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EFFECT OF STRIP TILLAGE AND WEEDING METHOD ON WEED INFESTATION OF SILAGE MAIZE PLANTED AFTER WINTER COVER CROP

Summary

A field experiment was conducted in 2012 to 2013 to determine the effect of tillage, including deep strip tillage, shallow strip tillage and conventional tillage, and weed control method (untreated control, mechanical, chemical) on weed infestation of maize planted after winter cover crop being intended for silage. Strip tillage was executed with the use of a universal active tool for the strip tillage and mechanical interrow cultivation. Cultivated straps were 25 cm wide and 20cm deep at deep strip tillage, and 25cm wide and 3-5cm deep at shallow strip tillage. Conventional tillage was performed with moldboard plow at a depth of 20cm. Strip tillage significantly reduced weed biomass in maize as compared to conventional tillage. Weed biomass and density after mechanical and chemical treatment was similar and significantly lower than at untreated control. The new developed active tool for the strip tillage and mechanical interrow cultivation ensures a good efficiency of weed control in maize planted after winter rye cover crop.
***Key words**: strip tillage, maize, mechanical weeding, winter cover crop*

WPŁYW PASOWEJ UPRAWY ROLI I SPOSOBU ZWALCZANIA CHWASTÓW NA ZACHWASZCZENIE KUKURYDZY UPRAWIANEJ W PLONIE WTÓRNYM

Streszczenie

Doświadczenie polowe przeprowadzono w latach 2012–2013 w celu określenia wpływu sposobu uprawy roli, w tym uprawy tradycyjnej, głębokiej uprawy pasowej, płytkiej uprawy pasowej oraz sposobu zwalczania chwastów (kontrola bez zwalczania, mechaniczne, chemiczne) na zachwaszczenie kukurydzy uprawianej w plonie wtórnym po życie na zielonkę. Pasową uprawę roli wykonano uniwersalnym narzędziem uprawowo pielęgnacyjnym. Uprawiane pasy miały 25 cm szerokości oraz 20cm głębokości w przypadku głębokiej uprawy pasowej, natomiast w wersji płytkiej głębokość wynosiła 3-5 cm. Tradycyjną uprawę roli wykonano pługiem odkładnicowym na głębokość 20 cm. Po pasowej uprawie roli biomasa chwastów była znacząco niższa, niż na obiektach z uprawą tradycyjną. Biomasa chwastów na obiektach odchwaszczanych mechanicznie i chemicznie nie różniła się od siebie i była istotnie niższa w porównaniu do nieodchwaszczanych obiektów kontrolnych. Nowo skonstruowane uniwersalne narzędzie do uprawy pasowej i pielęgnacji międzyrzędowej zapewniło wysoką skuteczność zwalczania chwastów w kukurydzy uprawianej po międzyplonie ozimym.
***Słowa kluczowe**: pasowa uprawa roli, kukurydza, pielenie, międzyplon ozimy*

1. Introduction

Double-cropping of silage maize with winter rye cover crop has the potential to generate additional forage for livestock and mitigate some of the environmental concerns associated with maize silage production [3, 4]. However conventional tillage involving moldboard plowing and secondary tillage, is time and labor consuming. Intensive tillage accelerates soil drying, delay planting and increase the risk of soil erosion. Reduced tillage, especially no-till, gives an opportunity to establish the maize crop just after rye harvest. Residues remaining on the soil surface have the potential to conserve moisture, reduce erosion and suppress some weeds [2, 7]. However planting maize into untilled soil can reduce maize crop emergence and slow plant development, resulting in lower yield [2, 5, 6, 8]. Mechanical weeding is absent or limited due to technical difficulties. Weed control relays on chemical method and in some situations, more herbicides are needed [7]. Strip tillage is an attractive compromise between no till and conventional tillage production system. Strip tillage creates a narrow zone for planting in which soil is cleaned from residues and tilled to prepare seedbed and allow for more even crop emergence [2, 7, 8]. This system is widely spread in North America, but seldom applied in Poland and other European Countries. Strip tillage designs are typically based on a tine and disc combination with some residue managers and rollers [7]. Most of maize is planted into previous crop residues. Strip tilling into living stubble is much more difficult. To achieve a good seedbed and mechanical weed control in difficult conditions, an active tool for the strip tillage and mechanical interrow cultivation was developed at Industrial Institute of Agricultural Engineering in Poznań [10, 11, 12].

