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EVALUATION OF WEED INFESTATION OF TRITICALE AND PEA MIXTURES GROWN FOR FODDER SEEDS

Summary

The aim of the study was to evaluate weed infestation of mixtures of pea with spring triticale with differentiated composition of seeds at sowing, in ecological farming system. Field experiments were carried out in 2014-2016 in split-plot design in 4-replication on good soil rye complex. Two pea cultivars with spring triticale with differentiated share of legume (40, 60 and 80%) were compared. An assessment of species weed composition, each species abundance, fresh and dry weed matter was performed. An assessment of the structure of weed communities in the cultivated crops was carried out using two ecological indicators: Shannon index (H) and Simpson domination index (SI). Analysis has shown that in the first and third year of study, the most competitive with weeds was mixture of the lowest percentage of legumes, while in the second year the mixture with 80% share of pea, as evidenced by significantly lower fresh and dry weeds matter. In all years of study, in the cultivation of all mixtures, weed phytocenoses consisted mainly of dicotyledonous species. The most abundant weed species, regardless of their components, were: Conyza canadensis, Chenopodium album, Eguisetum arvense, Rumex acetosella and Sonchus asper. In the first year of the study, the highest diversity of weeds, expressed by Shannon's diversity index, showed a mixture of triticale with 40% share of pea of Milwa cultivar, in the second year a mixture with 80% share of pea Klif cultivar and 40% of Milwa, while in the third year of study mixtures with 60% share of pea Milwa cultivar and 40% - of Klif cultivar.

Keywords: *pea, spring triticale, mixture, weed infestation, ecological farm, index of diversity, index of domination*

OCENA ZACHWASZCZENIA MIESZANEK PSZENŻYTA Z GROCHEM UPRAWIANYCH NA NASIONA

Streszczenie

Celem badań była ocena zachwaszczenia mieszanek grochu z pszenżytem jarym o zróżnicowanym udziale nasion komponentów przy wysiewie, w ekologicznym systemie gospodarowania. Doświadczenie polowe przeprowadzono w latach 2014-2016 w układzie split-plot, w 4 powtórzeniach, na glebie kompleksu żytniego dobrego. Porównywano mieszanki dwóch odmian grochu z pszenżytem jarym o zróżnicowanym udziale rośliny strączkowej (40, 60 i 80%). Przeprowadzono ocenę składu gatunkowego, liczebności poszczególnych gatunków, oznaczono świeżą i powietrznie suchą masę chwastów oraz wykonano ocenę struktury zbiorowisk chwastów w badanych uprawach za pomocą dwóch wskaźników ekologicznych: indeksu różnorodności Shannona (H') oraz indeksu dominacji Simpsona (SI). Badania wykazały, że w pierwszym i trzecim roku badań, najbardziej konkurencyjna w stosunku do chwastów była mieszanka o najmniejszym udziale rośliny strączkowej, natomiast w drugim roku mieszanka z 80% udziałem grochu wyróżniała się najmniejszym zachwaszczeniem, na co wskazuje istotnie mniejsza świeża i sucha masa chwastów. We wszystkich latach badań, w uprawie wszystkich mieszanek, fitocenozy chwastów składały się głównie z gatunków dwuliściennych. Najliczniej występującymi gatunkami chwastów, niezależnie od udziału komponentów były: Conyza canadensis, Chenopodium album, Eguisetum arvense, Rumex acetosella oraz Sonchus asper. Największą różnorodnością flory segetalnej, wyrażoną indeksem różnorodności Shannona, w pierwszym roku badań, wykazała się mieszanka pszenżyta z 40% udziałem grochu odmiany Milwa, w drugim roku mieszanka z 80% udziałem grochu odmiany Klif oraz 40% odmiany Milwa, zaś w trzecim roku mieszanka z 60% udziałem rośliny strączkowej odmiany Milwa oraz 40% odmiany Klif.

Słowa kluczowe*: groch, pszenżyto jare, mieszanka, zachwaszczenie, gospodarstwo ekologiczne, indeks różnorodności, indeks dominacji*

1. Introduction

Cultivation of legumes in pure sowing due to the difficult limitation of weed infestation is troublesome, therefore, the possibility of sowing them in mixtures with cereals is sought. Non-legume plants growing in the vicinity of legume plants use nitrogen assimilated by papillary bacteria, which is particularly significant in organic farming. Mixed sowing advantageously affects the soil and its sanitary condition and as a result is a very good forecrop for many plant species grown in the farm [10, 12]. The resulting contains a broader set of nutrients and obtained fodder quality. According to Kotecki [7], Creamer et al. [4] and Sobkowicz and Podgórska-Lesiak [11], mixed plants generally use better production space than the same crops in pure sowing, which is conducive to reducing weed infestation.

