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EFFECT OF DIFFERENT TILLAGE SYSTEMS ON MAIZE YIELD AND DEGRADATION DYNAMICS OF RIMSULFURON IN SOIL

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Abstract. The goal of the presented study carried out at the Experimental Station in Jelcz – Laskowice (51°3' N; 17°22' E) in the years 2005-2007 was to estimate the effect of the tillage simplifications on the infestation dynamics, maize grain yield and rimsulfuron degradation rate. Three-year long tillage simplifications affected average weed density per unit area. Tillage simplification in maize monoculture increased the total number of weeds in comparison with the conventional tillage (about 37%) and also caused compensation of two weed species: *Echinochloa crus-galli* and *Chenopodium album*. Significant differences in maize grain yield between conventional and simplified tillage systems were recorded. About 42% maize grain yield reduction was observed as an effect of tillage simplification. There were no significant differences in the efficiency of Titus 25 WG between tillage systems. Tillage simplifications did not significantly influence rimsulfuron residues in the 0-20 cm soil layer, but they affected the rate and the range of rimsulfuron translocation into the soil profile. In the reduced tillage system, the rate of rimsulfuron translocation to deeper soil layers was considerably lower.

Key words: degradation dynamics, maize, monoculture, rimsulfuron, tillage simplifications, weed infestation, yield

INTRODUCTION

Specialization in modern agriculture is manifested mainly in the simplification of both cropping systems and tillage. A reduction in the number of grown crops results in their necessary frequent succession, as a consequence leading to monocultures. In tillage, however, it is attempted to use the possibly smallest number of cultivation measures, with the trend being to a large extent the effect of economic considerations. Maize monoculture, in the first 3-5 years, generally results in a reduction in yields

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[Pabin et al. 2003, Włodek et al. 2005]. The application of reduced tillage, especially in monoculture lasting for many years, promotes the compensation of certain weed species, competitively affecting the growth and development of the crop [Machul 1995, Rola et al. 2005]. Also the application of the same herbicides year after year in the same field may have a significant effect on the dynamics of degradation, translocation and residue levels of these active substances in the soil. The determination of residue levels, degradation and translocation rates of herbicidal active substances in the soil is essential both for the farming practice and for the protection of the soil environment [Beckie and McKercher 1990, Sadowski and Kucharski 2004, Sekutowski and Sadowski 2005].

Until recently, atrazine (belonging to the triazines family) was the predominantly used active ingredient in maize protection against weeds. Popularity of atrazine resulted from a low unit price of this active ingredient, high selectivity to the majority of maize hybrids and very high effectiveness in weed control as well. Common atrazine application led to the accumulation of atrazine residues in the soil, then its penetration into groundwater, and finally water contamination. Therefore, the European Commission decision of 2004 contributed to the prohibition of triazines application in all European Union territory. The time of atrazine withdrawal in Poland was 30 of June 2007. In return, plant protection products market (herbicide market) offered other herbicides, for example from sylfonylurea group, where herbicide Titus 25 WG (rimsulfuron) belongs. Undoubtedly, merits of rimsulfuron are: selectivity to crop, high effectiveness against weeds, small doses introduced to the environment, low toxicity in relation to the homoeothermic organisms and the total safety for the consumer. Herbicide Titus 25 WG is recommended to weed infestation control in maize cultivation. It is a selective systemic herbicide absorbed by the foliage and roots, with rapid translocation to the meristematic tissues. It acts by inhibiting biosynthesis of the essential amino acids valine and isoleucine, hence stopping cell division and plant growth. Growing cells (meristems) slowly stop growing, as amino acid reservoir is depleted and proteins are not synthesized. Symptoms are similar to other sulfonylureas and to imidazolinones. Plants may become stunted, and both leaves and stems may turn yellow (chlorosis) and purple. Characteristic feature of rimsulfuron action is the reduction in root system growth with simultaneous root mass reduction [The Pesticide Manual 2006].

The aim of the investigations was to assess the effect of reduced tillage on weed infestation, yield and rimsulfuron degradation rates in the soil in maize monoculture.

The research hypothesis assumed that maize cultivation in monoculture in different tillage systems (conventional and reduced), using protection against weeds by Titus 25 WG (rimsulfuron) belonging to sylfonylurea chemical family, may after a few years of application lead to the yield reduction, as an effect of the compensation phenomenon or the resistance of some taxa in maize cultivation. Moreover, there may appear differences in phytotoxic residues of herbicide active ingredient in the soil to the maize crop with reference to tillage system. Conventional tillage system, taking plowing into consideration, may demonstrate a higher level of soil permeability, and consequently, a higher speed of rimsulfuron translocation and distribution. However, in the soil where simplified cultivation was carried out, higher rimsulfuron residues maintaining may increase the retention and the degradation time and may inhibit the process of the translocation to the deeper soil layers.

