Acta Sci. Pol., Agricultura 13(4) 2014, 65-76

THE EFFECT OF TILLAGE AND MANAGEMENT OF POST-HARVEST RESIDUES AND BIOSTYMULANT APPLICATION ON THE YIELD OF WINTER WHEAT IN INCREASING MONOCULTURE

Karol Kotwica, Iwona Jaskulska, Lech Gałęzewski,
Dariusz Jaskulski, Robert Lamparski
University of Science and Technology in Bydgoszcz

Abstract. The field experiment on agricultural practices in winter wheat in short-term monoculture was carried out over the years 2011/2012 and 2012/2013 in Chełmce (52°61'N; 18°44'E). The experimental factors included: A – tillage systems (variants with post-harvest tillage with a grubber or without and with the use of manure and sow ploughing and single ploughing, as well as direct sowing), B – method of managing post-harvest residues (four variants with the use of straw and effective microorganisms or without), C – application of a biostimulant Asahi SL (two levels). The aim of the study was determination of the effect of these factors on the yield components and grain yield of winter wheat cultivated in the 2nd and 3rd year of monoculture. The best tillage system for winter wheat yield, irrespective of the duration of monoculture and the course of weather conditions over the years of research, was grubbing the stubble field with a previous application of manure and conducting sow ploughing. Under conditions unfavorable for winter plant yield with a freezing snowless winter, double grubbing and direct sowing was also a good tillage method, leaving a large amount of post-harvest residues on the field surface. Fertilization with straw, especially with a simultaneous use of effective microorganisms, appeared to be relevant under unfavorable habitat conditions. In the year with a beneficial course of weather conditions this treatment generally did not increase the grain yield. Biostimulant Asahi SL caused increase in the quantity of yield components and grain yield in winter wheat, irrespective of the duration of monoculture or of weather conditions over the years of research.

Key words: Asahi SL, direct sowing, effective microorganisms, grubbing, manure, ploughing, straw

Corresponding author – Adres do korespondencji: dr hab. inż. Karol Kotwica, Department of Plant Production and Experimenting of University of Science and Technology in Bydgoszcz, A. Kordeckiego 20E, 85-225 Bydgoszcz, e-mail: kotwica@utp.edu.pl

INTRODUCTION

Reduction in conventional elements of agritechnology often requires the use of treatments reducing their negative habitat- and production effects. This role may be fulfilled by incorporating organic matter and microbiological preparations into the soil [Abdollahi *et al*. 2014, Kotwica *et al*. 2011]. Manure or post-harvest residues beneficially affect soil properties [Giemza-Mikoda *et al*. 2011]. Their effect depends, among other things, on the method of placing them in the soil and the dynamics of their decomposition, which is determined by a tillage system. More and more frequently used no-plough tillage and direct sowing result in leaving a large amount of post-harvest residues on the soil surface, which has an effect on their decomposition and on nutrient management. This type of tillage has a lot of organizational and economic advantages [Jaskulski *et al*. 2012] and may beneficially affect the physical [Lepiarczyk *et al*. 2007, Tian *et al*. 2013, Topa *et al*. 20014], chemical [Lenart and Sławiński 2010, Swedrzyńska *et al*. 2013] and biological properties of the soil [Swedrzyńska *et al*. 2013]. However, it often leads to an increase in its density and is the cause of an impediment in its emergence, reduction in development of the root system and plant yields, compared with conventional tillage [Małecka *et al*. 2012, Haliniarz *et al*. 2013b], though the yields may not differ significantly [Kulig *et al*. 2009, Wesołowski *et al*. 2011, Haliniarz *et al*. 2013a].

The effect of biopreparations on soil properties and plant yield arises a heated discussion between supporters and skeptics of their effectiveness. The result of using effective microorganisms may be an increase in the number of microbes in the soil [Kaczmarek *et al*. 2008], decrease in plant infection with pathogens [Stępień and Adamiak 2009] and improvement in the yield [Piskier 2006]. National literature also provides critical opinions concerning possibilities of using this type of means in agricultural production [Martyniuk 2011, Martyniuk and Księżak 2011]. More and more of such preparations on the market, interest in them in agricultural practice, scarce and ambiguous research results, all of them inspire further study on the effect of biopreparations on the soil environment. Currently, in agricultural practice, biostimulants also find their use, e.g. preparation Asahi SL, which through modifying plant metabolism, increases the use of its yield-producing potential [Matysiak *et al*. 2011].

In our study it was assumed that it would be possible to affect the yield of winter wheat through various methods of incorporating organic matter (manure and post--harvest residues) into the soil, being the result of a diversified tillage system and biostimulant application. This effect may be diverse in the subsequent two years of increasing winter wheat monoculture.

