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WEED INFESTATION OF PEA (*Pisum sativum* L.) CROP UNDER THE CONDITIONS OF PLOUGH AND PLOUGHLESS TILLAGE

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Abstract. Weed infestation depends on soil diaspore bank, the habitat conditions and the applied agricultural practices. Tillage constitutes one of the agrotechnical factors which significantly influence the condition and the level of weed infestation. In the conducted research, ploughless tillage practice and the application of herbicides considerably increased the number and the air-dry matter of weed populations per 1 m^2 of pea crop compared to plough tillage. It was also established that the number of weeds per 1 m^2 in the first term of weed infestation evaluation (in the phase of third true leaf) exceeded the number of weeds in the second term (ripening of pods and seeds). On the other hand, the air-dry matter of weeds was higher in the second term of evaluation. In addition, analyses revealed a higher number of weed species under the conditions of ploughless tillage (20–22 species) and herbicide application (20 species) than in the conventional tillage system (14–16 species). The predominant species under the conditions of conventional tillage were: *Amaranthus retroflexus* L. and *Echinochloa crus-galli* (L.) P.B. (in the first term of evaluation), and *Avena fatua* L. and *Chenopodium album* L. (in the second term). The predominant species in the ploughless tillage were: *Echinochloa crus-galli* (L.) P.B. and *Amaranthus retroflexus* L. (in the first term) as well as *Fallopia convolvulus* (L.) A. Löve, *Avena fatua* L. and *Galinsoga praviflora* Cav. (in the second term). In case of herbicide application, the prevailing species were: *Echinochloa crus-galli* (L.) P.B. and *Matricaria inodora* L. (in the first term) as well as *Matricaria inodora* L. and *Echinochloa crus-galli* (L.) P.B. (in the second term). The reduced tillage increased the number of perennial weeds: *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) P.B. and *Convolvulus arvensis* L.

Key words: legumes, agrotechnology, herbicide tillage, biodiversity of weed

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INTRODUCTION

Weed infestation of arable crops results from coupled effects of the soil diaspore bank and the applied agricultural technology [Fykse and Waernhus 1999, Wesołowski and Woźniak 2001, Mas and Verdu 2003, Gruber and Claupein 2009, Blecharczyk et al. 2010]. The number, air-dry matter and species composition of weeds are significantly influenced by soil tillage systems, especially their number as well as the method and period of their conduct [Knezevic et al. 2009, Brandsaeter et al. 2011], as well as by the chemical and mechanical conservation treatments [Fykse and Waernhus 1999, Locke et al. 2002, Gruber and Claupein 2009, Lundkvist 2009]. Opinions concerning the effect of ploughless tillage on the condition of weed infestation vary. Tuesca et al. [2001] claim that conventional tillage may increase weed infestation, whereas the ploughless tillage may decrease it, due to the fact that no weed diaspores are extracted from lower layers of the soil. A research conducted by Małecka et al. [2006] revealed a considerably higher level of weed infestation (number and weight of weed) of growing crops in the system of conventional tillage (plough) than in the reduced tillage and in direct drilling. Also, a study conducted by Faltyn and Kordas [2009], demonstrated a lower level of weed infestation in direct drilling than in the conventional and reduced tillage systems. In turn, Kraska and Pałys [2006] confirmed a greater weed biomass in the crop of spring barley sown in reduced tillage. Also, in a research by Woźniak [2011] ploughless tillage increased the mass of weed in spring wheat compared to conventional tillage. The level of weed infestation is effectively reduced by intercrop intended for fallow ploughing and mulch, which has simultaneously a beneficial influence on the quality of agricultural products obtained [Błażewicz-Woźniak et al. 2008, Konopiński 2011, Błażewicz-Woźniak and Konopiński 2011].

The purpose of the conducted experiment was to determine the effect of the conventional (plough) and ploughless (reduced and herbicide) tillage on the number, air-dry weight and species composition of weeds in two terms determined by the developmental stages of pea: third true leaf (13/14 on the BBSCH scale) – the first term of evaluation, and the ripening of pods and seeds (82/82 on the BBSCH scale) – the second term.

