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DIVERSITY OF WEEDS FLORA IN THE MAIZE CULTIVATION IN ORGANIC SYSTEM

Summary

The aim of the study was to evaluate the level of weed infestation of maize cultivated in organic farming depending on natural fertilization (20 and 40 t of composted manure per 1 ha) and cultivation method: A - control object (without weed control), B - brush weeder (three times during the vegetation season), C - weeding hoe (three times during the season), D - brush weeder (two times during the season) and hiller. The study was conducted at the Institute of Soil Science and Plant Cultivation - Agricultural Experimental Station Grabów (Mazowieckie Voivodeship). The study showed that the largest weed infestation was on control objects whereas the mechanical cultivation of maize has contributed to significant reduction of number and weight of weeds. The smallest number of weeds was recorded on the object cultivated by brush weeder and hiller. This method of mechanic cultivation of sorghum allowed destruction of weeds mass in about 76%, which should be considered as an effective method of weed control in organic farming conditions. The dose of organic fertilization didn't influence the number and composition of weed species. In all the years of experiment Echinochloa crus-galli and Chenopodium album were dominant weed species, as in the first and second period of the determination.
***Key words**: maize, organic farming, fertilization, weeds, experiment*

BIORÓŻNORODNOŚĆ FLORY SEGETALNEJ W UPRAWIE KUKURYDZY W EKOLOGICZNYM SYSTEMIE PRODUKCJI

Streszczenie

Celem badań była ocena różnorodności gatunkowej flory segetalnej oraz skuteczności wybranych metod mechanicznej regulacji zachwaszczenia w ekologicznej uprawie kukurydzy przy różnych dawkach nawożenia organicznego. Doświadczenie polowe przeprowadzono w latach 2011-2013 w Rolniczym Zakładzie Doświadczalnym Grabów IUNG-PIB. W doświadczeniu uwzględniono sposoby pielęgnacji kukurydzy: A – kontrola bez zwalczania chwastów; B – pielnik szczotkowy; C – opielacz; D – pielnik szczotkowy oraz obsypnik. Czynnikiem II rzędu była dawka nawożenia organicznego: (20 i 40 t/ha przekompostowanego obornika). W badaniach wykazano, że najbardziej skuteczną metodą mechanicznej pielęgnacji było zastosowanie pielnika szczotkowego wraz z obsypnikiem, które eliminowały średnio 76% chwastów w łanie. Największą liczbę oraz różnorodność gatunkową chwastów zanotowano na obiektach kontrolnych, na których nie stosowano mechanicznej pielęgnacji. Wielkość dawki nawożenia organicznego nie wpływała znacząco na liczebność i różnorodność gatunkową chwastów w uprawie kukurydzy. Skład gatunkowy chwastów był podobny we wszystkich latach badań. W łanie kukurydzy rozpoznano łącznie 36 gatunków chwastów, w tym 4 gatunki jednoliściennych. We wszystkich latach prowadzenia doświadczeń dominującymi gatunkami chwastów, tak w pierwszym, jak i drugim terminie oznaczeń, były chwastnica jednostronna (Echinochloa crus-galli) oraz komosa biała (Chenopodium album).
***Słowa kluczowe**: kukurydza, rolnictwo ekologiczne, nawożenie, chwasty, doświadczenie*

1. Introduction

Maize is a plant grown in wide rows having a slow initial growth rate, which makes it susceptible to strong weed competition in the early stages of development, especially under organic farming system. According to Rola and Rola [8], maize yield losses due to weeds can reach 70%, and under heavy occurrence of weeds - even more. Mechanical weed control is the basic element of organic farming. Little is known on the treatment of maize crops using mechanical treatments exclusively [4, 5]. According to the currently used assessment of weed control (by EPPO), the efficiency not lower than 80% is considered good. In organic farms, it is not allowed to use pesticides, hence the yields and economic effects of the cultivation of this species are dependent on mechanical weed control.

The soil in the ecological management system is characterized by a greater biomass of microorganisms than in a conventional system. The size and biological activity of the bacteria is larger [6]. Cultivation in environmental management system is associated, however, with more weeds, in comparison with a conventional system and integrated production [2, 3, 9].

The aim of the study was to evaluate species diversification of segetal flora and the effectiveness of selected methods of mechanical weed control in organic maize cultivation, under different doses of organic fertilization.