The aim of the study was finding the effect of various tillage variants, method of incorporating post-harvest residues into the soil, and also of the application of a biostimulant Asahi SL, on the yield components and grain yield of winter wheat in extended monoculture.

MATERIAL AND METHODS

The source material includes results of the field experiment, realized in the years 2011/2012 and 2012/2013. The experiments were carried out on an individual farm in Chełmce (52°61' N; 18°44' E). Static (2nd and 3rd year of winter wheat monoculture) 3-way experiment was set up in a split-plot-split-block design in 3 replications. The experimental factors included:

A – tillage systems (five variants):
- post-harvest: grubber with a roll; pre-sowing: grubber + seeder-cultivator unit (variant 1),
- post-harvest: grubber with a roll; sow ploughing + seeder-cultivator unit (variant 2),
- single ploughing + seeder-cultivator unit (variant 3),
- post-harvest: manure + grubber with a roll; pre-sowing: sow ploughing + seeder-cultivator unit (variant 4),
- direct sowing (variant 5).

Manure was applied at a rate of 30 $t \cdot ha^{-1}$. Seven days before direct sowing glyphosate was applied in a form of a preparation Roundup Max 680SG (2 $kg \cdot ha^{-1}$);

B – method of managing post-harvest residues:
- leaving shredded straw (SEM-),
- leaving shredded straw + EM (SEM+),
- removing straw (EM-),
- removing straw + EM (EM+).

(EM – preparation containing effective microorganisms „EM-A" at a dose of 40 $dm^3 \cdot ha^{-1}$);

C – application of a biostimulant:
- application of a biostimulant (A+),
- without biostimulant application (A-).

(biostimulant – Asahi SL was used at doses of: 0.5 $dm^3 \cdot ha^{-1}$ at the stage BBCH 23--25 in winter wheat and 0.5 $dm^3 \cdot ha^{-1}$ at the stage BBCH 39).

In total, 40 experimental objects were located on 120 plots, each having an area of 96 m^2.

The qualified seed material of winter wheat cv. Arktis dressed with Maxim Star (cyproconazole + difluorobenzene) at a rate of 200 g of preparation·100 kg^{-1} of grain, was sown at a density of 400 grains·m^{-2} on the 24th September 2011 and on the 30th of September 2012, with a row spacing of 14.3 cm, at a depth of 4 cm. Seeder-cultivator unit was used for sowing with an active cyclotiller section and seeder Horsch Pronto 4DC equipped with disk coulters, in variant 5 (direct sowing) cyclotiller section remained inactive. In the first year of study, wheat was sown on a plot after winter wheat, for which the forecrop was also winter wheat. In the second year of research, the 3rd year of monoculture, wheat was cultivated on the same field, keeping the same arrangement of objects. The experiment was conducted on soil of a very good rye complex of a granulometric composition of light loam, and the content of: C_{org} 2.31%, available forms of PK and Mg 16.1; 21.8 and 4.80 mg·100 g^{-1}, respectively, and pH_{KCl} 7.6. Phosphorus and potassium were applied onto the stubble field at doses of 15.7 kg $P \cdot ha^{-1}$ 76.4 kg $K \cdot ha^{-1}$, respectively. Nitrogen fertilization on the level of 160 kg $N \cdot ha^{-1}$ was used in spring in three doses: 70 kg $N \cdot ha^{-1}$ at the time of the start of growing, 60 kg $N \cdot ha^{-1}$ in the stage of shooting BBCH 32-33, 30 kg $N \cdot ha^{-1}$ in the stage of ear formation BBCH 54-56. In order to control loose silky bent and dicotyledonous weeds, in spring after the start of growing (BBCH 25-29) a herbicide tank-mixture was used: Atlantis 12 OD (iodosulfuron-methyl-sodium + mesosulfuron-methyl) at a dose of 0.45 $dm^3 \cdot ha^{-1}$ + Sekator 125 OD (amidosulfuron + iodosulfuron-methyl-sodium) at a dose of 150 ml·ha^{-1} + Esteron 600 EC (2,4-D) at a dose of 0.45 dm^3·ha^{-1}. In the stage BBCH 32, a mixture of growth regulators was used Antywylegacz 750 SL (chlormequat chloride) and Moddus 250 EC (trinexapac ethyl) at doses of 1.0 and 0.3 dm^3·ha^{-1}, respectively, along with a fungicide Capalo 337,5 SL (epoxiconazole + fenpropimorf + metrafenone) at a dose of 1.5 dm^3·ha^{-1} in order to reduce occurrence of fusarium wilt, eyespot and powdery mildew. In prophylaxis of reducing ear infections (BBCH 49-51), preparation Artea 330 EC (propiconazole + cyproconazole) was applied at a dose of 0.5 dm^3·ha^{-1}.