The aim of the study was evaluation of weed infestation of pea-spring triticale mixtures with differentiated share of seeds.

2. Materials and methods

The field experiment with triticale-pea mixtures was carried out in the years 2014-2016, at the Advisory Agricultural Center in Szepietowo (Podlaskie voivodeship), in split-plot design, with four replications. The first factor concerned the cultivar of *Pisum sativum* (L.): Milva (semi-leafless cultivar) and Klif (with bipinnate leaves). The sec-

ond factor referred to the percentage of *Pisum sativum* in mixture with *Triticale*: 40, 60 and 80%. The density of plants in pure sowing, used as the base to calculate their density in the mixtures, was as follows: *P. sativum* 100 seeds·m^{-2}, triticale (Milewo cultivar) 400 seeds·m^{-2}. The area of a plot was 30,0 m^2. The experiment was conducted on a soil belonging to a good rye complex, class IV b. The contents of available nutrients were in range (mg·100 kg^{-1} soil): phosphorus 6,2-6,4; potassium 6,1-6,9 and magnesium 5,0-5,6. Soil pH, as determined in 1 N KCl, was 5,2-5,4. In the first year winter rye was the forecrop, and in the second and third year- potatoes. The plots were harrowed twice to control weeds in the mixtures. Plants were harvested at the full maturity stage of mixture components in the first decade of August. Weed infestation of the mixtures was analyzed a couple days before harvesting plants, on the surface of 0,5 m^2, with four replications. The study included an evaluation of weed species composition, number of individual species and the designation of fresh and dry matter of weeds. Assessing the significance of the impact of the considered factors on the features under investigation was based on the variance analysis, indicating Tukey's confidence half-intervals at a significance level of 0,05.

The biomass coefficient calculated according to the formula by Patriquin [8] was used to compare the degree of weed infiltration of the mixtures according to their composition:

$$Biomass \cdot index = \frac{crop \cdot biomass \cdot x \cdot 100}{weed \cdot biomass + crop \cdot biomass}$$

The dry matter of the above ground mixtures and weeds from the surface of 1m^2 were taken into account.

The structure of weed composition in the studied crops was also described using two ecological indicators: the Shannon index (H') and the Simpson dominance index (SI). The Shanonn's index is an indicator of species diversity. Its value determines the probability that two sampled individuals will belong to different species. It depends on the number of species and their relative quantitative proportions and is calculated according to Shannon and Weaver's model [15]:

$$H' = - \Sigma Pi \ln Pi$$

where: Pi – ratio of species number to the overall weed abundance on each site. The proportion of species 'i' relative to the total number of species (Pi) is computed, and then multiplied by the natural logarithm of this proportion (ln Pi). The resulting product is summed across species, and multiplied by -1.

The Simpson I\index (SI) is an indicator used to estimate the biodiversity of habitats. It describes the probability of occuring two individuals of the same species. It takes into account the number of species and the relative abundance of each species and is described by the Simpson model [15]:

$$SI = \Sigma Pi2$$

Value ranges from 0 to 1, with values close to 1 indicating a clear dominance of one or more species and a low diversity of the community.

3. Results and discussion

An analysis of the obtained results showed that the level of weed infestation of the mixtures depended not only on the percentage of pea in the mixtures, but also on weather conditions during the growing period (Table 1). Weather conditions had a strong effect on the yield and weed infestation of the pea-triticale mixture. The most optimal conditions for growth and development of mixtures were recorded in the first year of the study (2014). Only in July, moisture deficiency was noted (65% of the mean of multi-years). In contrast, in 2015 moisture deficits occurred in June (36% of mean of multi-years), in July (46% of the mean of multi-years) and in August (13%), accompanied by high air temperatures, exceeding the standard for individual months by, respectively, 8, 13 and 36%. In 2016, in May and June, moisture deficiencies amounted to, respectively: 67 and 62% of the standard. In July, however, there were heavy rainfalls (the sum of precipitation was higher by 32% than the mean of multi-years for this month).

In the first and third year of the study, the mixture with the lowest share of a legume was the least competitive against weeds, while in the second year, the mixture with 80% of pea was the least weed-infested (statistically significant differences). In the first and third year, the weeds were the most abundant in the mixture with 80% of pea (in both cultivars), whereas in the second year, the inverse relationship was noted, as the largest weed infestation was found in mixtures with 40% share of this species, as evidenced by significantly higher fresh and dry matter of weeds (Table 2).