2. Material and methods

The study was conducted at the Institute of Soil Science and Plant Cultivation – Agricultural Experimental Station Grabów (Mazowieckie Voivodeship) in crossed subblock method, in four replications. The first trial's factor was: cultivation method: A – control object (without weed control), B - brush weeder (three times during the vegetation season), C - weeding hoe (three times during the season), D - brush weeder (two times during the season) and hiller. The second factor included dose of natural fertilization: 20 and 40 t of composted manure per 1 ha.

The experiment was conducted on the good rye soil complex, class III a. The concentration of available forms of nutrients in the soil amounted to (in mg per 100 g of the soil): P – 11.5, K – 12.6, Mg – 4.1. Soil pH determined in 1n KCl was 6.0.

The qualitative and quantitative analysis of weed infestation was done twice in growing season: one week after last cultivation method and before harvest. An analysis of the weed infestation of maize was performed by a frame-weight method, from the area of 1 m^2. Fresh and dry matter, species composition, and number of weeds were determined. The impact of the tested experimental factors on the observed characteristics were assessed using the analysis of variance, setting Tukey's confidence half-intervals at significance level of $\alpha = 0.05$.

3. Results and discussion

Weather conditions had a major impact on the yields and weed infestation of maize crops. In 2011, the total rainfall during the growing period was higher than the average rainfall from the multi-years, whereas its distribution was uneven. In 2011, very large rainfall was recorded in July (3.5 times higher than the average from the multi-year mean for this month), while deficit occurred in June (73% of the norm) and August (47%). The second year of the study (2012) was also unfavorable in terms of quantity and distribution of rainfall. Significant deficits were recorded in May (64% of the norm) and June (75%), accompanied by high temperatures. In 2013, excessive moisture occurred in May and June, exceeding, respectively, 96 and 63% of the multi-year norm.

In all the years of research, the highest weed infestation of maize crops was recorded in the plots without weed control, while mechanical treatments significantly contributed to the reduction in the weight of undesirable species (Tables 1-3). Using a brush hoe together with a hiller was the most effective method of mechanical weed control. In the thus treated plots, in 2011, dry matter of weeds was reduced by 68% on the first date of the determinations (one week after the last treatment) and by 61% on the second date (before the harvest), in 2012 – by respectively 93 and 80%, while in 2013 – by 81 and 73% compared with the unweeded treatments (statistically significant differences). In 2011, on the first date, a brush weeder and weeding hoe showed high efficiency as well. After using these tools, dry matter of weeds decreased by 69% compared to the control. In other years of the study (2012-2013) a weeding hoe was the least effective, reducing the dry matter of weeds by respectively by 63% in the first and 56% on the second date of determinations, and in 2013 by respectively, 56 and 34%. The effectiveness of a brush hoe in reducing weed infestation in those years amounted to, in 2012, respectively, 67% and 72%, while in 2013, respectively, 72% and 40%. The analysis of the three years of the study showed that a brush weeder used with a hiller were the most effective tools of mechanical treatment of maize crops, reducing 76% of weeds . The effectiveness of a brush weeder and weeding hoe, used three times during the growing season, was lower and amounted to, respectively, 61 and 49%. The effectiveness of mechanical treatments in reducing weeds of maize crops was also reported by Waligóra et al. [13], who showed that after a 2-time use of a brush weeder, the number of weeds decreased from more than 60 plants (control) to 24 per 1 m^2 Adamczewski et al. [1] recorded the effectiveness of mechanical treatments at the level of 50%, Hruszka [5] - from 47 to 53%, while Waligóra et al. [13] - over 60%. The research conducted by Staniak et al. [12] and Staniak et al. [11] showed that mechanical treatment of maize and sorghum significantly reduced the number and weight of segetal species, whereas the efficiency of the applied methods ranged from 47 to as much as 96%. A similar efficiency in reducing weeds among sorghum crops using mechanical methods (2-times use of a brush weeder) was recorded by Skrzypczak et al. [10]. The study conducted by Wilson [14], showed that the mechanical treatments used in the cultivation of maize reduced infestation up to 87%. *Echinochloa crus-galli* and *Chenopodium album* were the weed species that competed the strongest with the cultivated crops.