MATERIAL AND METHODS

The static experiment was established on grey-brown podsolic soil, formed from heavy loamy sand on light loam subsoil, class IVb. Maize in monoculture was sown in the years 2005-2007 at the IUNG – PIB Experimental Station in Jelcz – Laskowice (51°3' N; 17°22' E). The field experiment was divided into two parts differing in tillage systems: conventional and reduced (Table 1).

Table 1. Tillage systems in maize crop
Tabela 1. Sposób uprawy roli pod kukurydzę

Tillage system Uprawa roli	Cultivation measures – Zabiegi uprawowe
Conventional tillage Uprawa tradycyjna	post-harvest cultivation – cultivator, grubber at 15 cm + string roller uprawa pożniwna – kultywator; gruber na głębokość 15 cm + wał strunowy basic land preparation – plough to the depth of 25 cm + harrow uprawa podstawowa – orka pługiem na głębokość 25 cm + brona pre-plant tillage – tillage unit (cultivator + string roller) uprawa przedsiewna – agregat uprawowy (kultywator + wał strunowy)
Reduced tillage Uprawa uproszczona	post-harvest cultivation – grubber at 15 cm + string roller uprawa pożniwna – gruber na głębokość 15 cm + wał strunowy pre-plant tillage – tillage unit (cultivator + string roller) uprawa przedsiewna – agregat uprawowy (kultywator + wał strunowy)

The experiment was established in plots of 25 m^2 cropped to maize hybrid Antares, using the randomized split-plot method in the two-factorial design (factor I – herbicide, factor II – tillage method) in 4 replications. In the successive years of the experiment the following fertilization systems were applied: N – 126, P – 39, K – 75, Mg – 25 $kg \cdot ha^{-1}$. In turn, the herbicide application was performed at the phase of 3-5 leaves of maize (13-15 according to the BBCH scale), using Titus 25 WG (rimsulfuron = 25%) at a dose of 60 $g \cdot ha^{-1}$ jointly with the adjuvant Trend 90 EC at a dose of 0.2 $dm^3 \cdot ha^{-1}$. When the experiment was established and then in each successive year of the study the species composition and infestation rates for individual taxa were determined using the square-frame method prior to herbicide application. The square-frame of m^2 was placed at random in three locations on control objects, with weed species being counted per m^2.

The efficiency of the applied herbicide was analyzed based on the estimate of weed infestation, performed 4-6 weeks after herbicide application. This method makes it possible to determine the effect of herbicide on weeds based on a comparison of the number of weeds per m^2, using the square-frame in control plots, in relation to the weed infestation state and rates in plots where herbicide was applied [Domaradzki et al. 2001].

Maize was harvested by hand at the full maturity stage, while the yield of grain was determined at a moisture content of 15% in $t \cdot ha^{-1}$.

Degradation dynamics of rimsulfuron was determined in the soil depending on the adopted tillage system. From each experimental plot soil samples were collected from the 0-10 and 10-20 cm layers at specific time intervals of 0, 1, 2, 4, 6 and 8 weeks after herbicide application and after maize harvesting. Collected soil samples were used as a substrate for the establishment of biological tests. *Sinapis alba* was used as a plant biodetector. Dry weight of aboveground parts of *Sinapis alba* was determined 14 days after the onset of the test. Next, the weight loss percentage was calculated for test plants in relation to control plants (sown on soil not treated with the herbicide). The volume of weight reduction for test plants (*Sinapis alba*) determined from samples collected directly after the application of the herbicide was defined as a measure of the initial (100%) concentration of active substance of the tested herbicide in the soil. Thus, observations of changes in this concentration occurring during the experiment made it possible to determine the dynamics of rimsulfuron degradation in the soil. A detailed method of conducting observations and measurements was described in a previous study [Domaradzki et al. 2001]. Results respecting maize yields were analyzed statistically using the Tukey test at the significance level $LSD_{0.05}$.

Weather conditions during particular years of the investigations were differential. General characterization of the weather conditions in the years 2005-2007, against long-term averages, were presented in the Tables 2 and 3.