MATERIAL AND METHODS

Exact field studies were conducted in the years 2009–2011 at the Experimental Farm Uhrusk (51°18'12"N, 23°36'50"E) belonging to the University of Life Sciences in Lublin. The experiment was established on mixed rendzina soil with light, slightly sandy loam, with the method of randomized sub-blocks, in 3 replicates on 24 m^2 plots. The aim of the experiment was to evaluate weed infestation of a crop of pea (*Pisum sativum* L.) (Bohun cultivar) sown for seed, under conditions of conventional (plough) and reduced (ploughless and herbicide) tillage systems.

In the plough tillage system, tillage involved skimming (harrowed) done after the harvest of the forecrop (spring wheat) and autumn ploughing. The ploughless tillage involved only the cultivation of field, whereas the herbicide tillage – the application of Roundup 360 SL (active substance – glyphosate) – 4 $l \cdot ha^{-1}$. In all plots, spring tillage involved field cultivation and the use of a tillage assembly consisting of a cultivator, cage roller, and harrow. Before the sowing of seeds, 20 kg N·ha^{-1}, 17.5 kg P·ha^{-1} and 66.5 kg K·ha^{-1} were applied. In each study year, the sowing was conducted within the first ten days of April, in the dose of 100 seeds per 1 m^2 and with 20 cm row spacing. Before the sowing, the seeds were treated with T Seed Treatment Dressing (a.s.: Carbendazim – 20% and Tiuram – 45%). Pea plots were harrowed twice – once before the sprouting, and for the second time in the third true leaf stage of pea (13/14 BBCH--scale).

Weed infestation of a pea plot was evaluated by the botanical gravimetric method in two terms determined by the developmental stages of pea, i.e.: the third true leaf (13/14 BBCH) (before the harrowing of the crops) – the first term of evaluation, and the ripening of pods and seeds (81/82 BBCH) – the second term. The evaluation of weed infestation consisted in the determination of the species composition of weeds as well as their number and air-dry matter per 1 m^2 of the plot. The sampling area was randomly selected (twice) using a frame 1 m × 0.5 m in size. The determination of air-dry matter of weeds consisted in collecting all weeds from within the frame, removing their root systems and placing the weeds on openwork shelves in a well-aired and dry place until a constant weight is reached.

Thus obtained results were statistically elaborated with the use of the analysis of variance, and the recorded differences were verified with the Tukey's test at a significance level of $p = 0.05$.

RESULTS

The number of weeds per 1 m^2 in pea plot was found to depend on the applied tillage system, the term of weed infestation evaluation and the combination of these factors (tab. 1). A higher number of weeds per 1 m^2 was recorded on the plot with the herbicide tillage (mean 105.4 plants per 1 m^2) and ploughless tillage (91.9 per 1 m^2), whereas 46.0–52.9% less on the plot with plough tillage. Taking into account the number of weeds per 1 m^2 evaluated in the examined periods, it was established that it was higher by 25.5% in the first term (in the phase of third true leaf) than in the second term (ripening of pods and seeds) – on average 70.3 per 1 m^2. The number of weeds in the first term was also determined by the applied tillage method. The highest number of weeds was observed to emerge in the ploughless tillage (on average 122.1 per 1 m^2), a lower one (24.2% smaller) in the herbicide tillage, and the lowest one (44.1%) in the plough tillage. It shall also be added that weed seedlings were prevailing in this term. In the next term of weed infestation evaluation, i.e. in the phase of ripening of pods and seeds, the highest number of weeds (118.4 plants per 1 m^2) was recorded on the plot with herbicide tillage, a lower one (by 47.9%) on that with ploughless tillage, whereas the lowest one (30.8 plants per 1 m^2) on that with plough tillage. Significant differences in the number of weeds amounting to over 50% occurred also between the plough and ploughless tillage systems.

Table 1. Number of weeds per 1 m^2 of pea crop (means from 2009–2011)
Tabela 1. Liczba chwastów na 1 m^2 w uprawie grochu siewnego (średnio z lat 2009–2011)

Terms of evaluation Termin oceny	Plough tillage Uprawa płużna	Ploughless tillage Uprawa bezorkowa	Herbicide tillage Uprawa herbicydowa	Mean Średnio
First term – phase of third true leaf Pierwszy – faza trzeciego liścia właściwego	68.3 a*	122.1 b	92.5 c	94.3 A
Second term – phase of ripening of pods and seed Drugi – faza dojrzewania strąków i nasion	30.8 a	61.7 b	118.4 c	70.3 B
Mean Średnio	49.6 A	91.9 B	105.4 B	-

*means followed by the same letter are not significantly different at p = 0.05
*średnie oznaczone tymi samymi literami nie różnią się istotnie przy p = 0,05