Before harvest, ear density was determined, and next grain number per ear and 1000 grain weight. The yield was harvested from the whole area of the experimental plots with a field combine harvester Wintersteiger, and it was expressed in t·ha^{-1} with a 15% water content.

The results were elaborated statistically. Analysis of variance was used in a proper model for the experimental design, as well as an analysis of the multi-way experiment in the combined error model, finding F calculated based on the reproduced error increased by an interaction of the factor with years. Tukey's test was used to evaluate significance of differences in the means. Package of statistical programs ANALWAR-5.2-FR was used for analyses, while Rudnicki's method was used to determine the effect of particular yield components on differences in the yield between the experimental plots [Rudnicki 2000].

The results are presented separately for both years of research. As the experiment is static, the effect of extended monoculture may increase with each year, and besides the years were characterized by a strongly diversified course of weather conditions (Table 1). Synthesis of the analysis of variance indicated significance of an interaction of the experimental factors with the study years for ear density and grain yield in winter wheat, which also leads to a separate analysis of the results from the 1st and 2nd year.

RESULTS AND DISCUSSION

Weather conditions in both research years were strongly diversified (Table 1). Winter 2011/2012 was characterized by very low temperatures, especially in February with the lack of snow cover, which is seen as the cause of ear density being lower by almost half before harvest in 2012 than in 2013 (Table 2). Also, very low rainfall in March, April and May 2012 was not favorable for spring vegetation of plants. The subsequent cultivation season of 2012/2013 may be considered beneficial both for winter plants (snow cover protecting plants against frost and wind) and for further vegetation (warm spring and uniform rainfall distribution, similar to the mean from the long-term period).

Tillage system and method of managing post-harvest residues determined ear density, yet differently in both years of research (Table 2). In the first year of cultivation, ear density was 374 ears·m^{-2}, while in the second one it was by 70.1% higher. It probably resulted from unfavorable weather conditions in winter 2011/2012, which reduced plant density to such an extent that tillering was not able to provide a higher ear density. Despite a different effect of the tillage system on this trait in the study years, in both cases the highest ear density occurred on the plot where manure was used before skimming (variant 4). However, in the first year, density on this plot was similar to ear density on plots cultivated according to variant 1, without tillage, with direct sowing (variant 5). In the subsequent year of monoculture, however, direct sowing caused a strong reduction in ear density. The previous research of Haliniarz *et al*. [2013b] indicates that reduced tillage unfavorably affects ear density in winter wheat. However, this response is not confirmed in the results of Wesołowski and Cierpiała [2011].

Table 1. Mean monthly air temperatures (°C) and rainfall totals (mm) in the growing season and winter dormancy of winter spring. Data from Głębokie (52°61' N; 18°44' E)
Tabela 1. Średnie miesięczne temperatury powietrza (°C) i sumy opadów atmosferycznych (mm) w okresie wegetacji i spoczynku zimowego pszenicy ozimej; dane z punktu w Głębokim (52°61' N; 18°44' E)

Month Miesiąc	Mean monthly air temperature Średnia miesięczna temperatura powietrza				Mean monthly minimum temperature Średnia miesięczna temperatura minimalna			Monthly raifall total Miesięczna suma opadów			
	2011	2012	2013	1967--2013	2011	2012	2013	2011	2012	2013	1967--2013
January Styczeń	–	-0.5	-3.7	-2	–	-4.2	-7.5	–	45.6	38.9	25
February Luty	–	-5.3	-0.6	-1.1	–	-10.9	-3.2	–	19.5	23.7	21
March Marzec	–	5.1	-2.7	2.6	–	-2.4	-7.6	–	8	21.6	28
April Kwiecień	–	9.3	7.5	7.9	–	1.7	1.6	–	16.3	21.2	27
May Maj	–	15.3	14.4	13.6	–	6.7	7.6	–	29.3	74.5	52
June Czerwiec	–	16.1	17.4	16.6	–	9.7	10.5	–	103.7	51.3	69
July Lipiec	–	19.6	18.9	18.6	–	12.7	10.3	–	68.8	111.9	81
August Sierpień	–	18.7	18.7	18.1	–	11.3	11.1	–	37	55.4	60
September Wrzesień	14.9	14.0	–	13.4	7.6	7.6	–	30.7	26.2	–	41
October Październik	9.0	8.0	–	8.3	3.1	2.8	–	10.4	33	–	37
November Listopad	2.9	5.0	–	3.4	-2.2	1.8	–	0.9	36.7	–	34
December Grudzień	2.9	-2.3	–	-0.4	-1	-6.2	–	28.9	15.7	–	31

Beneficial effect of using straw on ear density, with a slight influence of effective microorganisms, manifested itself especially in 2011/2012. At the time it depended on the tillage system. The effect of a biostimulant Asahi SL in both years of study was similar, and dependent on the tillage system. It increased the ear number per unit of area by about 3.5-4%, though to an insignificant extent in the first year on the plot with the tillage variant 3 and 5, and in the second year with variant 1 and 5.

