvensis	9.6	0.4	–9.2	99.7
Myosotis spp.	3.4	0.3	–3.10	96.0
Stellaria media	23.1	9	–14.0	93.4
Galeopsis spp.	0.4	2.2	1.8	90.6
Cirsium spp.	14.1	3	–11.0	91.5
Chenopodium spp.	9.5	3.5	–6.0	89.0
Fallopia convolvulus	3.4	5.2	1.8	74.9

Differences in the number of *Myosotis* spp. and *Sonchus arvensis* were significant in spring wheat sowings. On the whole, the effect of herbicides on the number of weed species was low. A significant effect was established for *Cirsium* spp., *Sonchus arvensis* and *Myosotis* spp. The lowest probability was for weeds *Veronica* spp., *Viola* spp. and *Galium aparine*. Insufficient effect of herbicides could be explained only by wrong choice and inadequate use of herbicides.

Conclusions

In winter wheat sowings, dominant weed species with more than 5 pieces per 1 m^2 were *Elytrigia repens*, *Viola* spp., *Stellaria media*, *Matricaria perforata*, and *Polygonum* spp., in spring wheat sowings — *Elytrigia repens*, *Lamium purpureum*, *Stellaria media*, *Fallopia convolvulus*. The number of dominant weed species varied from 13 to 18 during the five investigation years. The number of weed species with occurrence over 50% decreased in winter wheat sowings, but the number of species with occurrence up to 10—20% increased during the investigations. Shannon index for annual and perennial weeds increased in winter wheat sowings. In spring wheat sowings, biological diversity index for annual species was higher (an increase from 0.69 in 1998 to 0.80 in 2002) than for perennial weeds. The periodicity of dominant weed species was established for *Polygonum* spp., which reproduces with seeds, and for winter weeds *Matricaria perforata* and *Viola* spp.

The amplitude of cyclic changes for winter weeds was greater when initial level of weed infestation was higher. The changes in the number of perennial weeds *Elytrigia repens* and *Cirsium* spp. were not cyclical.

The weed infestation in repeated spring wheat sowings was significantly higher than in sowings with crop rotation, especially for perennial weeds *Circium* spp. and *Elytrigia repens*. Differences in the weed infestation in repeated winter wheat sowings were insignificant, compared to sowings with crop rotation. The effect of years as a factor was higher than that of the pre-crop. The influence of herbicides was significant for occurrence of *Cirsium* spp. in winter wheat and for the number of *Sonchus arvensis* and *Myosotis* spp. in spring wheat.

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