Table 1. Weather conditions during the vegetation periods
Tab. 1. Przebieg warunków pogodowych w okresie wegetacji

Specification	Year	Month						Sum
		III	IV	V	VI	VII	VIII	(III-VIII)
Rainfalls (mm)	2014	35,1	38,0	42,1	74,3	56,2	63,3	309,0
	2015	30,1	35,5	45,1	25,4	40,0	9,5	185,6
	2016	28,3	38,4	38,3	43,9	114,2	68,8	333,9
Rainfalls mean from multi-years (mm)		32,9	34,8	57,0	70,9	86,5	70,9	58,8
		III	IV	V	VI	VII	VIII	Average (III-VIII)
Temperature (°C)	2014	6,0	9,1	13,5	15,1	20,6	17,7	13,7
	2015	4,8	8,5	12,7	16,9	19,4	22,2	14,1
	2016	2,7	8,6	14,5	17,7	18,8	16,1	13,1
Temperature mean from multi-years (°C)		0,4	6,5	12,6	15,7	17,1	16,3	11,4

** Average from multi-years*

Source: / Źródło: Datebase of Meteorological Service of IUNG-PIB / Baza danych Stacji Meteorologicznej IUNG-PIB

Table 2. Dry matter (g) of weeds depending on the cultivar of pea and its percentage in mixtures in the years 2014-2016
Tab. 2. Sucha masa (g) chwastów w zależności od odmiany grochu i jego udziału w mieszance w latach 2014-2016

Pea percentage (%)	Year						Mean	
	2014		2015		2016			
	Milwa	Klif	Milwa	Klif	Milwa	Klif	Milwa	Klif
40	13,4	6,7	43,0	48,1	49,4	38,8	35,3	31,2
60	11,4	12,2	34,5	44,8	63,2	70,4	36,4	42,5
80	34,2	20,0	25,4	40,4	44,6	87,8	34,7	49,4
Mean for variety								
Mean	19,7	13,0	34,3	44,4	52,4	65,7	35,5	41,0
Mean for pea percentage								
40	10,1a		45,6a		44,1a		33,3a	
60	11,8a		39,7a		66,8b		39,4a	
80	27,1b		32,9a		66,2b		42,1a	

** values marked with the same letter did not differ significantly (α=0.05)*

Source: own study / Źródło: opracowanie własne

The research of Płaza et al. [9] have recorded a lower weed infestation in the mixtures of spring wheat with pea cvs. Wiato and Klif with 40% and 60% shares of legume compared to 80%. In the first year (2014), the weed weight of the mixtures with an 80% share of legumes was about three times higher than in the other mixtures, and in the third year of research (2016), it was two times higher. In their previous studies, the authors showed that the mixture with 40% of pea were the most competitive against weeds, as it had the smallest fresh and dry matter of weeds [2].Also, Staniak et al. [13, 14], in their studies on weed infestation of mixtures of blue lupine with cereals and of oat with peas, showed that the mixtures in which a legume share was 40% of the standard for a pure sowing, while cereal was 60%, were the most competitive against weeds, as evidenced by the smallest number and the fresh and dry weeds matter. Increasing the percentage of legumes in a mixture resulted in an increased weed infestation. These results are consistent with the results of Buraczyńska [3], who found a significant decrease in the number and weight of weeds in the cereal-legume mixtures combined with a decrease in lupine percentage in the mixture (from 75% to 25%). In turn, Plaza et al. [9] recorded the lowest weed weight in pea-spring wheat mixtures at 40% and 60% share of legume compared to the mixtures with its 20% and 80% or pure pea sowings. The obtained results showed that a pea cultivar had no significant effect on fresh and dry weeds matter. These results coincide with the results obtained in the studies of Płaza et al. [9], which showed that the analyzed pea cultivars Klif and Wiato had no effect on the level of weed infestation. Also, Sobkowicz and Podgórska-Lesiak [11] found that a pea cultivar did not significantly affect the weed infestation of pea with spring barley mixtures. The comparison of pea cultivars showed that in the first year of the study (2014), the mixtures with pea cv. Klif were more competitive against the weight of weeds, whereas in the years with precipitation deficits (2015 and 2016) - the mixtures with blue leaf pea cultivar Milwa. In the first year of the study, pea cv. Klif had a higher competitiveness against weeds, while in the other two years, cv. Milwa.