The dose of organic fertilizer had a significant impact on the amount of fresh and dry matter of weeds only in the first year of the study, one week after the last mechanical treatment. Increasing the dose of fertilizer up to 40 $t \cdot ha^{-1}$ the weight of weeds decreased by 40%. Previous studies of the same authors did not show a significant impact of a dose of organic fertilizer on weed infestation of maize crops [10] and of legume-cereal mixtures [11] in the organic farming.

Table 1. Course of weather conditions during the vegetation periods
Tab. 1. Przebieg warunków pogodowych podczas sezonów wegetacyjnych

Specification	Year	Month						Sum (III-VIII)
		III	IV	V	VI	VII	VIII	
Rainfalls (mm)	2011	17,6	35,9	74,5	52,4	298,8	35,6	514,8
	2012	20,9	37,8	36,5	54,3	81,6	64,2	295,3
	2013	41,1	29,9	112,0	116,3	20,8	11,6	331,7
Rainfalls mean from multi-years (mm)		30,0	39,0	57,0	71,0	84,0	75,0	356,0 Average (III-VIII)
Temperature (°C)	2011	2,9	10,3	13,9	18,5	18,4	18,8	13,8
	2012	2,4	9,6	15,3	17,7	20,9	18,8	14,1
	2013	-2,1	8,3	15,3	18,6	19,7	19,2	13,2
Temperature mean from multi-years (°C)*		1,6	7,7	13,4	16,7	18,3	17,3	12,5

* Average from years 1871-2000

Source: own work / *Źródło:* opracowanie własne

Table 2. Fresh and dry matter of weeds depending on cultivation method and dose of organic fertilization ($g \cdot m^{-2}$) in 2011
Tab. 2. Masa chwastów w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2011 roku

Cultivation method	Dose of organic fertilization ($t \cdot ha^{-1}$)	Fresh matter [$g \cdot m^2$]	Dry matter [$g \cdot m^2$]	Fresh matter [$g \cdot m^2$]	Dry matter [$g \cdot m^2$]
		one week after last cultivation method		before harvest	
A – control object	20	1522,6	242,8	1423,7	531,3
	40	722,9	128,3	1814,6	681,7
B – brush weeder	20	327,2	48,7	631,1	223,1
	40	363,4	66,4	1334,7	403,2
C – weeding hoe	20	441,5	69,9	876,3	325,0
	40	289,4	43,2	734,9	248,9
D – brush weeder +hiller	20	516,3	79,4	511,3	179,1
	40	264,4	38,7	691,0	289,4
Mean for cultivation method					
A – control object		1122,8b*	185,5b	1619,1c	606,5c
B – brush weeder		345,3a	57,5a	982,9b	313,1a
C – weeding hoe		365,5a	56,6a	805,6b	287,0a
D – brush weeder +hiller		390,3a	59,1a	601,2a	234,2a
Mean for manure dose					
20		701,9b*	110,2b	860,6a	314,6a
40		410,0a	69,2a	1143,8a	405,8a

* - Values followed by a different letter are significantly different ($p<0.05$)

Source: own work / *Źródło:* opracowanie własne

Table 3. Fresh and dry matter of weeds depending on cultivation method and dose of fertilization in 2012
Tab. 3. Masa chwastów w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2012 roku

Cultivation method	Dose of organic fertilization ($t \cdot ha^{-1}$)	Fresh matter [$g \cdot m^2$]	Dry matter [$g \cdot m^2$]	Fresh matter [$g \cdot m^2$]	Dry matter [$g \cdot m^2$]
		one week after last cultivation method		before harvest	
A – control object	20	1946,2	292,6	1839,5	814,0
	40	1637,0	275,8	1695,2	654,5
B – brush weeder	20	563,7	76,0	738,4	233,5
	40	773,9	113,2	503,4	200,8
C – weeding hoe	20	907,4	110,4	1054,8	397,5
	40	701,6	97,9	708,0	241,1
D – brush weeder +hiller	20	126,2	15,4	496,9	194,5
	40	160,6	23,9	265,0	104,5
Mean for cultivation method					
A – control object		1791,6c*	284,2c	1767,4c	734,1c
B – brush weeder		668,8b	94,6b	620,9b	217,2a
C – weeding hoe		804,5b	104,2b	881,4bb	319,3b
D – brush weeder +hiller		143,4a	19,7a	380,9a	149,5a
Mean for manure dose					
20		885,9a*	123,6a	1032,4b	409,9a
40		818,3a	127,7a	792,9a	300,2a