Table 2. Ear density in winter wheat (ear·m^{-2}) depending on the tillage method, management of post-harvest residues and biostimulant application.
Tabela 2. Obsada kłosów pszenicy ozimej (szt.·m^{-2}) w zależności od sposobu uprawy roli, zagospodarowania resztek pożniwnych i aplikacji biostymulatora

Year Rok	Level of B and C Poziom B i C	Tillage variant – Wariant uprawy (A)					Mean – Średnia	
		1	2	3	4	5		
2011/2012	SEM-	417	372	356	424	419	398	mean (B) średnia (B)
	SEM+	423	390	358	431	424	405	
	EM-	350	342	314	398	359	352	
	EM+	336	325	311	392	350	343	
	mean (A) średnia (A)	381	357	335	411	388	374	
	$LSD_{0.05}$ – $NIR_{0,05}$		A 24.1	B 19.6	B/A 26.1		A/B 30.1	
	A+	387	370	339	417	393	381	mean (C) średnia (C)
	A-	375	345	330	405	383	368	
	$LSD_{0.05}$ – $NIR_{0,05}$			C 11.4	C/A 13.4	A/C 25.4		
2011/2012	SEM-	606	659	616	721	595	639	mean (B) średnia (B)
	SEM+	604	677	626	733	596	647	
	EM-	584	631	633	731	574	631	
	EM+	580	640	628	731	572	630	
	mean (A) średnia (A)	594	652	626	729	584	637	
	$LSD_{0.05}$ – $NIR_{0,05}$		A 20.0	B 16.3	B/A ns – ni		A/B ns – ni	
	A+	599	670	649	738	593	650	mean (C) średnia (C)
	A-	588	634	603	720	575	624	
	$LSD_{0.05}$ – $NIR_{0,05}$			C 7.1	C/A 15.1	A/C 25		

„EM-" – plots without the application of effective microorganisms – obiekty bez aplikacji efektywnych mikroorganizmów; „EM+" – plots with the application of effective microorganisms – obiekty z aplikacją efektywnych mikroorganizmów;
„SEM-" – plots with the forecrop straw left, without the application of effective microorganisms – obiekty z pozostawioną słoma przedplonu, bez aplikacji efektywnych mikroorganizmów; „SEM+" – plots with the forecrop straw left and with the application of effective microorganisms – obiekty z pozostawioną słomą przedplonu i z aplikacją efektywnych mikroorganizmów;
„A-" – without the application of a biostimulant – bez aplikacji biostymulatora; „A +" with the application of a biostimulant – z aplikacją biostymulatora
ns – ni – non-significant differences – różnice nieistotne

Incorporating straw and an inoculation of effective microorganisms into the soil had no effect on 1000 grain weight. However, this trait was determined by the tillage system and application of a biostimulant (Table 3). In the season 2011/2012, the ears contained by 1.9 fewer grains than in the subsequent year of cultivation. From the controlled sources of variability this trait was to a significant degree determined only by the application of a biostimulant Asahi SL, increasing grain number per ear in the two subsequent years by 8.2 and 10.5%, respectively. Preparation Asahi SL also caused increase in 1000 grain weight by 6.9 and 5.8%, respectively. This trait was also changed under the effect of tillage with earlier manure application. On object 4 in both years of research, 1000 grain weight was significantly higher than on other plots. Other variants, despite the degree of reduction in conventional tillage, had no effect on this trait.

Wesołowski and Cierpiała [2011] also did not find any effect of reduced tillage both on the grain number per ear or on 1000 grain weight in winter wheat.

Table 3. Grain number per ear (grain) and 1000 grain weight (g) in winter wheat depending on the tillage system and biostimulant application
Tabela 3. Liczba ziaren w kłosie (szt.) i masa tysiąca ziaren (g) pszenicy ozimej w zależności od sposobu uprawy roli i aplikacji biostymulatora