Table 2. Average monthly daily air temperatures in the growing season of maize
Tabela 2. Średnie miesięczne dobowe temperatury powietrza w okresie wegetacji kukurydzy

Specification – Wyszczególnienie	Month – Miesiąc					
Daily mean temperature in 2005-2007, °C Średnia dobowa temperatura w latach 2005-2007, °C	April Kwiecień	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień
2005	9.4	12.9	17.0	18.6	19.6	14.8
2006	9.3	14.2	18.3	19.9	17.4	16.2
2007	10.2	15.7	19.6	23.2	19.0	12.7
Temperature – long-term mean Temperatura – średnia z wielolecia (1956-2001), °C	8.0	13.3	16.6	18.2	17.5	13.5

From among 3 years of investigations, the highest sum of precipitation was noticed in 2006; despite this fact, the year mentioned above was not favorable for maize growth, because of the uneven precipitation distribution (Table 3). During sowing period (beginning of May) moisture and thermal conditions for maize plants were favorable in 2006 and 2007 (Table 2-3). The most advantageous sowing time was noticed in 2006, because the total precipitation in this year was about 25 mm higher in comparison with long-term average. Sowing time in 2005 was the most unfavorable period, because precipitation deficiency compared with long-term average was about 24 mm (Table 3).
The higher sum and distribution of the precipitation and thermal conditions during panicle formation were noticed in 2006 (Table 2-3). The beginning of panicle appearing in particular years were uneven and occurred between the 1st and 4th week of July. The highest water deficiency for the period mentioned above was noticed in 2007 – precipitation amounted to only 4.8 mm in July and was about 75.2 mm lower from long-term average (Table 3). Also thermal conditions were not optimal – an average temperature in July (1st to 4th week) was 19.6°C and was about 3.0°C higher from long-term average (Table 2). Low air humidity with average day and night temperatures 20--23°C during June and August contributed to the appearance of maize „water stress", where leaf coiling was observed. Such conditions did not influence the further maize growth and development. Turn of the August and September is the time of maize grain yield formation (the time of cob formation); therefore, moisture-thermal conditions should be very favorable. The best conditions for that period were noticed in 2006, and less favorable in 2005 and 2007 – in both years weather conditions contributed to the

maturity period elongation. From among 3 years of the investigations, the most favorable weather conditions to maize cultivation were noticed in 2006 (Tables 2-3).

Table 3. Monthly precipitation totals in the growing season of maize
Tabela 3. Miesięczne sumy opadów w okresie wegetacji kukurydzy

Specification Wyszczególnienie	Month – Miesiąc						Period Okres
Total precipitation in 2005-2007, mm Suma opadów w latach 2005-2007, mm	April Kwiecień	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	April – September Kwiecień – Wrzesień
2005	27.0	37.3	46.8	55.3	47.9	20.3	234.6
2006	23.7	86.2	24.6	123.7	34.8	31.1	324.1
2007	4.2	54.2	66.5	4.8	30.5	34.9	195.1
Precipitation – long-term mean Opady – średnia z wielolecia (1956-2001), mm	37.6	61.3	71.4	80.0	67.7	47.6	365.6

RESULTS AND DISCUSSION

Weed infestation dynamics

Based on observations conducted in the years 2005-2007, it was found that from among 17 weed species, only 5 appeared in large numbers, i.e. at the intensity exceeding 15 specimens·m^{-2} (Table 4). In the first year (2005) one species, *Echinochloa crus-galli*, predominated markedly, irrespective of the tillage method, and it was accompanied by 3 other taxa: *Chenopodium album*, *Anthemis arvensis* and *Viola arvensis*. In the successive years numerous changes were observed in individual species, first of all of quantitative character. In the seasons of 2006 and 2007 *Chenopodium album* was the taxon dominating in the maize field and it was accompanied by *Echinochloa crus-galli* (irrespective of the tillage method). In contrast, the population size of *Anthemis arvensis* and *Viola arvensis* successively decreased in the successive years of the study. A different trend was found for *Viola arvensis* in conventional tillage, since its population increased considerably in 2006, to be reduced in the next season to 17 specimens·m^{-2}. Irrespective of the adopted tillage system, the population size of *Geranium pusillum* increased markedly in the last two years of the study (22-30 specimens·m^{-2} in conventional tillage and 22-39 specimens·m^{-2} in reduced tillage).

In reduced tillage, the number of weeds in terms of the 3-year mean was by 37% higher than in conventional tillage, while in individual years of the study the difference ranged from 28% to 45% (Table 5). Simplified tillage measures resulted in an increase in infestation rates of 2 dominant species, i.e. *Echinochloa crus-galli* and *Chenopodium album* (Table 4). Also Majchrzak et al. [2003b], Menzel and Dubas [2003], Szulc et al. [2005] indicated tillage reduction as a factor which significantly modifies infestation rates, while this effect for the maize agrophytocenosis species composition was found to be less marked.