* - Values followed by a different letter are significantly different ($p<0.05$)

Source: own work / *Źródło:* opracowanie własne

The largest number and species diversity of weeds were noted in the control plots without mechanical treatments (Tables 4-10). In 2011, on the first date of the determinations (a week after the last mechanical treatment), we recorded on average 78.0 plants, while on the second date (before the harvest) - 60.8 plants per 1 m^2; in 2012, respectively 88.9 and 71.0; while in 2013 – 120.5 and 89.5. In the treatments without mechanical care, the number of undesirable species was much lower, whereas the lowest number of weeds was noted in the treatments with a brush weeder a brush weeder and a hiller. In 2011, this number was on average 9.5 plants per 1 m^2 in the first and 21,3 in the second date of determinations; in 2012, respectively, 6.4 and 9.5; while in 2013- 25.5 and 19.3. The dose of organic fertilizer did not significantly affect the number and diversity of weed species in maize crops. Species composition of weeds was similar in all the years of study. Among maize crops, 36 species of weeds in total were identified, including monocotyledonous weeds. The highest number of species was recorded in the plots without mechanical treatments (on average, 12.6), while in the other treatments, the number of species was lower and, amounting to on average 6.4 - in the treatments where a brush hoe was used, 8.4 – in the treatments with a hoe, 6.7 - in the treatments with a brush weeder together with a hiller. In all the years of the experiment, both on the first and second date of determinations, the dominant weed species were: *Echinochloa crus-galli* and *Chenopodium album* (Tables 4-10). *Chenopodium album* is one of the species, which may cause a reduction of maize yields down to 69% [7]. In 2013, high numbers of *Veronica persica* and *Capsella bursa-pastoris* were recorded.

Table 4. Fresh and dry matter of weeds depending on cultivation method and dose of fertilization in 2013
Tab. 4. Masa chwastów w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2013 roku

Cultivation method	Dose of organic fertilization ($t \cdot ha^{-1}$)	Fresh matter [$g \cdot m^2$]	Dry matter [$g \cdot m^2$]	Fresh matter [$g \cdot m^2$]	Dry matter [$g \cdot m^2$]
		one week after last cultivation method		before harvest	
A – control object	20	1133,5	188,5	1022,7	384,6
	40	883,6	151,7	1040,7	392,5
B – brush weeder	20	392,3	56,1	459,4	164,8
	40	234,3	40,8	400,9	147,4
C – weeding hoe	20	770,1	153,0	585,4	205,9
	40	770,6	123,9	772,8	305,9
D – brush weeder +hiller	20	215,2	28,0	104,9	58,5
	40	198,2	35,3	346,8	155,1
Mean for cultivation method					
A – control object		1008,6c*	170,1c	1031,7c	388,6c
B – brush weeder		313,1a	48,5a	430,2b	156,1a
C – weeding hoe		770,4b	138,5b	679,1b	255,9b
D – brush weeder +hiller		206,7a	31,6a	225,9a	106,8a
Mean for manure dose					
20		627,8a*	106,4a	543,1a	203,5a
40		521,7a	87,93a	640,3a	250,2a

* - Values followed by a different letter are significantly different ($p<0.05$)

Source: own work / *Źródło:* opracowanie własne

Table 5. Weed species composition and number of weeds ($plants \cdot m^{-2}$) depending on cultivation method and dose of fertilization in 2011 (one week after last cultivation method)
Tab. 5. Skład gatunkowy chwastów w kukurydzy w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2011 roku (tydzień po ostatnim zabiegu mechanicznym)