Factor Czynnik	Trait Cecha	Grain number per ear Liczba ziaren w kłosie		1000 grain weight Masa tysiąca ziaren	
	year of study rok badań	2011/2012	2012/2013	2011/2012	2012/2013
Tillage variant Wariant uprawy (A)	1	29.3	31.5	40.5	42.5
	2	28.8	31.0	40.1	42.2
	3	28.4	30.1	39.1	42.6
	4	29.9	31.3	42.8	44.9
	5	29.2	31.3	40.4	41.3
	$LSD_{0.05}$ – $NIR_{0,05}$	ns – ni	ns – ni	2.2	1.8
Biostimulant Biostymulator (C)	A+	30.3	32.6	41.9	43.9
	A-	28.0	29.5	39.2	41.5
	$LSD_{0.05}$ – $NIR_{0,05}$	1.1	1.6	1.3	1.2

explanations under Table 2 – objaśnienia pod tabelą 2

Higher winter wheat yields were obtained in the second year of research, i.e. in the third year of monoculture, than in the first year of the field experiment (the second year of being cultivated after itself) (Table 4). Probably, this result is not the effect of a beneficial influence of the extended cultivation period of winter wheat in monoculture on the grain yield, but of the weather in its growing season. Season 2012/2013 was characterized by definitely more beneficial weather conditions than 2011/2012. In both years of study, the highest grain yield in winter wheat was obtained on the plot where manure was used, and tillage consisted of skimming and sow ploughing (variant 4). In 2011/2012, the second year of monoculture, the lowest grain yield occurred after single ploughing, while in the third year of monoculture as a result of direct sowing (Table 5). Over the years of study, this difference, compared with the highest yield, was 41.7% and 31.8%, respectively. Under favorable weather conditions, which guaranteed high yields, direct sowing turned out to be the worst tillage method. Our own results correspond to a high degree with the conclusions of Haliniarz *et al*. [2013b], who prove that reduced tillage decreases winter wheat yield compared with the plough system. Wesołowski and Cierpiała [2011] also indicate reduction in winter wheat yield after single ploughing. Also, Małecka *et al*. [2012] report a similar unfavorable effect of single ploughing and other reduced tillage methods on winter wheat yield. Also, Brennan *et al*. [2014] indicate variability in the winter wheat yield cultivated in cold Atlantic climate over the years of research, depending on the tillage system.

Straw fertilization, especially with a simultaneous application of effective microorganisms, appeared to be relevant under unfavorable habitat conditions of 2011/2012. Incorporating shredded straw into the soil, irrespective of the use of a preparation containing EM, beneficially affected the grain yield when sow ploughing or single ploughing was conducted during tillage, variants 2 and 3 (Table 4). Brennan *et al*. [2014], however, did not find any effect of applying straw on the grain yield in winter wheat. In the second year of research, the third year of monoculture, beneficial effect of straw on winter wheat yield occurred only in case of using effective microorganisms on the cultivation object: grubber, sow ploughing, seeder-cultivator unit. The previous studies of Kotwica *et al*. [2011] indicated a positive effect of straw fertilization and application of strains of effective microorganisms on winter wheat yield. This effect was particularly visible in the monoculture of this species. Kołodziejczyk *et al*. [2012], however, prove that microbiological preparations improving soil properties, to a slight degree affected spring wheat yield. The greatest increase in the grain yield, on average by 0.4 $t \cdot ha^{-1}$, the authors observed on plots with an application of microbiological preparations, mainly as a result of an ear density higher by 4%.

Table 4. Grain yield in winter wheat ($Mg \cdot ha^{-1}$) depending on the tillage method, management of post-harvest residues and biostimulant application.
Tabela 4. Plon ziarna pszenicy ozimej ($Mg \cdot ha^{-1}$) w zależności od sposobu uprawy roli, zagospodarowania resztek pożniwnych i aplikacji biostymulatora

Year Rok	Level of B and C Poziom B i C	Tillage variant – Wariant uprawy (A)					Mean – Średnia	
		1	2	3	4	5		
2011/2012	SEM-	4.17	4.01	3.31	4.77	4.20	4.09	mean (B) średnia (B)
	SEM+	4.73	4.36	3.37	4.90	4.79	4.43	
	EM-	3.46	2.88	2.16	4.76	3.76	3.41	
	EM+	3.76	2.98	2.28	4.65	3.88	3.51	
	mean (A) średnia (A)	4.03	3.56	2.78	4.77	4.16	3.86	
	$LSD_{0.05}$ – $NIR_{0,05}$		A 0.58	B 0.29	B/A 0.55		A/B 0.76	
	A+	4.25	3.91	2.90	4.80	4.30	4.03	mean (C) średnia (C)
	A-	3.81	3.21	2.66	4.75	4.01	3.69	
	$LSD_{0.05}$ – $NIR_{0,05}$			C 0.13	C/A 0.19	A/C 0.60		
2011/2012	SEM-	5.40	6.64	6.14	7.61	5.18	6.19	mean (B) średnia (B)
	SEM+	5.58	6.82	6.35	7.64	5.42	6.36	
	EM-	5.32	6.19	6.13	7.58	5.11	6.07	
	EM+	5.53	5.91	6.11	7.50	4.97	6.00	
	mean (A) średnia (A)	5.46	6.39	6.18	7.58	5.17	6.15	
	$LSD_{0.05}$ – $NIR_{0,05}$		A 0.23	B ns – ni	B/A 0.78		A/B 0.36	
	A+	5.74	6.63	6.34	7.75	5.45	6.38	mean (C) średnia (C)
	A-	5.18	6.15	6.02	7.41	4.89	5.93	
	$LSD_{0.05}$ – $NIR_{0,05}$			C 0.22	C/A ns – ni	A/C ns – ni		