Table 2. Air-dry matter of weed in g·m^2 of pea crop (means from 2009–2011)
Tabela 2. Powietrznie sucha masa chwastów w g na 1 m^2 w uprawie grochu siewnego (średnio z lat 2009–2011)

Terms of evaluation Termin oceny	Plough tillage Uprawa płużna	Ploughless tillage Uprawa bezorkowa	Herbicide tillage Uprawa herbicydowa	Mean Średnio
First term – phase of third true leaf Pierwszy – faza trzeciego liścia właściwego	23.1 a	82.1 b	67.2 b	57.5 A
Second term – phase of ripening of pods and seeds Drugi – faza dojrzewania strąków i nasion	58.2 a	66.2 a	129.1 b	84.5 B
Mean Średnio	40.6A	74.1 B	98.1 B	-

Explanations as in Table 1.
Objaśnienia w tabeli 1.

Air-dry matter of weeds depended on the applied tillage system and the term of evaluation (tab. 2). Weeds on plots with herbicide (98.1 g·m^{-2} on average) and ploughless (74.1 g·m^{-2}) tillage systems developed a higher air-dry matter, whereas a considerably lower air-dry matter (by 45.2–58.6%) was recorded on plots with plough tillage. The air-dry matter of weeds was also determined by the evaluation term, its higher values (by 31.9%) were observed in the second term (ripening of pods and seeds) than in the first one (third true leaf). Taking into consideration air-dry matter of the weeds in the examined tillage methods and evaluation terms, it should be noted that in the first term a larger bulk was generated by weeds in the ploughless (82.1 g·m^{-2} on average) and herbicide (67.2 g·m^{-2}) tillage systems, whereas a significantly smaller one (by 65.6–71.8%) in the plough tillage. In the second term of evaluation, a significantly higher air-dry matter mass was recorded in herbicide tillage (129.1 g·m^{-2}) than in the plough and ploughless tillage systems (lower by 48.7–54.9%).

Table 3. Species composition and number of weeds per 1 m^2 of pea crop in the first evaluation term (phase of third true leaf) (means from 2009–2011)
Tabela 3. Skład gatunkowy i liczba chwastów na 1 m^2 w łanie grochu siewnego w pierwszym terminie oceny (w fazie trzeciego liścia właściwego) (średnio z lat 2009–2011)

	Species composition Skład gatunkowy	Plough tillage Uprawa płużna	Ploughless tillage Uprawa bezorkowa	Herbicide tillage Uprawa herbicydowa	Mean Średnio
Short-lived Krótkotrwałe	*Amaranthus retroflexus* L.	38.0	22.0	9.0	23.0
	Echinochloa crus –galli (L.) P.B.	11.0	57.0	24.0	30.7
	Chenopodium album L.	5.0	-	-	1.7
	Galium aparine L.	4.0	-	2.0	2.0
	Galeopsis tetrahit L.	2.5	1.2	6.4	3.4
	Stellaria media (L.) Vill.	2.0	12.0	6.0	6.7
	Lamium amplexicaule L.	2.0	1.0	-	1.0
	Galinsoga parviflora Cav.	1.2	2.0	2.5	1.9
	Avena fatua L.	1.0	1.0	4.5	2.2
	Papaver rhoeas L.	0.5	1.0	1.0	0.8
	Sonchus asper (L.) Hill.	0.5	0.8	-	0.4
	Consolida regalis Gray	0.2	0.2	4.5	1.6
	Poa annua L.	0.2	0.2	-	0.1
	Centaurea cyanus L.	0.2	0.8	-	0.3
	Veronica persica Poir.	-	12.0	5.0	5.7
	Capsella bursa-pastoris (L.) Med.	-	2.0	4.5	2.2
	Vicia hirsuta (L.) S.F. Gray	-	2.0	2.5	1.5
	Thlaspi arvense L.	-	1.2	-	0.4
	Lithospermum arvense L.	-	1.0	1.5	0.8
	Viola arvensis Murr.	-	1.0	1.0	0.7
	Matricaria inodora L.	-	-	14.0	4.6
	Apera spica-venti (L.) P.B.	-	-	2.2	0.7
	Fallopia convolvulus (L.) A. Löve	-	-	1.0	0.3
	Anagallis arvensis L.	-	-	0.2	0.1
	Number of short-lived weeds (I) Liczba chwastów krótkotrwałych (I)	68.3	118.4	91.8	92.8
Perennial Wieloletnie	*Cirsium arvense* (L.) Scop.	-	2.2	0.2	0.8
	Elymus repens (L.) P.B.	-	1.5	0.5	0.7
	Number of perennial weeds (II) Liczba chwastów wieloletnich (II)	-	3.7	0.7	1.5
Total I + II – Razem I + II		68.3	122.1	92.5	-
Number of species – Liczba gatunków		14	20	20	26