Weed species	A	B	C	D	A	B	C	D	Average
	Dose of manure 20 $t \cdot ha^{-1}$				Dose of manure 40 $t \cdot ha^{-1}$				
Monocotyledonous									
Echinochloa crus-galli	27,5	-	5,0	-	44,0	10,5	4,0	1,0	11,5
Poa annua	15,0	0,5	-	-	-	0,5	-	-	2,0
Sum of Monocotyledonous	42,5	0,5	5,0	-	44,0	11,0	4,0	1,0	12,9
Dicotyledonous									
Anthemie arvensis	0,5	0,5	0,5	-	1,0	-	0,5	-	0,4
Capsella bursa-pastoris	5,5	2,5	3,0	-	6,5	4,0	1,5	0,5	2,9
Chenopodium album	19,5	4,5	6,0	7,5	10,0	7,0	5,0	4,0	7,9
Cirsium arvense	-	-	1,5	5,0	0,5	-	-	-	0,3
Erigeron canadensis	-	-	-	-	0,5	-	-	-	0,0
Fallopia convolvulus	-	-	-	-	-	0,5	-	-	0,0
Filaginella uliginosa	-	-	-	-	1,0	0,5	-	-	0,2
Geranium dissectum	-	-	-	-	-	0,5	-	-	0,0
Geranium molle	-	-	-	-	1,0	-	-	-	0,1
Lamium amplexicaule	1,5	-	-	-	-	-	-	-	0,2
Lamium purpureum	0,5	0,5	-	-	-	-	-	-	0,1
Lapsena communis	-	-	-	-	0,5	-	-	-	0,0
Plantago lanceolata	1,5	-	-	-	1,5	0,5	-	-	0,4
Plantago major	4,5	-	-	-	-	-	-	-	0,6
Polygonum aviculare	0,8	-	0,5	0,5	-	0,5	1,0	-	0,4
Polygonum persicaria	1,0	-	-	-	-	-	-	-	0,2
Solanum nigrum	1,0	-	-	-	-	-	-	-	0,2
Sonchus arvensis	-	-	-	-	0,5	-	-	-	0,0
Stellaria media	4,0	-	-	-	0,5	-	-	-	0,6
Trifolium arvense	1,5	0,5	-	-	-	-	-	-	0,3
Veronica persica	-	-	-	-	1,0	-	-	-	0,2
Viola arvensis	1,0	9,0	0,5	-	1,0	-	-	-	1,4
Sum of Dicotyledonous	42,8	17,5	12,0	13,0	25,5	13,5	8,0	4,5	17,1
Eguisetum arvense	1,0	-	-	0,5	0,5	-	-	-	0,3
Total	86,3	18,0	17,0	13,5	70,0	24,5	12,0	5,5	30,9
Number of species	16	7	7	4	15	9	5	3	8,3

Source: own work / *Źródło:* opracowanie własne

Table 6. Weed species composition and number of weeds (plants·m^{-2}) depending on cultivation method and dose of fertilization in 2011 (before harvest)

Tab. 6. Skład gatunkowy chwastów w kukurydzy w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2011 roku (przed zbiorem)

Weed species	A	B	C	D	A	B	C	D	Average
	Dose of manure 20 t·ha^{-1}				Dose of manure 40 t·ha^{-1}				
Monocotyledonous									
Echinochloa crus-galli	7,5	4,5	3,0	5,0	29,5	7,0	4,5	2,0	7,9
Elymus repens	-	-	-	-	11,0	0,5	-	-	1,4
Poa annua	5,5	2,5	6,5	0,5	3,0	0,5	0,5	-	2,4
Setaria pumila	33,5	1,5	1,5	0,5	-	-	-	-	4,6
Sum of Monocotyledonous	46,5	8,5	11,0	6,0	43,5	8,0	4,5	2,0	15,8
Dicotyledonous									
Capsella bursa-pastoris	2,0	2,5	2,0	2,0	-	-	2,0	0,5	1,4
Chenopodium album	8,5	5,0	5,0	9,0	6,0	2,5	5,0	6,0	5,8
Cirsium arvense	-	-	2,5	1,0	-	-	-	-	0,4
Erigeron canadensis	-	0,5	-	-	1,0	-	-	-	0,2
Fallopia convolvulus	-	-	-	0,5	-	-	-	-	0,0
Filaginella uliginosa	0,5	1,5	2,0	2,5	-	-	-	-	0,8
Galinsoga parviflora	0,5		--	-	-	-	0,5	-	0,2
Geranium dissectum	1,5	2,5	3,0	1,5	-	-	0,5	-	1,1
Lamium purpureum	1,0	-							0,2
Matricaria maritima subsp. inodora	-	-	0,5	1,0	-	-	-	-	0,2
Plantago lanceolata	0,5	-	-	-	1,5	-	-	-	0,3
Plantago major	3,5	10,0	8,0	2,5	2,0	2,0	-	1,5	3,7
Polygonum aviculare	0,5	-	-	-	-	-	-	-	0,0
Senecio vulgaris	-	1,0	-	-	-	-	-	-	0,2
Solanum nigrum	0,5	0,5	0,5	-	0,5	0,5	0,5	-	
Stellaria media	-	1,0	8,0	3,5	1,0	1,0	0,5	0,5	1,0
Trifolium arvense	0,5	0,5							0,2
Veronica persica	-	0,5	0,5	-	-	-	-	-	0,2
Viola arvensis	-	0,5	-	-	-	-	-	-	0,0
Sum of Dicotyledonous	19,5	26,0	32,0	23,5	12,0	6,0	9,0	8,5	17,1
Eguisetum arvense	-	-	3,0	-	-	-	-	2,5	0,7
Total	66,0	34,5	43,0	29,5	55,5	14,0	13,5	10,0	35,3
Number of species	14	15	14	12	9	7	8	6	10,6