explanations under Table 2 – objaśnienia pod tabelą 2

In our studies, a significant increase in the grain yield of winter wheat was obtained as a result of the application of a biostimulant Asahi SL (Table 4). In the subsequent years of research it was 8.5 and 7.1%, respectively. A beneficial effect of the biostimulant on the yield did not manifest itself only in 2011/2012 on the plot with manure application. A positive effect of this preparation on crop plants, including spring wheat, was proved by Matysiak *et al*. [2011]. According to these authors the effect of this preparation depends on the course of weather and the plant's developmental stage in which it was used.

Differences in the grain yields of winter wheat resulting from a change in the tillage system, management of post-harvest residues or using a biostimulant, were to a various extent caused by a change in the quantity of particular yield components. Change in the yield quantity under the influence of post-harvest residues, especially of the tillage method in both years of study, resulted mainly from a difference in ear density, and to a lesser degree from a change in the number of grains per ear and 1000 grain weight (Table 5). For example, difference in the yield between a plot with manure application (variant 4) and grubber cultivation (variant 1) in 2011/2012 was 0.74 Mg·ha^{-1}. In 52% it resulted from an increased ear density, 16% from an increased grain number per ear and 32.1% from a higher 1000 grain weight in winter wheat on plot 4. Grain number per ear and 1000 grain weight, though, had a greater contribution in a change in the yield quantity under the effect of biostimulant application.

Table 5. Difference in the yields (Mg·ha^{-1}) between the means of particular factor levels and share [%] of yield components in this difference

Tabela 5. Różnica plonów **(**Mg·ha^{-1}**)** pomiędzy średnimi poszczególnych poziomów czynników i udział [%] elementów plonowania w tej różnicy

Factor Czynnik	Year of study Rok badań		2011/2012				2012/2013			
	Level poziom		yield difference różnica plonu	ear density obsada kłosów	g.n.p.e l.z.k.	1000 grain weight MTZ	yield difference różnica plonu	ear density obsada kłosów	g.n.p.e l.z.k.	1000 grain weight MTZ
Tillage – Uprawa roli	2	1	-0.47	-63.7	-28.2	-8.1	0.93	88.2	15.5	-3.7
	3	1	-1.25	-54.5	-34.4	-11.1	0.72	89.8	8.7	1.5
	4	1	0.74	52.0	16.0	32.1	2.12	79.3	7.6	13.1
	5	1	0.13	86.5	18.4	-4.8	-0.29	-35.2	-12.4	-52.4
	3	2	-0.78	-53.1	-35.7	-11.2	-0.21	-80.6	-49.2	29.8
	4	2	1.21	60.6	19.3	20.1	1.19	64.1	2.0	33.9
	5	2	0.60	71.9	23.7	4.4	-1.22	-69.5	-18.6	-11.8
	4	3	1.99	62.7	24.0	13.2	1.40	68.2	8.5	23.2
	5	3	1.38	65.8	27.9	6.3	-1..1	-69.0	-11.9	-19.1
	5	4	-0.61	-42.1	-17.2	-40.7	-2.41	-61.9	-12.7	-25.4
Management of post--harvest residues Zagospodarowanie resztek pożniwnych	SEM+	SEM-	0.34	22.2	54.7	23.0	0.17	-42.7	45.9	96.8
	EM-	SEM-	-0.68	-104.8	-10.7	15.5	-0.13	-114.7	-39.4	54.1
	EM+	SEM-	-0.58	-77.5	-11.6	-11.0	-0.19	-24.1	-59.7	-16.2
	EM-	SEM+	-1.02	-72.2	-27.4	-0.4	-0.30	-38.4	-41.8	-19.8
	EM+	SEM+	-0.92	-59.1	-25.4	-15.5	-0.36	16.1	-53.7	-62.4
	EM+	EM-	-0.10	38.1	-18.4	-119.7	0.06	266.4	-10.6	-155.8
Biostimulant Biosty-mulator	Asahi -	Asahi +	-0.34	14.4	-39.5	-74.9	-0.45	32.6	-53.7	-78.9

g.n.p.e. – l.z.k. – grain number per ear – liczba ziaren w kłosie
explanations under Table 2 – objaśnienia pod tabelą 2

CONCLUSIONS

1. Higher winter wheat yield in the 2nd than in the 1st year of the study resulted from very unfavorable weather conditions in winter 2011/2012 and a lower ear density, and not from a probably good tolerance of this plant towards being cultivated after itself.