Table 4. Dynamics of weed infestation in maize crop in conventional tillage and reduced tillage systems
Tabela 4. Dynamika zachwaszczenia kukurydzy uprawianej systemem tradycyjnym oraz uproszczonym

Weed species specimens·m^{-2} Gatunki chwastów szt.·m^{-2}	Conventional tillage – Uprawa tradycyjna				Reduced tillage – Uprawa uproszczona			
	Year of investigation Rok badań			Mean for 2005-2007 specimens·m^{-2} Średnia z lat 2005-2007 szt.·m^{-2}	Year of investigation Rok badań			Mean for 2005-2007 specimens·m^{-2} Średnia z lat 2005-2007 szt.·m^{-2}
	2005	2006	2007		2005	2006	2007	
Echinochloa crus-galli (L.)	218	135	145	166	308	234	350	297
Apera spica-venti (L.)	3	–	1	1	1	3	15	6
Chenopodium album (L.)	124	246	372	247	243	317	373	311
Thlaspi arvense (L.)	3	3	–	2	3	–	–	1
Brassica napus (L.)	6	8	10	8	5	14	12	10
Lamium aplexicuale (L.)	2	3	–	2	1	–	–	1
Fumaria officinalis (L.)	5	3	5	4	6	3	3	4
Centaurea cyanus (L.)	10	4	–	5	10	14	5	10
Anthemis arvensis (L.)	48	18	12	26	39	22	10	24
Viola arvensis (Murray)	39	70	17	42	53	32	25	37
Veronica persica (Poiret)	2	–	–	1	1	–	–	1
Geranium pusillum (L.)	5	22	30	19	6	22	39	22
Papaver rhoeas (L.)	7	7	10	8	7	7	10	8
Sinapis arvensis (L.)	–	3	–	1	–	2	–	1
Convolvulus arvensis (L.)	–	5	–	2	–	3	–	1
Galium aparine (L.)	–	3	–	1	–	–	–	–
Artemisia vulgaris (L.)	–	–	7	2	–	–	5	2
Sonchus arvensis (L.)	–	–	–	–	–	5	–	2
∑ weed species, specimens·m^{-2} ∑ gatunków chwastów, szt.·m^{-2}	472	530	609	537	683	678	847	736

Table 5. Comparison of weed infestation rates in different tillage systems
Tabela 5. Porównanie poziomu zachwaszczenia w zależności od systemu uprawy

Year of research Rok badań	Total weed infestation, specimens·m^{-2} Zachwaszczenie ogółem, szt.·m^{-2}		Increase of weed infestation as a result of reduced tillage, % Wzrost zachwaszczenia pod wpływem stosowania uproszczeń uprawowych, %
	Conventional tillage Uprawa tradycyjna	Reduced tillage Uprawa uproszczona	
2005	472	683	44.7
2006	530	678	27.9
2007	609	847	39.1
Mean for 2002-2005 Średnia z lat 2002-2005	537	736	37.1

Weed control

In the investigations conducted by the authors of this study, tillage reduction was found to have no significant effect on the weed control efficiency of the applied herbicide Titus 25 WG. In contrast, weather conditions were observed to have a significant effect on the efficiency of the tested preparation (Table 2-3). Extended periods of water deficiency, a factor of considerable importance for light soil, as well as high temperatures resulted in the occurrence of large numbers of the thermophilous species *Echinochloa crus-galli*. Probably such a situation resulted in a reduced efficiency of Titus 25 WG in reduced tillage in case of *Echinochloa crus-galli*, as the efficiency of this herbicide dropped from 95% (conventional tillage) to 90% (reduced tillage) (Table 6).

Table 6. Weed control depending on the tillage system (mean for 2005-2007)
Tabela 6. Zniszczenie chwastów w zależności od systemu uprawy (średnia z lat 2005-2007)

Treatment Obiekt	Dose per ha Dawka na ha	T	Tillage system Rodzaj uprawy	Weed control – Zniszczenie chwastów, %						
				Echinochloa crus-galli	*Chenopodium album*	*Viola arvensis*	*Anthemis arvensis*	*Geranium pusillum*	*Centaurea cyanus*	*Brassica napus*
Control Kontrola	–	–	u.t.	166*	247*	42*	26*	19*	5*	8*
			u.u.	297*	311*	37*	24*	22*	10*	10*
Titus 25 WG +	60 g	T-3	u.t.	95	71	80	95	83	90	95
Trend 90 EC	0.2 dm^3	T-3	u.u.	90	70	78	97	84	90	95
$LSD_{0.05}$ – $NIR_{0,05}$				4.332						

* for untreated plots – number of weeds per sq. m – dla kontroli podano liczbę chwastów, szt.·m^{-2}
u.t. – conventional tillage – uprawa tradycyjna
u.u. – reduced tillage – uprawa uproszczona
T – time of application – termin stosowania

According to literature data, changes in weed infestation state and rates of maize caused by monoculture and reduced tillage may have an effect on the efficiency of applied herbicides. As it was reported by Mueller and Hayes [1997] and Blecharczyk et al. [2000], simplifications in tillage systems result in increased weed infestation, which as a consequence leads to the reduced efficiency of herbicides. In their study Mueller and Hayes [1997] found a reduced efficiency of applied herbicides for Brachiaria platyphylla in treatments with reduced tillage. In contrast, Majchrzak et al. [2003a] and Rola et al. [2006] did not observe significant differences in the efficiency of tested herbicides depending on the adopted tillage system.