Source: own work / *Źródło:* opracowanie własne

Table 7. Weed species composition and number of weeds (plants·m^{-2}) depending on cultivation method and dose of fertilization in 2012 (one week after last cultivation method)

Tab. 7. Skład gatunkowy chwastów w kukurydzy w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2012 roku (tydzień po ostatnim zabiegu mechanicznym)

Weed species	A	B	C	D	A	B	C	D	Average
	Dose of manure 20 t·ha^{-1}				Dose of manure 40 t·ha^{-1}				
Monocotyledonous									
Echinochloa crus-galli	23,0	2,3	5,0	1,0	10,3	2,5	4,8	1,0	6,2
Lolium perenne	0,3	-	-	-	-	-	-	-	0,0
Sum of Monocotyledonous	23,3	2,3	5,0	1,0	10,3	2,5	4,8	1,0	6,2
Dicotyledonous									
Amaranthus retroflexus	0,8	-	1,0	-	1,8	-	-	-	0,5
Capsella bursa-pastoris	2,5	-	-	-	2,0	-		0,3	0,6
Chenopodium album	71,3	4,3	11,5	3,3	46,5	14,5	23,5	3,5	22,3
Cirsium arvense	-	-	-	-	0,5	-	-	0,5	0,2
Fallopia convolvulus	-	-	0,8	-	-	-	0,3	-	0,2
Galium aparine	0,5	-	1,3	-	1,5	-	0,3	-	0,5
Geranium dissectum	0,5	-	0,3		0,3	-	-	-	0,2
Lamium purpureum	0,8	-	-	-	0,5	-	0,3	-	0,2
Lapsena communis	-	-	-	-	0,3	-	-	-	0,1
Matricaria maritima subsp. inodora	0,3	-	-	0,3	0,3	-	-	-	0,2
Plantago major	-	-	-	-	0,5	-	0,3	-	0,1
Polygonum aviculare	-	-	-	-	0,5	-	--	-	0,0
Polygonum hydropiper	0,5	0,3	0,3	0,5	0,3	-	0,3	0,5	0,3
Polygonum persicaria	0,3	-	-	-	-	-	-	-	0,0

cont. of table 7 / *cd tab. 7*

Sonchus arvensis	-	-	0,3	-	-	-	-	-	0,0
Sonchus asper	-	-	-	-	0,3	-	-	-	0,0
Stellaria media	0,3	-	-	-	2,0	-	-	-	0,4
Trifolium arvense	2,0	0,3	0,5	-	3,5	0,5	0,3	-	0,9
Trifolium campestre	1,0	-	-	-	-	-	-	-	0,2
Veronica persica	1,8	-	-	-	0,5	-	-	-	0,3
Viola arvensis	-	-	-	-	0,3	-	-	--	0,0
Sum of Dicotyledonous	82,6	4,9	16,0	4,1	61,6	15,0	25,3	4,8	26,8
Eguisetum arvense	-	-	-	0,8	-	-	-	1,0	0,2
Total	105,9	7,2	21,0	5,9	71,9	17,5	30,1	6,8	33,3
Number of species	15	4	9	5	18	3	8	6	8,5

Source: own work / *Źródło:* opracowanie własne

Table 8. Weed species composition and number of weeds (plants·m^{-2}) depending on cultivation method and dose of fertilization in 2012 (before harvest)

Tab. 8. Skład gatunkowy chwastów w kukurydzy w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2012 roku (przed zbiorem)