The objectives of this study were to evaluate effect of strip tillage and mechanical weeding, executed with the use of a universal active tool, on weed infestation of silage maize planted after winter cover crop.

2. Materials and methods

The field study was conducted during 2012 and 2013 on private farm in Duszniki Wielkopolskie, near Poznań, on a soil classified as Albic Luvisols developed on loamy sands overlying loamy material. The experiment was a random complete block with a split-plot arrangement and with four replications. Main plots have been subject to three tillage systems including conventional tillage, deep strip tillage and shallow strip tillage. Subplots have been subject to three weed management systems including untreated control, mechanical weed control and chemical weed control. Plot size was 3 m (four rows with a 0.75 m row spacing) by 10 m.

Winter rye for haylage was mowed at boot stage and baled after one day of drying. Conventional tillage was conducted with the moldboard plow with furrow press at depth of about 20 cm and spring harrow with rolling baskets at about 5 cm. Strip tillage was executed with the use of a universal active tool for the strip tillage and mechanical interrow cultivation, equipped with the universal load-bearing frame. The tool consisted of tines, rotary hoe, and roller. Tine loosens soil in row to about 20cm deep, rotary hoe makes strips 25 cm wide and 3-5 cm deep, roller reconsolidates soil for good seedbed. tines were removed from frame for shallow strip tillage and only 5 cm of soil was tilled with rotary hoe. Maize (Zea mays L. cv. Bejm) was planted at density of 10 seed·m^{-2}, in separate strip, with disk planter. Weeds were controlled, when maize was at 4 leafs stage, by spraying with 0.15 kg·ha^{-1} of Maister 310WG (foramsulfuron + jodosulfuron) with 2 l·ha^{-1} of Actirob 842 EC (adjuvant) at chemical weed control treatment. Mechanical weeding was carried out with the use of universal tool equipped with rotary hoe and weed harrow. Rotary hoe cultivated soil between rows and weed harrow worked in rows.

Weed infestation was evaluated shortly prior to maize harvest, at milk stage. Weeds were collected by hand, from two random places per plot, 0.75 m wide and 1m long. Weed density and fresh biomass for individual species and the sum of all weed species was recorded. Rye, regrowing from stubble, was counted as number of heads. Dry weed biomass was determined after drying in 65°C.

Data were analyzed by analysis of variance and means were compared using Tuckey's LSD test at the $P \leq 0.05$ probability level.

3. Results and Discussion

Weed density was not significantly affected by tillage (Table 1). However the population tended to be lower in deep strip tillage and shallow strip tillage (respectively 32.1and 31.1 plant·m^{-2}) than in conventional tillage (45.2 plant·m^{-2}). After weed control the weed population was reduced by over 90% as compared with untreated plots, and no significant differences were observed between mechanical and chemical method. Differences in weed biomass were more evident than in weed density. Reduction in weed biomass after strip tillage, as compared to conventional tillage, was statistically significant in both, fresh and dry weight. Significant biomass reduction was also obtained after weed control, weeding method did not influence final biomass of weeds. Under reduced tillage systems weed control has proved more difficult compared to conventional system [7]. In some situations, more herbicides are needed to control weeds [7]. In no-till and strip tillage technologies most of the field area is not cultivated and chemical burndown is standard option prior planting [2, 6, 7, 9]. In this study weed population was efficiently controlled without chemical burndown and with only one application of postemergence herbicide at standard rate or one mechanical cultivation. It shows possibility of efficient weed control in reduced tillage systems without increasing herbicide applications. The new developed tool for strip tillage and mechanical weed control proved to be useful and efficient in difficult conditions of living rye stubble.

Weed community composition was affected by the tillage system (Table 2). *Chenopodium album* was dominating weed species at conventional tillage, plant density exceeded 100 plants·m^{-2}. Population of *C. album* at strip tillage treatments, was over two times lower than at conventional tillage, but still it was dominating species of weeds.