In the first (2014) and third (2016) years of the study, the highest number of weeds per unit area was recorded for the mixtures with 80% share of pea (116 and 149 plants per 1 m^2, respectively), whereas in the second year (2015), the largest number of undesirable species was found in mixtures with a 40% share of legumes (68 plants per 1 m^2 - on average for both pea cultivars) (Tables 3-5).

Table 3 Weed species composition and number of weeds (plants·m^{-2}) depending on the cultivar of pea and its percentage share in the mixture in the first year of the study (2014)
Tab. 3. Skład gatunkowy i liczebność chwastów w zależności od odmiany grochu i jego udziału w mieszance w pierwszym roku badań (2014)

Weed species	Pea percentage (%)						
	40		60		80		mean
	Milwa	Klif	Milwa	Klif	Milwa	Klif	
Monocotyledonous:							
Echinochloa crus-galli	-	-	-	-	0,5	0,5	0,2
Elymus repens	5,0	2,0	3,0	8,5	3,5	6,0	4,7
Setaria pumila	7,0	7,0	7,0	2,5	11,5	7,0	7,0
Sum of Monocotyledonous	12,0	9,0	10,0	11,0	15,5	13,5	11,8
Dicotyledonous:							
Anthemie arvensis	-	2,5	2,5	1,0	-	2,5	1,4
Capsella bursa-pastoris	-	-	-	-	2,0	-	0,3
Centaurea cyanus	-	-	-	0,5	-	-	0,1
Chenopodium album	8,0	8,5	13,5	8,0	8,0	9,5	9,3
Cirsium arvense	0,5	-	-	-	-	-	0,1
Convolvulus arvensis	-	-	-	-	0,5	0,5	0,2
Conyza canadensis	23,0	17,5	19,5	17,0	12,0	13,5	17,1
Fallopia convolvulus	9,0	2,5	3,0	1,5	1,0	1,5	3,1
Gypsophila muralis	6,5	6,5	8,5	4,5	2,0	4,5	5,4
Matricaria maritima	2,0	-	1,0	0,5	1,5	0,5	0,9

Myosotis arvensis	0,5	-	-	0,5	-	-	0,2
Plantago lanceolata	3,0	0,5	-	-	-	-	0,6
Polygonum aviculare	-	2,0	2,0	2,5	2,5	1,0	1,7
Polygonum lapathifolium	-	0,5	-	-	-	-	0,1
Polygonum persicaria	-	-	-	-	0,5	-	0,1
Rumex acetosella	11,0	21,5	16,5	19,0	28,0	22,5	19,8
Scleranthus annuus	15,0	18,0	20,5	13,5	24,0	19,5	18,4
Sinapis arvensis	0,5	0,5	0,5	-	-	-	0,3
Spergula arvensis	-	-	0,5	-	-	-	0,1
Stellaria media	1,0	-	-	-	-	-	0,2
Trifolium arvense	0,5	1,0	-	-	-	2,0	0,6
Veronica arvensis	-	-	-	0,5	-	-	0,1
Viola arvensis	3,0	5,5	4,0	4,5	9,5	9,0	5,9
Sum of Dicotyledonous	83,5	87,0	92,0	73,5	91,5	86,5	85,7
Eguisetum arvense	1,3	-	0,5	1,0	16,5	7,5	4,5
Total	96,8	96,0	102,5	85,5	123,5	107,5	102,0
Mean for pea percentage	96,4		94,0		115,5		
Mean for species							
Milwa	107,6						
Klif	96,3						
Number of weed species	17	15	15	16	16	16	15,8

Source: own study / Źródło: opracowanie własne

Table 4. Weed species composition and number of weeds (plants·m^{-2}) in mixtures depending on the cultivar of pea and its percentage share in mixture in the second year of the study (2015)
Tab. 4. Skład gatunkowy i liczebność chwastów w zależności od odmiany grochu i jego udziału w mieszance w drugim roku badań (2015)