Yields

The average yield for the period of 2005-2007 for the control treatment (with no herbicide protection) in conventional tillage was 2.44 t·ha^{-1}, while in reduced tillage it was 1.42 t·ha^{-1}. In case of the treatment where Titus 25 WG was applied also in the conventional tillage system, the yield was markedly higher in comparison to reduced tillage, amounting to 5.16 and 4.45 t·ha^{-1}, respectively. Thus simplified tillage caused a grain yield reduction by 42% (in the control treatments) and by 14% in the plots where herbicide protection was used (Table 7). Moreover, significant differences were also observed between individual years of the study in terms of yielding. Grain yields of maize in conventional tillage were always significantly higher in those years in comparison to reduced tillage. Moreover, significant variation was also found in the treatments where the herbicide Titus 25 WG was applied, irrespective of the adopted tillage system (Table 7).

Table 7. Effect of tillage systems on maize yield
Tabela 7. Wpływ sposobu uprawy na plon ziarna kukurydzy

Treatment Obiekt	Time of application Termin stosowania	Dose per ha Dawka na ha	2005		2006		2007		Mean for Średnia z lat 2002-2005	
			Yield – Plon, t·ha^{-1}							
			u.t.	u.u.	u.t.	u.u.	u.t.	u.u.	u.t.	u.u.
Control Kontrola	–	–	2.56	1.38	2.10	1.18	2.67	1.69	2.44	1.42
Titus 25 WG + Trend 90 EC	T-3 T-3	60 g 0.2 dm^3	5.18	4.69	4.16	3.27	6.15	5.38	5.16	4.45
$LSD_{0.05}$ – $NIR_{0,05}$			0.1684							

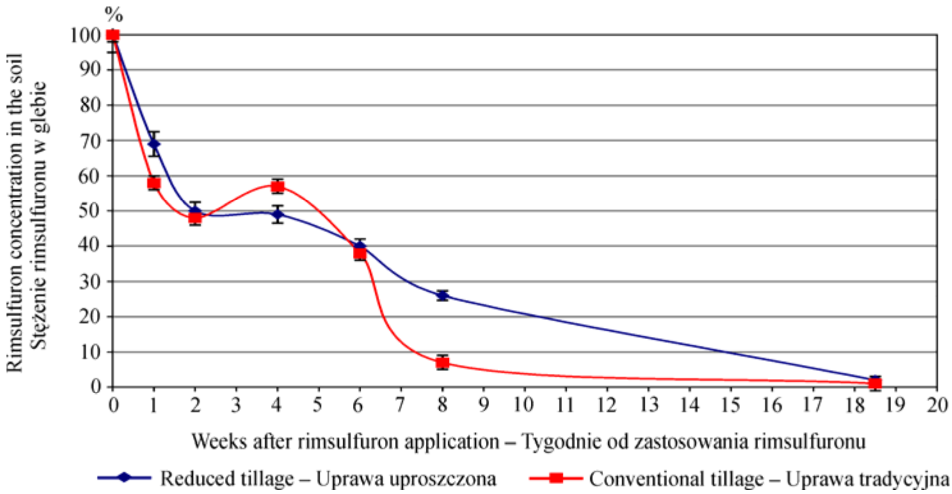
For explanation see Table 6 – objaśnienia jak w tabeli 6

In some literature sources we may find the statement that the effect of monoculture and tillage simplifications on grain yield in maize is not really clearly defined. There is an opinion that reduced tillage has a negative effect on grain yield or green matter yield of maize. This thesis was confirmed in studies by Bathke et al. [1992], Włodek et al. [2005] and Rola et al. [2006], who observed a marked decrease in yielding as a result of considerable tillage reductions, especially in maize grown in long-term monoculture.

Dynamics of rimsulfuron degradation and translocation

When observing the course of degradation curves for rimsulfuron over the entire analyzed soil layer of 0-10 and 10-20 cm, a certain regularity can be found for the years 2005-2007 (irrespective of the tillage system). Already in the first few weeks following herbicide application, a translocation of the tested active substance was observed in the 0-20 cm layer (Figs. 1-3). Within 8-18 weeks after rimsulfuron application, residue concentrations of this substance were found to become slowly uniform over the entire analyzed soil layer (Fig. 1). In the first 2 weeks after herbicide application, the concentration of rimsulfuron dropped by almost 50% in comparison to the initial level. After 4 weeks, an increase was observed in the contents of the analyzed active substance in the soil. This was probably caused by a repeated influx of the herbicide from the crop surface and from the dying weeds. This process was observed up to week 6 from the application of rimsulfuron. In the next period, i.e. approx. 18 weeks from herbicide application (maize harvest), the concentration of rimsulfuron in the soil profile was gradually decreasing and reached 1-2% initial concentration. The dynamics trend for the degradation of this substance indicates that in the case of conventional tillage this process is slightly more rapid in comparison to reduced tillage (Figs. 1-3). Comparable results were reported by Rola and Sekutowski [2005] when investigating the degradation of nicosulfuron, belonging to the same chemical group as rimsulfuron (the group of sulfonylurea derivatives).