Table 4. Species composition and number of weeds per 1 m^2 of pea crop in the second evaluation period (phase of ripening of pods and seeds) (means from 2009–2011)
Tabela 4. Skład gatunkowy i liczba chwastów na 1 m^2 w łanie grochu siewnego w drugim terminie oceny (w fazie dojrzewania strąków i nasion) (średnio z lat 2009–2011)

	Species composition Skład gatunkowy	Plough tillage Uprawa płużna	Ploughless tillage Uprawa bezorkowa	Herbicide tillage Uprawa herbicydowa	Mean Średnio
Short-lived Krótkotrwałe	*Avena fatua* L.	13.0	10.0	7.2	10.1
	Chenopodium album L.	6.5	9.0	11.5	9.0
	Echinochloa crus-galli (L.) P.B.	6.0	8.2	15.0	9.7
	Amaranthus retroflexus L.	2.0	3.5	9.5	5.0
	Matricaria inodora L.	0.8	-	15.8	5.5
	Fallopia convolvulus (L.) A. Löve	0.5	10.2	14.2	8.3
	Galinsoga parviflora Cav.	0.2	10.0	12.5	7.6
	Galium aparine L.	0.2	0.5	0.8	0.5
	Lamium amplexicaule L.	0.2	0.5	0.8	0.5
	Papaver rhoeas L.	0.2	1.2	6.5	2.6
	Viola arvensis Murr.	0.2	0.5	0.4	0.3
	Apera spica-venti (L.) P.B.	0.2	0.2	12.0	4.1
	Veronica persica Poir.	0.2	0.2	0.2	0.2
	Veronica hederifolia L.	0.2	-	-	0.1
	Vicia angustifolia L.	0.2	-	-	0.1
	Vicia villosa Roth	-	2.2	4.0	2.1
	Galeopsis tetrahit L.	-	1.2	1.0	0.7
	Capsella bursa-pastoris (L.) Med.	-	1.2	2.0	1.1
	Sonchus asper (L.) Hill	-	1.0	3.5	1.5
	Thlaspi arvense L.	-	0.8	-	0.2
	Euphorbia helioscopia L.	-	0.2	-	0.1
	Anagallis arvensis L.	-	0.2	-	0.1
	Number of short-lived weeds (I) Liczba chwastów krótkotrwałych (I)	30.6	60.8	116.9	69.4
Perennial Wieloletnie	*Convolvulus arvensis* L.	0.2	0.5	0.8	0.5
	Elymus repens (L.) P.B.	-	0.2	0.5	0.2
	Cirsium arvense (L.) Scop		0.2	0.2	0.1
	Number of perennial weeds (II) Liczba chwastów wieloletnich (II)	0.2	0.9	1.5	0.8
Total I + II – Razem I + II		30.8	61.7	118.4	-
Number of species – Liczba gatunków		16	22	20	25

Diversified tillage influenced the biodiversity of weed in pea (tab. 3). In the first term of evaluation, 14 species of short-lived weeds were recorded on the plot with plough tillage. The most numerous species were: *Amaranthus retroflexus* L. and *Echinochloa crus-galli* (L.) P.B., which constituted over 71% of weed community. Other numerous species included: *Chenopodium album* L., *Galium aparine* L., *Galeopsis* *tetrahit* L., *Stellaria media* (L.) Vill. and *Lamium amplexicaule* L. In turn, 18 species of short-lived weeds and 2 perennial species were identified on the plot with ploughless tillage. It should be noted that two species, namely *Echinochloa crus-galli* (L.) P.B. and *Amaranthus retroflexus* L., constituted as much as 64.7% of weed community. They were followed by other numerous species, i.e.: *Stellaria media* (L.) Vill., *Veronica persica* Poir., *Galinsoga parviflora* Cav., *Capsella bursa-pastoris* (L.) Med. and *Vicia hirsuta* (L.) S.F. Gray. Among the perennial weed species predominant were: *Cirisum arvense* (L.) Scop. and *Elymus repens* (L.) P.B. The herbicide tillage resulted in the emergence of 18 short-lived and 2 perennial weed species. In this tillage system two species, namely *Echinochloa crus-galli* (L.) P.B. and *Matricaria inodora* L., constituted over 41%, whereas *Amaranthus retroflexus* L., *Galeopsis tetrahit* L., *Stellaria media* (L.) Vill. and *Veronica persica* Poir. – 28.5% of all the weed species. The perennial weed species were represented by: *Elymus repens* (L.) P.B. and *Cirsium arvense* (L.) Scop.