Weed species	A	B	C	D	A	B	C	D	Average
	Dose of manure 20 t·ha^{-1}				Dose of manure 40 t·ha^{-1}				
Monocotyledonous									
Echinochloa crus-galli	12,5	2,3	3,3	0,8	5,0	1,8	2,3	1,5	3,7
Sum of Monocotyledonous	12,5	2,3	3,3	0,8	5,0	1,8	2,3	1,5	3,7
Dicotyledonous									
Amaranthus retroflexus	1,0	-	0,3	-	0,3	0,3	0,3	-	0,8
Capsella bursa-pastoris	-	-	-	0,3	0,3	-	0,3	0,3	0,2
Cerastium arvense	-	-	-	-	0,3	-	-	-	0,0
Chenopodium album	63,3	3,5	14,0	3,5	50,5	7,5	9,3	6,0	19,7
Filaginella uliginosa	-	-	-	-	0,8	-	-	0,8	0,2
Geranium dissectum	-	-	-	-	-	-	-	0,3	0,1
Lamium purpureum	0,3	-	0,8	-	-	-	-	0,3	0,2
Plantago major	0,3	-	-	-	0,5	-	-	0,3	0,2
Polygonum hydropiper	-	-	-	-	0,5	-	-	-	0,0
Raphanus raphanistrum	-	-	-	-	0,3	-	-	-	0,0
Sonchus arvensis	-	-	0,3	-	-	-	-	-	0,0
Taraxacum officinale	-	-	-	0,3	-	0,3	0,3	-	0,2
Trifolium arvense	1,3	-	-	-	1,5	-	1,0	0,5	0,3
Veronica persica	2,5	-	-	-		-	-	0,5	0,4
Viola arvensis	0,8	-	-	-	-	-	-	0,5	0,2
Sum of Dicotyledonous	69,5	3,5	15,4	4,1	55,0	8,1	11,2	9,5	22,0
Eguisetum arvense	-	-	-	0,5	-	-	-	2,5	0,4
Total	82,0	5,8	18,7	5,4	60,0	9,9	13,5	13,5	26,1
Number of species	8	2	5	5	10	4	6	11	6,4

Source: own work / *Źródło:* opracowanie własne

Table 9. Weed species composition and number of weeds (plants·m^{-2}) depending on cultivation method and dose of fertilization in 2013 (one week after last cultivation method)

Tab. 9. Skład gatunkowy chwastów w kukurydzy w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2013 roku (tydzień po ostatnim zabiegu mechanicznym)

Weed species	A	B	C	D	A	B	C	D	Average
	Dose of manure 20 t·ha^{-1}				Dose of manure 40 t·ha^{-1}				
Monocotyledonous									
Echinochloa crus-galli	26,5	20,0	31,0	13,0	30,0	8,0	33,5	14,0	22,0
Elymus repens	-	-	0,3	-	-	-	-	-	0,0
Poa annua	-	-	-	-	2,0	-	-	-	0,3
Sum of Monocotyledonous	26,5	20,0	31,3	13,0	32,0	8,0	33,5	14,0	22,3
Dicotyledonous									
Anthemis arvensis	-	0,5	-	0,5	-	-	0,5	-	0,2
Capsella bursa-pastoris	29,0	7,0	20,0	4,0	49,0	4,5	25,0	9,0	18,4
Chenopodium album	27,0	8,5	7,0	3,5	31,0	5,0	29,0	3,0	14,3
Cirsium arvense	8,5	-	1,0	-	3,0	-	-	-	1,6
Erigeron canadensis	0,5	-			12,5	-	-	-	1,6
Fallopia convolvulus	4,0	-	1,5	-	12,5	-	0,5	0,5	2,4

cont. of table 9 / *cd tab. 9*

Galium aparine	-	-	0,3		-	-	2,5	-	0,4
Geranium dissectum	2,0	-	-	-	1,0	1,5	3,5	-	1,0
Lamium purpureum	-	-	0,5	0,5	-	-	-	-	0,2
Matricaria discoidea	-	-	-	0,5	-	-	-	-	0,0
Senecio vulgaris	-	-	-	-	0,5	-	-	-	0,0
Sonchus asper	0,5	-	-	-	-	0,5	-	-	0,2
Spergula arvensis	-	-	-	-	-	1,0	-	-	0,2
Stellaria media	1,0	-	0,3	-	0,5	0,5	-	-	0,3
Trifolium arvense	0,5	-	-	-	-	2,0	-	-	0,3
Veronica persica	6,0	2,0	20,5	0,5	5,5	4,0	24,5	0,5	7,9
Viola arvensis	-	2,5	1,0	1,5	0,5	-	0,5	-	0,8
Sum of Dicotyledonous	79,0	20,5	52,0	11,0	103,5	19,0	86,0	13,0	48
Total	105,5	40,5	83,3	24,0	135,5	27,0	119,5	27,0	70,3
Number of species	11	6	11	8	12	9	9	5	8,9