2. The best tillage method for winter wheat yield in short-term monoculture was skimming with previous manure application and then conducting sow ploughing. Under unfavorable conditions for winter crop yields with a freezing snowless winter, good tillage methods were also double grubbing and direct sowing, leaving a large amount of post-harvest residues on the field surface.

3. Straw fertilization, especially with a simultaneous use of effective microorganisms turned out to be relevant under unfavorable habitat conditions. In the year with a beneficial course of weather, this treatment generally did not increase the grain yield.

4. Biostimulant Asahi SL caused increase in the quantity of yield components and grain yield of winter wheat, irrespective of the duration of monoculture or weather conditions over the years of research.

The study was carried out as part of our research project PB-7294/B/P01/2011/40.

REFERENCES

Abdollahi L., Schjønning P, Elmholt S., Munkholm L., 2014. The effects of organic matter application and intensive tillage and traffic on soil structure formation and stability. Soil Till. Res. 136, 28-37

Brennan J., Hackett R., McCabe T., Grant J., Fortune R., Forristal, P., 2014. The effect of tillage system and residue management on grain yield and nitrogen use efficiency in winter wheat in a cool Atlantic climate Europ. J. Agr. 54, 61-69

Giemza-Mikoda M., Wacławowicz R., Zimny L., Malak D., 2011. Wpływ zróżnicowanego nawożenia organicznego i wzrastających dawek azotu na wskaźniki struktury roli. Fragm. Agron. 28(3), 16-25.

Haliniarz M., Bujak K., Gawęda D., Kwiatkowski C., 2013a. Response of spring wheat to reduced tillage systems and to different levels of mineral fertilization. Acta Sci. Pol., Agricultura 12(3), 13-24, www.agricultura.acta.utp.edu.pl

Haliniarz M., Gawęda D., Bujak K., Frant M., Kwiatkowski C., 2013b. Yield of winter wheat depending on the tillage system and level of mineral fertilization. Acta Sci. Pol., Agricultura 12(4), 59-72, www.agricultura.acta.utp.edu.pl

Jaskulski D., Kotwica K., Jaskulska I., Piekarczyk M., Osiński G., Pochylski B., 2012. Elementy współczesnych systemów uprawy roli i roślin – skutki produkcyjne oraz środowiskowe. Fragm. Agron. 29(3), 61-70.

Kaczmarek Z., Wolna-Maruwka A., Jakubus M., 2008. Zmiany liczebności wybranych grup drobnoustrojów glebowych oraz aktywności enzymatycznej w glebie inokulowanej efektywnymi mikroorganizmami (EM). J. Res. Appl. Agrie. Eng. 53 (3), 122-127.

Kołodziejczyk M., Szmigiel A., Kulig B., 2012. Plonowanie pszenicy jarej w warunkach zróżnicowanego nawożenia azotem oraz stosowania mikrobiologicznych preparatów poprawiających właściwości gleby. Fragm. Agron. 29(1), 60-69.

Kotwica K, Jaskulska I., Jaskulski D., Gałęzewski L., Walczak D., 2011. Wpływ nawożenia azotem i użyźniania gleby na plonowanie pszenicy ozimej w zależności od przedplonu. Fragm. Agron. 28(3), 53-62.