An integral part of herbicide active substance degradation is the process of its translocation into the soil. The process of rimsulfuron migration was affected by the tillage system (Figs. 2-3) as well as weather conditions in the analyzed vegetation seasons (the volume and distribution of precipitation) (Table 3). The rate of translocation in the 10-20 cm layer was markedly higher in the conventional tillage (Fig. 3). Also Domaradzki et al. [2005] recorded comparable results for iodosulfuron and chlorsulfuron. Results recorded by those authors confirm the thesis that the type of tillage measures has an effect on the rate and scale of herbicide translocation into the soil profile. Conventional tillage causes a loosening of soil structures in the 0-20 cm layer and in this way it facilitates the transport of the active substance into the soil profile. In turn, simplified tillage very frequently causes changes in the compactness, density and moisture content of soil, which slows down the translocation process into the soil profile [Weber et al. 2000].



* significant difference for $LSD_{0.05}$ – różnica istotna dla $NIR_{0,05}$

Fig. 1. Rimsulfuron degradation rates in the 0-20 cm soil layer (mean in 2005-2007)
Rys. 1. Dynamika zanikania rimsulfuronu w warstwie gleby 0-20 cm (średnia z lat 2005-2007)

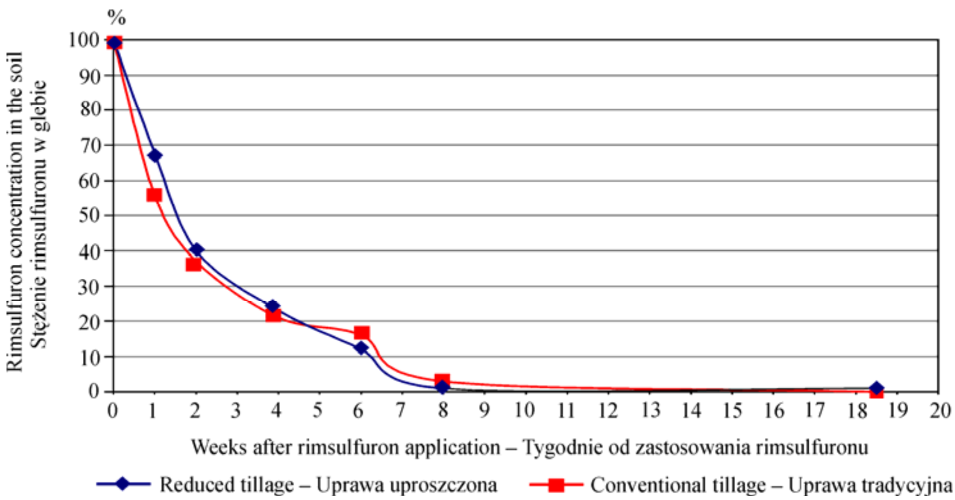


Fig. 2. Rimsulfuron translocation rates in the 0-10 cm soil layer (mean in 2005-2007)
Rys. 2. Przemieszczanie rimsulfuronu w warstwie gleby 0-10 cm (średnia z lat 2005-2007)