Source: own work / *Źródło:* opracowanie własne

Table 10. Weed species composition and number of weeds (plants·m^{-2}) depending on cultivation method and dose of fertilization in 2013 (before harvest)

Tab. 10. Skład gatunkowy chwastów w kukurydzy w zależności od sposobu pielęgnacji i dawki nawożenia organicznego w 2013 roku (przed zbiorem)

Weed species	A	B	C	D	A	B	C	D	Average
	Dose of manure 20 t·ha^{-1}				Dose of manure 40 t·ha^{-1}				
Monocotyledonous									
Echinochloa crus-galli	23,5	15,0	15,5	8,0	32,0	15,0	28,5	12,0	18,7
Elymus repens	1,0	-	-	-	-	-	-	-	0,2
Poa annua	-	-	-	-	-	-	0,5	-	0,0
Setaria pumila	-	-	-	-	0,5	-	-	-	0,0
Sum of Monocotyledonous	24,5	15,0	15,5	8,0	32,5	15,5	29,0	12,0	18,9
Dicotyledonous									
Amaranthus retroflexus	-	-	0,5	-	-	-	-	0,5	0,2
Anthemis arvensis	0,5	-	-	-	-	-	-	0,5	0,2
Capsella bursa-pastoris	29,0	3,0	10,5	6,5	20,0	2,5	5,5	1,5	9,8
Centaurea cyanus	-	-	0,5	-	-	1,5	1,5	-	0,3
Chenopodium album	27,5	4,0	8,5	1,0	19,5	7,0	27,0	4,5	12,4
Chenopodium hybridum	0,5	-	-	-	-	-	2,0	-	0,3
Cirsium arvense	1,0	1,0	-	0,5	0,5	-	-	-	0,4
Erigeron canadensis	0,5	-	-	-	-	-	-	-	0,0
Fallopia convolvulus	7,5	-	3,5	0,5	2,0	-	-	-	1,7
Filaginella uliginosa	0,5	-	0,5	-	-	-	-	-	0,2
Galium aparine	-	-	-			-	0,5	-	0,0
Geranium dissectum	1,5							0,5	0,3
Matricaria maritima subsp. inodora	-	-	-	-	-	0,5	-	-	0,0
Polygonum aviculare	2,5	-	-	0,5	-	-	1,0	-	0,5
Solanum nigrum	-	-	-	0,5		-	-	-	0,0
Sonchus arvensis	-	-	-	-	0,5	-	-	-	0,0
Veronica persica	5,5	1,0	7,5	1,0	3,0	5,0	4,5	0,5	3,5
Viola arvensis	0,5	-	1,0	-	-	-	-	-	0,2
Sum of Dicotyledonous	76,5	9,0	32,5	10,5	45,5	17,0	42,0	8,0	30,1
Total	101,0	24,0	48,0	18,5	78,0	32,5	71,0	20,0	49,1
Number of species	14	5	9	8	8	6	9	7	8,3

Source: own work / *Źródło:* opracowanie własne

4. Conclusions

Using a brush hoe together with a hiller was the most effective method of mechanical treatment, eliminating 76% of weeds in the canopy. The dose of organic fertilizer significantly affected the amount of fresh and dry matter of weeds only in the first year of the study within one week after the last mechanical treatment. The highest number and variability of weed species were observed on the plots, which were not mechanically treated. The dose of organic fertilization did not affect significantly the number and species diversity of weeds in maize crops. Species composition of weeds was similar throughout the whole study period. In maize crops, a total of 36 weed species were identified, including four monocotyledonous ones. The highest number of species was recorded in the control plots, which were not mechanically treated (on average, 12.6). In all the years of the studies, both on the first and second fate of the determinations, barnyard grass (*Echinochloa crus-galii)* and white goose-foot (*Chenopodium album)* were the dominant weed species.

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