Lenart S., Sławiński P., 2010. Wybrane właściwości gleby oraz występowanie dżdżownic w warunkach siewu bezpośredniego i płużnej uprawy roli. Fragm. Agron. 27(4), 86-93.
Lepiarczyk A., Stępnik K., Szylak A. 2007. Wpływ systemów uprawy roli na niektóre właściwości fizyczne gleby pod wybranymi roślinami. Fragm. Agron. 24(1), 157-163.
Małecka I., Blecharczyk A., Sawinska Z., Piechota T., Waniorek B., 2012. Plonowanie zbóż w zależności od sposobów uprawy roli. Fragm. Agron. 29(1), 114-123.
Martyniuk S., 2011. Skuteczne i nieskuteczne preparaty mikrobiologiczne stosowane w ochronie i uprawie roślin oraz rzetelne i nierzetelne metody ich oceny. Post. Mikrobiol. 50(4), 321-328.
Martyniuk S., Księżak J., 2011. Ocena pseudomikrobiologicznych preparatów stosowanych w uprawie roślin. Pol. J. Agron. 6, 27-33.
Matysiak K., Adamczewski K., Kaczmarek S., 2011. Wpływ biostymulatora Asahi SL na plonowanie i wybrane cechy ilościowe i jakościowe niektórych roślin rolniczych uprawianych w warunkach wielkopolski. Prog. Plant Prot./Post. Ochr. Roślin 51(4), 1849-1857.
Piskier T., 2006. Reakcja pszenicy jarej na stosowanie biostymulatorów i absorbentów glebowych. J. Res. Appl. Agric. Eng. 51(2), 136-138.
Rudnicki F., 2000. Wyznaczanie wpływu poszczególnych elementów plonowania na różnice plonów między obiektami doświadczalnymi. Fragm. Agron. 17(3), 53-65.
Stępień A, Adamiak E., 2009. Efektywne mikroorganizmy (EM-1) i ich wpływ na występowanie chorób zbóż. Prog. Plant Prot./Post. Ochr. Roślin 49(4), 2027-2030.
Swedrzyńska D., Małecka I., Blecharczyk A., Swedrzyński A., Starzyk J., 2013. Effects of various long-term tillage systems on some chemical and biological properties of soil. Pol. J. Envir. St. 22(6), 1835-1844.
Tian S., Wang Y., Li N., Nin T., Wang B., Zhao H., Li Z. 2013. Effects of different tillage and straw systems on soil water-stable aggregate distribution and stability in the North China Plain. Shengtai Xuebao/ Acta Ecol. Sinica 33(22), 7116-7124.
Topa D., Jitareanu G., Ailincai C., Lucian R., 2013. The effect of reduced tillage on soil physical properties and winter wheat yield response. J. Food, Agric. Envir. 11(3-4), 2174-2177.
Wesołowski M., Cierpiała R., 2011. Plonowanie pszenicy ozimej w zależności od sposobu wykonania uprawy przedsiewnej. Fragm. Agron. 28(2), 106-118.

WPŁYW SPOSOBU UPRAWY ROLI I ZAGOSPODAROWANIA RESZTEK POŻNIWNYCH ORAZ APLIKACJI BIOSTYMULATORA NA PLONOWANIE PSZENICY OZIMEJ W NARASTAJĄCEJ MONOKULTURZE

Streszczenie. Doświadczenie polowe nad agrotechniką pszenicy ozimej w krótkotrwałej monokulturze wykonano w latach 2011/2012 i 2012/2013 w Chełmcach (52°61’ N; 18°44’ E). Czynnikami doświadczenia były: A – sposób uprawy roli (warianty z uprawą pożniwną gruberem lub bez i stosowaniem obornika oraz orką siewną i razówką, a także siew bezpośredni), B – sposób zagospodarowania resztek pożniwnych (cztery warianty ze stosowaniem słomy i efektywnych mikroorganizmów lub bez), C – aplikacja biostymulatora Asahi SL (dwa poziomy). Celem badań było określenie wpływu tych czynników na elementy plonowania i plon ziarna pszenicy ozimej uprawianej w 2. i 3. roku monokultury. Najlepszym sposobem uprawy roli dla plonowania pszenicy ozimej, niezależnie od długości okresu monokultury oraz przebiegu warunków pogodowych w latach badań, było gruberowanie ścierniska poprzedzone stosowaniem obornika i wykonanie orki siewnej. W warunkach niesprzyjających plonowaniu roślin ozimych z mroźną, bezśnieżną zimą dobrymi sposobami uprawy roli było także dwukrotne gruberowanie oraz siew bezpośredni, pozostawiające dużą ilość resztek pożniwnych na powierzchni pola. Nawożenie słomą, zwłaszcza z jednoczesnym stosowaniem efektywnych mikroorganizmów, okazało się zasadne w niekorzystnych warunkach siedliskowych. W roku o korzystnym przebiegu pogody zabieg ten na ogół nie zwiększał plonu ziarna. Biostymulator Asahi SL spowodował wzrost wielkości elementów plonowania i plonu ziarna pszenicy ozimej niezależnie od długości okresu monokultury i warunków pogodowych w latach badań.

Słowa kluczowe: Asahi SL, efektywne mikroorganizmy, gruberowanie, obornik, orka, siew bezpośredni, słoma

Accepted for print – Zaakceptowano do druku: 15.09.2014

For citation – Do cytowania:

Kotwica K., Jaskulska I., Gałęzewski L., Jaskulski D., Lamparski R., 2014. The effect of tillage and management of post-harvest residues and biostymulant application on the yield of winter wheat in increasing monoculture. Acta Sci. Pol., Agricultura 13(4), 65-76.