Weed species	Pea percentage (%)						
	40		60		80		mean
	Milwa	Klif	Milwa	Klif	Milwa	Klif	
Monocotyledonous							
Echinochloa crus-galli	3,5	3,5	3,5	16,5	4,0	5,0	6,0
Elymus repens	-	-	1,0	1,5	3,5	2,5	2,1
Juncus bufonius	1,5	0,5	-	-	-	-	1,0
Sum of Monocotyledonous	5,0	4,0	4,5	18,0	7,5	7,5	7,8
Dicotyledonous							
Anthemis arvensis	1,5	0,5	4,0	1,5	1,0	0,5	1,5
Capsella bursa-pastoris	-	-	1,0	5,5	3,0	3,0	3,1
Chenopodium album	17,0	13,5	19,0	19,5	21,5	12,5	17,2
Cirsium arvense	3,0	2,0	2,5	-	-	1,0	2,1
Convolvulus arvensis	6,0	7,5	1,5	3,0	0,5	-	3,7
Conyza canadensis	1,0	-	-	-	0,5	0,5	0,7
Fallopia convolvulus	-	1,0	2,0	1,5	-	6,0	2,6
Matricaria maritima subsp. inodora	-	-	-	1,0	-	-	1,0
Myosotis arvensis	0,5	-	-	-	-	0,5	0,5
Plantago major	-	-	-	-	0,5	-	0,5
Polygonum aviculare	1,0	1,5	-	0,5	0,5	-	0,9
Rumex acetosella	-	-	-	-	1,0	-	1,0
Sonchus arvensis	0,5	-	-	0,5	0,5	-	0,5
Sonchus asper	6,5	4,0	4,0	3,0	6,0	8,5	5,3
Veronica persica	2,0	0,5	1,0	1,5	-	1,0	1,2
Viola arvensis	4,0	1,0	3,5	3,0	1,5	7,5	3,4
Sum of Dicotyledonous	43,0	31,5	38,5	40,5	36,5	41,0	38,5
Eguisetum arvense	24,0	27,5	9,0	1,5	4,5	8,5	12,5
Total	72,0	63,0	52,0	60,0	48,5	57,0	59,6
Mean for pea percentage	67,5		56,0		52,8		
Mean for species:							
Milwa	57,5						
Klif	60,0						
Number of weed species	14	12	12	14	14	13	13,2

Source: own study / Źródło: opracowanie własne

Table 5. Weed species composition and number of weeds (plants·m^{-2}) in mixtures depending on the cultivar of pea and its percentage share in mixture in the third year of the study (2016)
Tab. 5. Skład gatunkowy i liczebność chwastów w zależności od odmiany grochu i jego udziału w mieszance w trzecim roku badań (2016)

Weed species	Pea percentage (%)						
	40		60		80		mean
	Milwa	Klif	Milwa	Klif	Milwa	Klif	
Monocotyledonous:							
Echinochloa crus-galli	1,5	-	1,5	0,5	0,5	-	0,7
Elymus repens	-	1,0	1,0	1,0	1,5	-	0,8
Setaria viridis	1,0	8,5	10,0	2,5	3,5	5,0	5,1
Sum of Monocotyledonous	2,5	9,5	12,5	4,0	5,5	5,0	6,5
Dicotyledonous:							
Anthemis arvensis	1,0	1,0	3,5	1,5	0,5	1,0	1,4
Aphanes arvensis	12,5	12,5	5,5	4,5	3,0	7,0	7,5
Capsella bursa-pastoris	-	0,5	0,5	0,5	0,5	0,5	0,4
Centaurea cyanus	-	1,0	-	0,5	-	-	0,3
Cerastium arvense	1,5	4,5	7,0	1,0	4,0	1,0	3,2
Chenopodium album	17,0	16,5	22,5	16,5	9,0	15,0	16,1
Cirsium arvense	1,0	-	2,0	-	-	-	0,5
Conyza canadensis	16,5	16,5	22,0	10,0	24,5	19,0	18,1
Fallopia convolvulus	7,5	10,0	16,0	5,5	7,5	11,0	9,6
Matricaria maritima subsp. inodora	2,5	6,5	1,5	0,5	3,5	3,0	2,9
Plantago lanceolata	1,0	1,0	5,0	1,5	-	1,5	1,7
Plantago major	6,0	6,0	3,0	8,0	2,5	5,0	5,1
Polygonum aviculare	1,5	3,0	5,0	8,0	10,0	7,0	5,8
Polygonum lapathifolium	1,0	5,5	2,5	0,5	3,5	2,5	2,6
Rumex acetosella	7,0	10,0	12,0	2,0	6,0	3,5	6,8
Sonchus arvensis	0,5	1,5	5,0	3,0	8,0	2,0	3,3
Sonchus asper	25,0	3,0	6,0	25,0	1,5	20,0	13,4
Sonchus oleraceus	1,0	0,5	1,0	-	-	0,5	0,5
Spergula arvensis	6,5	7,5	6,0	2,0	2,0	0,5	4,1
Trifolium repens	1,0	-	0,5	-	0,5	-	0,3
Veronica arvensis	-	2,0	1,5	0,5	1,0	0,5	0,9
Viola arvensis	5,0	11,5	6,0	7,5	10,0	8,5	8,1
Sum of Dicotyledonous	115,0	120,5	134,0	98,5	97,5	109,0	112,4
Eguisetum arvense	11,0	15,0	23,0	24,0	27,5	52,5	25,5
Total	128,5	145,0	169,5	126,5	130,5	166,5	144,4
Mean for pea percentage	136,8		148,0		148,5		
Mean for cultivar							
Milwa	142,9						
Klif	146,0						
Number of weed species	22	25	22	25	24	22	23