Table 1. Weed density (no·m^{-2}), fresh and dry biomass weight (g·m^{-2}) depending on tillage method and weed control
Tab. 1. Liczba (szt·m^{-2}), świeża i sucha masa (g·m^{-2}) chwastów w zależności od sposobu uprawy roli i zwalczania chwastów

Tillage (A) / *Uprawa roli*	Weed control (B) / *Zwalczanie chwastów*			Mean / *Średnia*
	Untreated *Kontrola*	Mechanical *Mechaniczne*	Chemical *Chemiczne*	
Weed density (no·m^{-2})				
Conventional tillage / *Uprawa tradycyjna*	109.8	18.2	8.2	45.4
Strip tillage – deep / *Uprawa pasowa głęboka*	73.7	13.5	9.0	32.1
Strip tillage – shallow / *Uprawa pasowa płytka*	72.0	10.7	10.5	31.1
Mean / *Średnio*	85.2	14.1	9.2	
$LSD_{0,05}$; $NIR_{0,05}$; A=ns; B=20.4; B/A=ns; A/B=ns				
Fresh weight (g·m^{-2})				
Conventional tillage / *Uprawa tradycyjna*	1307.6	126.7	103.5	512.6
Strip tillage – deep / *Uprawa pasowa głęboka*	808.6	75.9	39.6	308.0
Strip tillage – shallow / *Uprawa pasowa płytka*	801.7	58.2	52.5	304.1
Mean / *Średnio*	972.7	86.9	65.2	
$LSD_{0,05}$; $NIR_{0,05}$; A=181.2; B=245.5; B/A=ns; A/B=ns				
Dry biomass (g·m^{-2})				
Conventional tillage / *Uprawa tradycyjna*	263.8	25.7	47.6	112.3
Strip tillage – deep / *Uprawa pasowa głęboka*	122.7	11.7	7.5	47.3
Strip tillage – shallow / *Uprawa pasowa płytka*	113.6	9.7	8.8	44.0
Mean / *Średnio*	166.7	15.7	21.3	
$LSD_{0,05}$; $NIR_{0,05}$; A=26.9; B=35.9; B/A=62.3; A/B=57.4				

ns– not significant difference – *różnica nieistotna*

Source: own work / Źródło: opracowanie własne

Table 2. Density of weed species at untreated plots, mean of the years 2012–2013 (No·m^{-2})
Tab. 2. Liczba chwastów według gatunków, na obiektach nieodchwaszczanych, średnio za lata 2012–2013 (szt·m^{-2})

Gatunki *Species*	Tillage / *Sposób uprawy roli*		
	Conventional tillage *Uprawa tradycyjna*	Strip tillage – deep *Uprawa pasowa głęboka*	Strip tillage – shallow *Uprawa pasowa płytka*
Echinochloa crus-galli (L.) Beauv.	3.7	0.3	4.5
Secale cereale L.	+	21.5	20.8
Chenopodium album L.	100.5	42.8	42.7
Fallopia convolvulus (L.) A. Love	4.7	5.0	2.0
Lamium spp.	+	-	-
Lycopsis arvensis L.	+	+	+
Polygonum aviculare L.	-	+	+
Tripleurospermum inodorum L.	+	-	-
Veronica spp.	+	+	+
Viola arvensis Murr.	0.2	3.8	1.5

+ – occuring sporadically, below 0,1 No./m^2 – występuje sporadycznie, poniżej 0,1 szt./m^2

Source: own work / Źródło: opracowanie własne

Changes in weed community in reduced tillage systems are often reported [2, 7, 9]. High levels of mulch may reduce emergency of many weed species [1] but in our study only winter rye stubble was left on soil surface. However cereal rye is known for high allelopathic potential.

C. album, dominating in weed community, was effectively controlled with herbicide and mechanical cultivation (Table 3). Efficiency of mechanical and chemical method was similar and was over 90% in plant density and biomass.

Secale cereale – winter rye regrowing from stubble was occurring sporadically at conventional tillage plots (Table 4). At strip tillage, both deep and shallow, about 20 heads per square meter was counted. Considering over 500 rye heads·m^{-2} prior to harvest, the regrowth was below 5%. Proper terminating, including timing and efficiency, is crucial in winter cover crop based technologies [1]. Tillage and chemical burndown are often applied but also rolling and mowing are possible. In our study moldboard plow gave practically complete rye terminating. Mowing was not so effective, but in combination with postemergence mechanical or chemical weed control gave almost complete termination of rye, without additional costs.