In the second term of evaluation (ripening of pods and seeds), 14 short-lived and 1 perennial weed species emerged on plots with plough tillage (tab. 4). The most numerous species in this community were: *Avena fatua* L., *Chenopodium album* L. and *Echinochloa crus-galli* (L.) P.B. They constituted almost 83% of weed community. Among the perennial weed species predominant was *Convolvulus arvensis* L. On the plot with reduced tillage, 19 short-lived and 3 perennial species emerged, with predominating species including: *Avena fatua* L., *Fallopia convolvulus* (L.) A. Löve, *Galinsoga parviflora* Cav. and *Chenopodium album* L.. These constituted 63.5% of weed community. Perennial weeds: *Convolvulus arvensis* L., *Elymus repens* (L.) P.B. and *Cirsium arvense* (L.) Scop., constituted barely 1.5% of weed species. In the herbicide tillage, the weed community was constituted by 17 short-lived and 3 perennial species, with the most numerous being: *Matricaria inodora* L. and *Echinochloa crus-galli* (L.) P.B. (26% of weed community), followed by: *Fallopia convolvulus* (L.) A. Löve, *Galinsoga parviflora* Cav., *Apera spica-venti* (L.) P.B. and *Chenopodium album* L. (42.4% of weed community). The identified perennial weeds included: *Convolvulus arvensis* L., *Elymus repens* (L.) P.B. and *Cirsium arvense* (L.) Scop.

DISCUSSION

Due to a long period of sprouting and slow initial growth pea is exposed to fast weed infestation. Hence, a crucial concern is the selection of a proper site, cultivation method and tillage system [Tuesca et al. 2001, Locke et al. 2002, Pilipavicius et al. 2009]. As it results from the research conducted by Blecharczyk et al. [2010], the effect of tillage system on weed infestation is inexplicit. This has also been confirmed in this research. As it was recorded, the number and air-dry matter of weeds were lower on the plots under the conditions of plough tillage than under the conditions of ploughless and herbicide tillage systems. On the plots with herbicide tillage the number and weed biomass were slightly higher than in the ones with ploughless tillage, however this difference was not confirmed statistically. According to some authors [Buhler et al. 1994, Tuesca et al. 2001, Woźniak 2011], long-term simplifications in tillage result in increased infestation with perennial weeds. At the same time, other experiments [Małecka et al. 2006, Faltyn and Kordas 2009] indicate a higher weed infestation under plough tillage than under the ploughless one and under direct drilling.

The number and biomass of weed in a pea plot was also dependent on the term of evaluation. A higher number of weeds per 1 m^2 was recorded in the first term of evaluation (phase of third true leaf) than in the second one (ripening of pods and seeds). It can be presumed that it resulted from the abundance of weed seedlings, especially *Echinochloa crus-galli* (L.) P.B., *Amaranthus retroflexus* L., *Stellaria media* (L.) Vill. and *Galeopsis terahit* L., in that period. In the second evaluation term, prevailing were fruiting weeds and seedlings developed as a result of seed shedding. This is also confirmed by the air-dry matter of weeds, which at this time was significantly higher than in the phase of third true leaf. Worth mentioning is also weed infestation of pea in the first term of evaluation (in the phase of third true leaf). More weeds with a higher air-dry matter were recorded on the plots under ploughless tillage than on those treated with plough and herbicide tillage systems. This was likely to be due to the use of a cultivator on this area. As Weber and Hryńczuk [2005] state, these tools destroy the emerging weeds, however, at the same time they facilitate the sprouting of seeds extracted from lower layers of the soil. In the second evaluation term, a higher number and air-dry matter of weeds was determined on the plots treated with a long-term herbicide tillage than on the plots with plough and ploughless tillage. According to Wrzesińska et al. [2003], ploughless tillage results in the fact that the majority of weed seeds are found in topsoil, whereas herbicides in direct drilling effectively decrease the number of weeds.