Source: own study / Źródło: opracowanie własne

In the mixtures with 60% share of pea, on average 87.4 plants of weeds per 1 m^2, were recorded while with 80% - 62,4 pcs per 1 m^2. The mixtures with pea cv. Klif were more competitive than the ones with Milwa against the number of weeds per unit area only in the first year (2014) of the study. In all the years of the study, in the cultivation of all mixtures, weed phytocenoses in the analyzed treatments consisted mainly of dicotyledonous species (Tables 3-5). The dicotyledonous weed group accounted for an average of 76% of the total number of undesirable species. The species diversity of segetal flora was similar in the cultivation of all mixtures. The most abundant weed species, independent of the components involved, were *Conyza Canadensis, Chenopodium album, Eguisetum arvense, Rumex acetosella* and *Sonchus asper*.

The weed species composition was similar in all the years of the study. Total of 27 species of weeds, including 5 monocotyledon species, were identified for triticale and pea mixtures. The highest number of weed species occurring in mixtures was recorded in 2016. In addition, a large number of *Eguisetum arvense, Fallopia convolvulus, Anthemis arvensis* and *Viola arvensis* were recorded. By contrast, in 2014, there was a large number *Scleranthus annuus*. In the studies of Staniak et al. [12], the most abundant species of weeds in the organic crops were: *Chenopodium album, Echinochloa crus-galli, Stellaria media*, and *Capsella bursa-pastoris*. According to Barankiewicz and Misiewicz [1], a big problem in growing spring cereals are, among others: *Galinsoga parviflora, Capsella bursa-pastoris, Stellaria media* and *Chenopodium album*, while according to Kapeluszny and Haliniarz [6] - *Sonchus arvensis, Chenopodium album, Echinochloa crus - galli* and *Equisetum arvense*. Feledyn-Szewczyk [5], however, indicated *Chenopodium album* and *Stellaria media* as particularly oppressive.

Biomass index was additional factor indicating the degree of weed infestation. The lowest values of this factor were found for the mixtures with 80% of legumes, which shows a high share of weed matter in the total biomass of cereal-legume mixture per unit area, while the highest values of the biomass factor were recorded for the mixtures with 40% of pea, yet they did not significantly differ from the other mixtures, where the value of this factor was also very high (Table 6).