4. Conclusions

1. Strip tillage significantly reduced weed biomass in maize as compared to conventional tillage.
2. Weed biomass and density after mechanical end chemical weed control was similar, at untreated control was significantly bigger.
3. Efficient terminating of cover crop and weed control in strip tilled maize is possible without preplant chemical burndown.
4. The new developed active tool for the strip tillage and mechanical interrow cultivation provides a good efficiency of weed control in maize planted after winter rye cover crop.

Table 3. Plant density (no·m^{-2}) and fresh weight (g·m^{-2}) of *Chenopodium album* (L.) depending on tillage method and weed control
Tab. 3. Obsada roślin (szt·m^{-2}) oraz świeża masa (g·m^{-2}) Chenopodium album (L.) *w zależności od sposobu uprawy roli i zwalczania chwastów*

Tillage (A) / *Uprawa roli*	Weed control (B) / *Zwalczanie chwastów*			Mean *Średnia*
	Untreated *Kontrola*	Mechanical *Mechaniczne*	Chemical *Chemiczne*	
Plant density (no·m^{-2})				
Conventional tillage / *Uprawa tradycyjna*	100.5	6.7	4.0	37.1
Strip tillage – deep / *Uprawa pasowa głęboka*	42.8	4.3	2.3	16.5
Strip tillage – shallow / *Uprawa pasowa płytka*	42.7	2.7	2.8	16.1
Mean / *Średnio*	62.0	4.6	3.1	
$LSD_{0,05}$; $NIR_{0,05}$; A=16.4; B=17.6; B/A=30.6; A/B=29.6				
Fresh biomass (g·m^{-2})				
Conventional tillage / *Uprawa tradycyjna*	1186.5	53.8	81.5	440.6
Strip tillage – deep / *Uprawa pasowa głęboka*	650.0	47.9	15.2	237.7
Strip tillage – shallow / *Uprawa pasowa płytka*	540.7	30.0	29.8	200.1
Mean / *Średnio*	792.4	43.9	42.1	
$LSD_{0,05}$; $NIR_{0,05}$; A=149.4; B=213.2; B/A=369.3; A/B=336.0				

ns– not significant difference – *różnica nieistotna*

Source: own work / Źródło: opracowanie własne

Table 4. Plant density ($no \cdot m^{-2}$) and fresh weight (($g \cdot m^{-2}$) of *Secale cereale* (L.) depending on tillage method and weed control

Tab. 4. Obsada roślin ($szt \cdot m^{-2}$*)oraz świeża masa (*$g \cdot m^{-2}$*) Secale cereale* (L.) *w zależności od sposobu uprawy roli i zwalczania chwastów*

Tillage (A) / *Uprawa roli*	Weed control (B) / *Zwalczanie chwastów*			Mean *Średnia*
	Untreated *Kontrola*	Mechanical *Mechaniczne*	Chemical *Chemiczne*	
Plant density ($no \cdot m^{-2}$)				
Conventional tillage / *Uprawa tradycyjna*	0.0	0.0	0.0	0.0
Strip tillage – deep / *Uprawa pasowa głęboka*	21.5	0.8	0.8	7.7
Strip tillage – shallow / *Uprawa pasowa płytka*	20.8	1.8	1.0	7.9
Mean / *Średnio*	14.1	0.9	0.6	
$LSD_{0,05}$; $NIR_{0,05}$; A=5.0; B=4.3; B/A=7.5; A/B=7.9				
Fresh biomass ($g \cdot m^{-2}$)				
Conventional tillage / *Uprawa tradycyjna*	0.0	0.0	0.0	0.0
Strip tillage – deep / *Uprawa pasowa głęboka*	91.7	9.2	3.1	34.9
Strip tillage – shallow / *Uprawa pasowa płytka*	120.3	8.0	2.9	43,7
Mean / *Średnio*	70.7	5.9	2.0	
$LSD_{0,05}$; $NIR_{0,05}$; A=32.2; B=30.9; B/A=53.6; A/B=54.2				

ns– not significant difference – *różnica nieistotna*

Source: own work / Źródło: opracowanie własne

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Universal tool for strip-tillage. Research project No. N N313 788940 supported by the Ministry of Science and Higher Education, Warsaw (Poland).