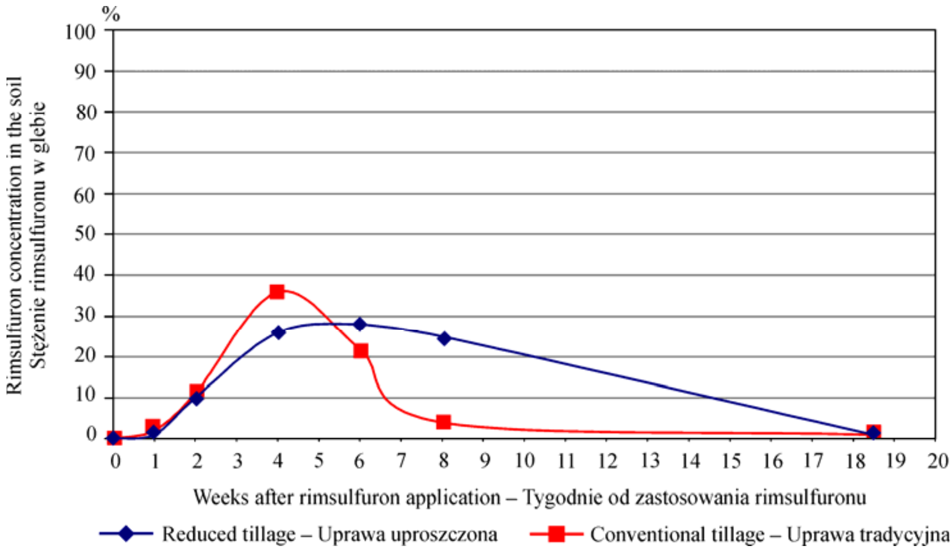


Fig. 3. Rimsulfuron translocation rates in the 10-20 cm soil layer (mean in 2005-2007)
Rys. 3. Przemieszczanie rimsulfuronu w warstwie gleby 10-20 cm (średnia z lat 2005-2007)

CONCLUSIONS

1. Tillage reductions caused an increase in total infestation by 37% in comparison to conventional tillage. A marked increase was found in weed infestation and dominance of 2 species: *Echinochloa crus-galli* and *Chenopodium album*.
2. Tillage simplification did not have an effect on weed control efficiency of the herbicide Titus 25 WG. Only in case of *Echinochloa crus-galli* a reduced efficiency of the tested herbicide was recorded.
3. The application of simplified tillage resulted in a reduction of grain yield of maize both in the control treatments and in the treatments with herbicide application.
4. Reduced tillage did not have a significant effect on the dynamics of rimsulfuron degradation in the soil, but it affected the rate of rimsulfuron translocation in the 0-20 cm soil layer.

REFERENCES

Bathke G.R., Porter P.M., Robinson D., Gibson J., 1992. Double and mono-cropped corn and soybean response to tillage. Proc. South. Cons. Til. Conf., Tennessee, Pub. 92-101, 46-52.
Beckie H.J., McKercher R.B., 1990. Mobility of two sulfonylurea herbicides in soil. J. Agric. Food Chem. 38, 310-315.
Blecharczyk A., Skrzypczak G., Małecka I., Piechota T., 2000. Wpływ systemów uprawy roli na efektywność preparatów Milagro 040 SC i Mikado 300 SC w uprawie kukurydzy [The effect of tillage systems on efficiency of Milagro 040 SC and Mikado 300 SC preparations in maize growing]. Prog. Plant Prot./Post. Ochr. Rośl. 40(2), 736-738 [in Polish].
Domaradzki K., Badowski M., Filipiak K., Franek M., Gołębiowska H., Kieloch R., Kucharski M., Rola H., Rola J., Sadowski J., Sekutowski T., Zawerbny T., 2001. Metodyka doświadczeń

biologicznej oceny herbicydów, bioregulatorów i adiuwantów. Cz. 1. Doświadczenia polowe [Methodology of experimentation concerning biological evaluation of herbicides, bioregulators and adjuvants. Part 1. Field experiments]. Wyd. IUNG Puławy [in Polish].

Domaradzki K., Sekutowski T., Rola H., 2005. Agroekologiczne skutki stosowania herbicydów sulfonylomocznikowych [Agri-ecological effects of sulfonylurea herbicide application]. Prog. Plant Prot./Post. Ochr. Rośl. 45(1), 100-107 [in Polish].

Machul M., 1995. Wpływ przedsiewnego przygotowania roli na plonowanie kukurydzy uprawianej w pięcioletniej monokulturze [The effect of seedbed preparation on yielding of maize grown in 5-year monoculture]. Pam. Puł. 106, 47-62 [in Polish].

Majchrzak L., Skrzypczak G., Pudełko J., 2003a. Zmiany w zachwaszczeniu kukurydzy w zależności od sposobu uprawy roli [Changes in weed infestation of maize depending on tillage method]. Zesz. Probl. Post. Nauk Rol. 490, 153-161 [in Polish].

Majchrzak L., Skrzypczak G., Pudełko J., 2003b. Wpływ systemów uprawy roli na skuteczność chwastobójczą herbicydów stosowanych w kukurydzy [The effect of tillage systems on weed control efficiency of herbicides applied in maize]. Prog. Plant Prot./Post. Ochr. Rośl. 43(2), 791-794 [in Polish].

Mueller T.C., Hayes R.M., 1997. Effect of tillage and soil-applied herbicides on broadleaf signalgrass (*Brachiaria platyphylla*) control in corn (*Zea mays*). Weed Technol. 11, 698-703.

Menzel L., Dubas A., 2003. Reakcja kukurydzy uprawianej w monokulturze na uproszczenia w uprawie roli [Response of maize grown in monoculture to reduced tillage]. Pam. Puł. 133, 123-134 [in Polish].