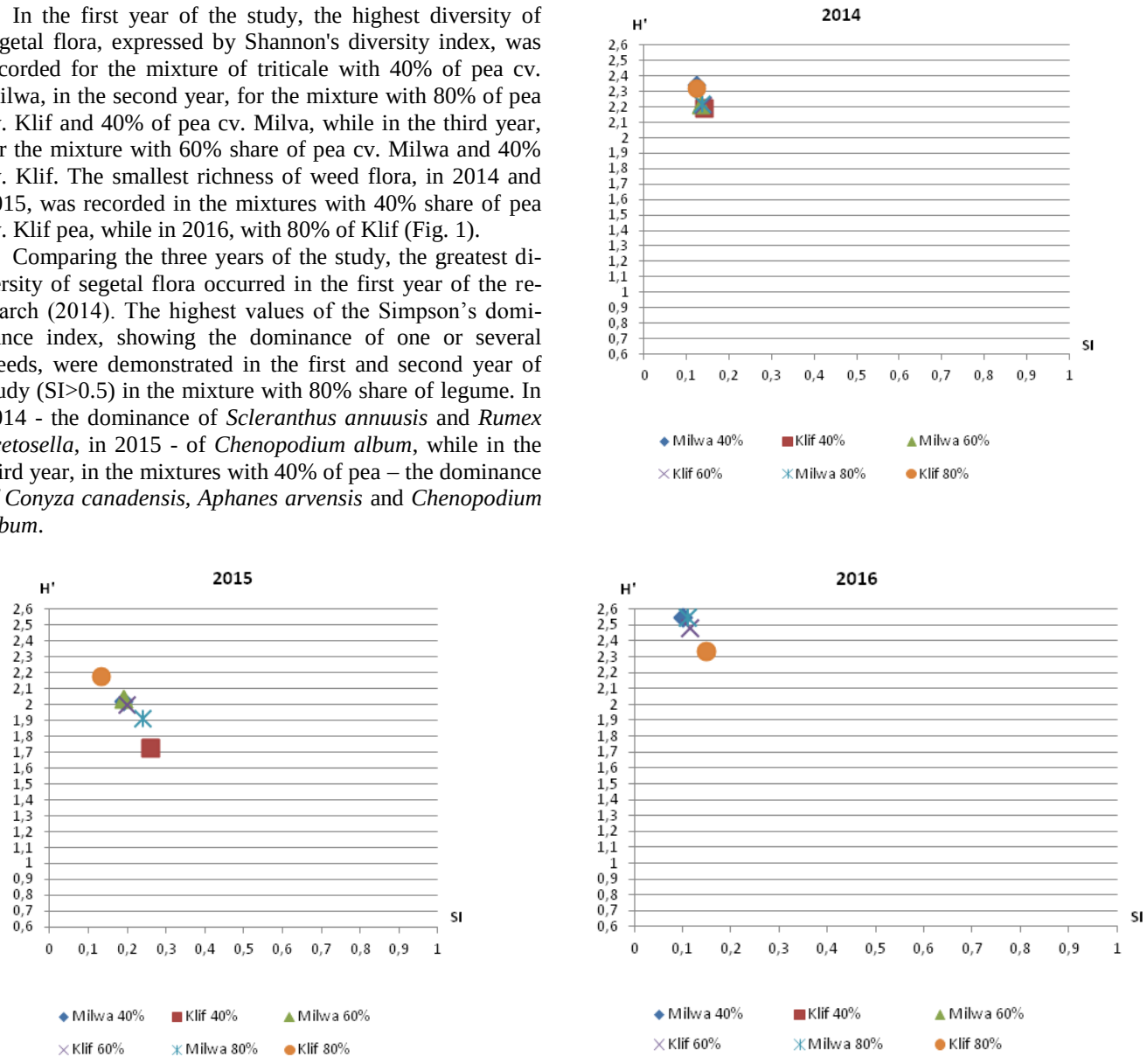
Table 6. Biomass index (%)
Tab. 6. Współczynnik biomasy (%)

Pea percentage (%)	Year						Mean	
	2014		2015		2016			
	Milwa	Klif	Milwa	Klif	Milwa	Klif	Milwa	Klif
40	96,4	98,2	88,0	87,0	86,7	88,4	90,4	91,2
60	96,8	96,5	89,7	87,3	83,2	82,2	89,9	88,7
80	90,5	94,2	91,9	87,7	86,9	76,5	89,8	86,1
Mean for variety								
Mean	94,6a	96,3a	89,9a	87,3a	85,6a	85,7a	90,0a	88,7a
Mean for pea percentage								
40	97,3a		87,5a		87,6a		90,8a	
60	96,7a		88,5a		82,7a		89,3a	
80	92,4a		89,8a		81,7a		88,0a	

Source: own study / Źródło: opracowanie własne

In the first year of the study, the highest diversity of segetal flora, expressed by Shannon's diversity index, was recorded for the mixture of triticale with 40% of pea cv. Milwa, in the second year, for the mixture with 80% of pea cv. Klif and 40% of pea cv. Milva, while in the third year, for the mixture with 60% share of pea cv. Milwa and 40% cv. Klif. The smallest richness of weed flora, in 2014 and 2015, was recorded in the mixtures with 40% share of pea cv. Klif pea, while in 2016, with 80% of Klif (Fig. 1).

Comparing the three years of the study, the greatest diversity of segetal flora occurred in the first year of the research (2014). The highest values of the Simpson's dominance index, showing the dominance of one or several weeds, were demonstrated in the first and second year of study (SI>0.5) in the mixture with 80% share of legume. In 2014 - the dominance of *Scleranthus annuusis* and *Rumex acetosella*, in 2015 - of *Chenopodium album*, while in the third year, in the mixtures with 40% of pea – the dominance *of Conyza canadensis*, *Aphanes arvensis* and *Chenopodium album*.