Simplifications in tillage increased the contribution of perennial weeds in a pea plot. In both evaluation terms the following species emerged: *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) P.B., and *Convolvulus arvensis* L. Also, Buhler et al. [1994] revealed that long-term simplifications in tillage resulted in an increased number of perennial weeds. Weber and Hryńczuk [2005] claim that reduced tillage affected a greater diversity of weed species composition than the conventional (plough) one and direct drilling. Also, in the conducted research, the plot under reduced tillage showed a greater biodiversity of weeds than that under plough tillage system.

CONCLUSION

1. Compared to plough tillage system, the ploughless and herbicide tillage significantly increased the number and air-dry matter of weeds per 1 m^2 of pea plot.

2. A higher number of weeds per 1 m^2 was recorded in the phase of third true pea leaf than in the ripening of pods and seeds. Air-dry matter of weeds was higher in the second term than in the first one.

3. A higher number of weed species in a pea plot was recorded in the ploughless tillage and herbicide one than in the plough tillage.

4. In the plough tillage predominant were: *Amaranthus retroflexus* L. and *Echinochloa crus-galli* (L.) P.B. (in the first term of evaluation), and *Avena fatua* L. and *Chenopodium album* L. (in the second term of evaluation). In the ploughless tillage the most numerous were: *Echinochloa crus-galli* (L.) P.B. and *Amaranthus retroflexus* L. (in the

first term) as well as *Fallopia convolvulus* L. A. Löve, *Avena fatua* L. and *Galinsoga praviflora* Cav. (in the second term). In the herbicide tillage predominant were: *Echinochloa crus-galli* (L.) P.B. and *Matricaria inodora* L. (the first term) and *Matricaria inodora* L. and *Echinochloa crus-galli* (L.) P.B. (the second term).

5. Simplifications in tillage increased the contribution of perennial weeds in a pea plot. In both evaluation terms predominant were *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) P.B. and *Convolvulus arvensis* L.

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ZACHWASZCZENIE GROCHU SIEWNEGO (*Pisum sativum* L.) W TRADYCYJNEJ I UPROSZCZONEJ UPRAWIE ROLI

Streszczenie. Zachwaszczenie łanu zależy od zawartości diaspor chwastów w glebie, warunków siedliska oraz stosowanej agrotechniki. Z czynników agrotechnicznych na stan i stopień zachwaszczenia znacząco wpływa uprawa roli. W przeprowadzonych badaniach bezorkowa i herbicydowa uprawa roli istotnie zwiększały liczbę i powietrznie suchą masę chwastów na 1 m^2 w łanie grochu siewnego, w stosunku do uprawy płużnej. Stwierdzono również więcej chwastów na 1 m^2 w pierwszym terminie oceny zachwaszczenia grochu (w fazie trzeciego liścia właściwego) niż w drugim (dojrzewania strąków i nasion). Z kolei powietrznie sucha masa chwastów była większa w drugim terminie oceny niż w pierwszym. Ponadto wykazano większą liczbę gatunków chwastów w warunkach uprawy bezorkowej (20–22 gatunki) i herbicydowej (20 gatunków) niż płużnej (14–16 gatunków). W uprawie płużnej dominowały: *Amaranthus retroflexus* L. i *Echinochloa crus-galli* (L.) P.B. (w pierwszym terminie oceny) oraz *Avena fatua* L. i *Chenopodium album* L. (w drugim terminie). W uprawie bezorkowej najliczniejszymi były: *Echinochloa crus-galli* (L.) P.B. i *Amaranthus retroflexus* L. (w pierwszym terminie), a także *Fallopia convolvulus* (L.) A. Löve, *Avena fatua* L. i *Galinsoga praviflora* Cav. (w drugim terminie). W herbicydowej uprawie przeważały: *Echinochloa crus-galli* (L.) P.B. i *Matricaria inodora* L. (w pierwszym terminie) oraz *Matricaria inodora* L. i *Echinochloa crus-galli* (L.) P.B. (w drugim terminie). Uproszczenia w uprawie roli zwiększyły udział chwastów wieloletnich: *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) P.B. i *Convolvulus arvensis* L.

Słowa kluczowe: strączkowe, agrotechnika, uprawa herbicydowa, bioróżnorodność chwastów

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