Pabin J., Włodek S., Biskupski A., 2003. Effect of different tillage techniques on soil properties and crop yields. Pol. J. Soil Sci. Soil Tech. XXXVI(2), 187-194.

Rola H., Sekutowski T., 2005. Wpływ systemów uprawy na dynamikę rozkładu wybranych herbicydów sulfonylomocznikowych stosowanych w kukurydzy [The effect of tillage systems on degradation dynamics of selected sulfonylurea herbicides used in maize]. Pam Puł. 140, 239-243 [in Polish].

Rola H., Sekutowski T., Gierczyk T., 2005. Wpływ systemów uprawy kukurydzy w monokulturze na stan zachwaszczenia łanu [The effect of maize growing systems in monoculture on field weed infestation rates]. Pam. Puł. 140, 245-249 [in Polish].

Rola H., Sekutowski T., Gierczyk T., 2006. Ochrona kukurydzy przed chwastami w świetle zróżnicowanej technologii uprawy [Protection of maize against weeds in view of diverse cultivation technology]. Zesz. Probl. Post. Nauk Rol. 508, 153-158 [in Polish].

Sadowski J., Kucharski M. 2004. Wpływ czynników agrometeorologicznych na pobieranie i fitotoksyczność pozostałości herbicydów zawartych w glebie [The effect of agrimeteorological factors on uptake and phytotoxicity of herbicide residue in soil]. Prog. Plant Prot./Post. Ochr. Rośl. 44(1), 355-363 [in Polish].

Sekutowski T., Sadowski J., 2005. Wpływ technologii uprawy na dynamikę rozkładu pozostałości nikosulfuronu [The effect of tillage technology on degradation dynamics of nicosulfuron residue]. Prog. Plant Prot./Post. Ochr. Rośl. 45(2), 1065-1068 [in Polish].

Szulc P., Menzel L., Dubas A., 2005. Wpływ uproszczeń w uprawie roli na stan zachwaszczenia kukurydzy uprawianej w monokulturze [The effect of reduced tillage on weed infestation rates of maize grown in monoculture]. Prog. Plant Prot./Post. Ochr. Rośl. 45(2), 1137-1140 [in Polish].

The Pesticide Manual, 2006. 14th Edition, British Crop Production Council.

Weber R., Hryńczuk B., Biskupski A., Włodek S., 2000. Zmienność zwięzłości, gęstości i wilgotności gleby w zależności od technik uprawy roli [Variation in compactness, density and moisture content of soil depending on tillage technologies]. Inż. Rol. 6(17), 319-325 [in Polish].

Włodek S., Gierczyk T., Biskupski A., 2005. Efekty uproszczenia uprawy roli w monokulturze kukurydzy [Effects of tillage reduction in maize monoculture]. Fragm. Agron. 2(86), 268-275 [in Polish].

WPŁYW UPROSZCZEŃ W UPRAWIE ROLI NA PLONOWANIE KUKURYDZY I DYNAMIKĘ ZANIKANIA RIMSULFURONU W GLEBIE

Streszczenie. W pracy przedstawiono wyniki badań przeprowadzonych w latach 2005-2007 w Instytucie Uprawy Nawożenia i Gleboznawstwa – PIB w Jelczu – Laskowicach (51°3’ N; 17°22’ E) nad oceną skutków stosowania uproszczeń uprawowych na dynamikę zachwaszczenia i plonowania kukurydzy oraz tempo zanikania rimsulfuronu w glebie. Stosowanie uproszczeń w uprawie roli w 3-letniej monokulturze kukurydzy spowodowało 37% wzrost zachwaszczenia w porównaniu z uprawą tradycyjną. Uproszczenia w uprawie wpłynęły na kompensację 2 gatunków chwastów: *Echinochloa crus-galli* i *Chenopodium album*. Stwierdzono również istotne różnice w plonowaniu kukurydzy spowodowane uproszczeniami uprawowymi (spadek plonu ziarna o 42% w stosunku do uprawy tradycyjnej). Nie odnotowano istotnych różnic w skuteczności działania badanego herbicydu Titus 25 WG (rimsulfuron) w zależności od sposobu uprawy roli. Uproszczenia w uprawie nie wpłynęły w istotny sposób na wielkość pozostałości rimsulfuronu w warstwie gleby 0-20 cm. Sposób uprawy miał istotne znaczenie dla szybkości i skali przemieszczania rimsulfuronu w głąb profilu glebowego; w uprawie uproszczonej szybkość przenikania do głębszych warstw gleby była zdecydowanie mniejsza.

Słowa kluczowe: dynamika zanikania, kukurydza, monokultura, plon, rimsulfuron, uproszczenia uprawowe, zachwaszczenie

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