Source: own study / Źródło: opracowanie własne

Fig. 1. Index of Shannon's diversity (H') and Simpson's dominance (SI)
Rys. 1. Indeks różnorodności Shannona (H') oraz indeks dominacji Simpsona (SI)

4. Conclusions

1. In 2014 and 2016 of the study, the mixture with the least percentage of pea was the most competitive in relation to weeds, while in 2015 the mixture with 80% of pea (both cultivars), as evidenced by the smaller fresh and dry matter of weeds.
2. In a year with better soil moisture (2014) the mixture with Klif cultivar of pea was more competitive mixture in relation to weeds species, whereas in the years characterized by deficits of soil moisture (2015 and 2016) - mixtures with Milwa.
3. In all years of study, weed phytocenoses consisted mainly of dicotyledonous species, of 76% of the total number of weeds species.
4. The species diversity of segetal flora was similar in the cultivation of all mixtures. The most abundant species of weed, independent of the components percentage were: *Conyza canadensis, Chenopodium album, Eguisetum arvense, Rumex acetosella* and *Sonchus asper.*
5. The greatest biodiversity of segetal flora, expressed in Shannon's diversity index, in 2014, a mixture of triticale with 40% of Milwa peas has shown, in the second year the mixture with 80% of Klif peas and 40% of Milwa while in the third year with a 60% share of Milwa cultivar and 40% of Klif cultivar. The largest biodiversity of segetal flora was found in the first year of research (2014).
6. The lowest values of biomass index were found for mixtures with 80% share of legume, which is a testimony of the high weed weight in the total yield of cereal-legume biomass per unit area.

5. References

[1] Barankiewicz A., Misiewicz J.: Specify of weeding of cereals in ecological farms in the Kujawy and Pomorze areas. Pam. Puł., 2000, 122, 77-82.
[2] Bojarszczuk J., Staniak M., Księżak J.: Ocena zachwaszczenia mieszanek grochu z pszenicą jarą uprawianych w systemie ekologicznym. J. Res. Applic. Agric. Engng, 2013, 58(3), 33-40.
[3] Buraczyńska D.: Zachwaszczenie mieszanek strączkowo-zbożowych przy zróżnicowanym składzie ilościowo-jakościowym. Prog. Plant Prot./Post. Ochr. Rośl., 2009, 49(2), 779-783.
[4] Creamer N.G.: Mechanism of weed suppression in cover crop-based production systems. Hort. Sci., 1996, Vol. 31(3), 410-413.
[5] Feledyn-Szewczyk B.: Zachwaszczenie odmian pszenicy jarej uprawianej w ekologicznym systemie produkcji. J. Res. Appl. Agric. Engng, 2011, 56(3), 71-76.
[6] Kapeluszny J., Haliniarz M.: Weed infestation of cereal crops grown on ecological farms in the Lublin region. Pam. Puł., 2000, 122, 40-49.
[7] Kotecki A.: Wpływ składu gatunkowego oraz zróżnicowanego udziału komponentów w mieszankach na plon nasion peluszki uprawianej w różnych warunkach glebowych. Zesz. Nauk. AR Wrocław, Rozpr. Hab., 1990, 87, 54.
[8] Patriquin D.G.: Weed control in organic forming system. In: Weed management in agroecosystems: ecological approaches. Altieri M.A., Liebman M. (eds), CRC Press, Inc., 1988, 303-317.
[9] Płaza A., Ceglarek F., Buraczyńska D., Rudziński R.: Ocena plonowania mieszanek grochu siewnego z pszenicą jarą uprawianych w rejonie Siedlec. Zesz. Probl. Post. Nauk Roln., 2007, 516, 153-159.
[10] Pozdísek J.: Utilizing legume-cereal intercropping for increasing self-sufficiency on organic farms in feed for monogastric animals. Agron. Res., 2011, 9 (1–2), 343-356.
[11] Sobkowicz P., Podgórska-Lesiak M.: Zmiany w zachwaszczeniu zasiewów czystych i mieszanych dwóch odmian grochu z jęczmieniem pod wpływem nawożenia azotowego. Prog. Plant Prot./Post. Ochr. Rośl., 2007, 47(3), 271-275.
[12] Staniak M., Bojarszczuk J., Księżak J.: The assessment of weed infestation of oats-pea mixtures grown in organic farm. J. Res. Applic. Agric. Engng, 2014, 59(4), 83-88.
[13] Staniak M., Bojarszczuk J., Księżak J.: Zachwaszczenie mieszanek łubinu wąskolistnego ze zbożami jarymi w ekologicznym systemie gospodarowania. J. Res. Applic. Agric. Engng, 2013, 58(4), 155-160.
[14] Staniak M., Księżak J., Bojarszczuk J.: Estimation of productivity and nutritive value of pea-barley mixtures in organic farming. J. Food Agric. Environ., 2012, 10(2), 318-323.
[15] Zanin G., Mosca G., Catizone P.: A profile of the potential flora in maize fields of the Po Valley. Weed Res., 1992, 32, 407-418.

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