

## **RESPONSE OF SPRING WHEAT TO REDUCED TILLAGE SYSTEMS AND TO DIFFERENT LEVELS OF MINERAL FERTILIZATION**

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**Abstract.** Cost reduction in plant production, as well as ecological aspects, force farmers to apply numerous modifications in tillage. Usually, they consist in shallowing ploughing and replacing it with cultivating measures not overturning the soil. The aim of the study was determination of the effect of conventional and reduced tillage systems as well as of two levels of mineral fertilization on the yield of spring wheat in the second cycle of crop rotation: potato – spring wheat – field pea (edible form) – winter wheat. The research was carried out in the years 2003-2006 on lessive soil formed from loess included in the good wheat complex. Autumn tillage under spring wheat, cultivar Helia, included the following cultivation measures: A – pre-winter ploughing (18-22 cm), B – cultivating (10-15 cm), C – heavy harrowing (8-10 cm). In spring, harrowing was conducted on all plots as well as cultivating, harrowing, seeding and harrowing. The second experimental factor was mineral fertilization on two levels: 117.3 kg NPK (50 kg N, 17.5 kg P, 49.8 kg K) and 175.9 kg NPK (75 kg N, 26.2 kg P, 74.7 kg K). The conducted research indicated that replacing pre-winter ploughing with cultivating (B) or heavy harrowing (C) resulted in a statistically insignificant yield decrease, by 4.3% and 7.1% respectively, as well as in a deterioration of its structural components. On lessive soil formed from loess, an increase in fertilization with nitrogen, potassium and phosphorus by 50% did not vary significantly the spring wheat yield or its components. Under conditions of a higher fertilization level, the yield increased by 4.1%. Spring wheat yield was significantly modified only by weather conditions in particular years of research. An increase in the yield and its structural components was indicated in the second cycle of crop rotation in all experiment variants, compared to the research from the years 1999-2002. Therefore, it may be concluded that reduced tillage, consisting in conducting shallow cultivating measures not overturning the soil, is well tolerated by spring wheat.

**Key words:** conservation tillage, fertilization requirements, productivity, spring wheat

## INTRODUCTION

Aiming at reducing production costs forces farmers to search for new cheaper tillage methods. Introducing the change, usually consists in shallowing ploughing or replacing it with shallow surface tillage. In some cases, mechanical tillage is completely omitted, and instead direct sowing is applied [Gawrońska-Kulesza 1997, Tebrügge and Düring 1999, Włodek *et al.* 1999, Ciesielska and Rzeźnicki 2007].

Results of previous research indicate that modifications in tillage in particular habitats change soil properties, affect weed infestation of the field, plant infestation with pathogens, yield components, and finally the quantity and quality of obtained yields [Lafond *et al.* 1992, Halvorson *et al.* 2001, Nowicki and Orzech 2002, Blecharczyk *et al.* 2007, Idkowiak and Kordas 2007, Weber 2009, Kraska 2010, Kraska and Mielniczuk 2012, Rymuza *et al.* 2012, Weber 2012].

The aim of the research was determination of the effect of two methods of reduced tillage and diversified mineral fertilization on the yield of spring wheat in the second cycle of crop rotation: potato – spring wheat – field pea – winter wheat.

## MATERIAL AND METHODS

Field experiments were carried out in the years 2003-2006 at the Experimental Field Station in Czesławice near Nałęczów (51°18' N; 22° 16' E). The four-year experiment included the second cycle of crop rotation.

Statistical field experiment was located on lessive soil formed from loess included in a good wheat complex. The soil in the plough layer was characterized by a slightly acidic reaction (pH in 1 M KCL 6.5-6.6), as well as by a high content of available potassium and magnesium.

The experiment was set up with a split-block design in four replications. In a four-year rotation, three tillage methods were compared and two levels of mineral fertilization under plants grown in a crop rotation: potato – spring wheat – field pea (edible form) – winter wheat. In the whole crop rotation on plot A (conventional) in total 7 ploughings were conducted per rotation, on plot B (reduced) – 3 ploughings per rotation, on plot C (reduced) – 1 ploughing per rotation. Ploughings were replaced mainly with cultivating and disking. In the case of spring wheat, autumn tillage on particular plots included the following cultivation measures: A – pre-winter ploughing (18-20 cm), B – cultivating (10-15 cm), C – heavy harrowing (8-10 cm). In spring, harrowing was carried out on all plots as well as cultivating (10-15 cm), harrowing, seeding and harrowing. The second experimental factor were two levels of mineral fertilization, being on average annually per rotation 127.4 kg NPK and 191.2 kg NPK, including the applied under spring wheat 117.3 kg NPK (50 kg N, 17.5 kg P, 49.8 kg K) and 175.9 kg NPK (75 kg N, 26.2 kg P, 74.7 kg K). All phosphorus and potassium fertilizers were applied 2-3 days before sowing. On plots with a basic dose of NPK, nitrogen was applied before sowing, while on plots with an increased dose of NPK, additionally at the stage of shooting, 25 kg N were applied.

Spring wheat, cultivar Helia, was sown in the first decade of April at a rate of 4.5 million grains per 1 ha. Before sowing, the seed was dressed with Funaben T 480 FS (thiuram + carbendazim) at a rate of 200 g per 100 kg of grain. In order to decrease the effect of any external factors, which might modify the effect of experimental factors on

plants in the growing season of spring wheat, full chemical protection against weeds, diseases, pests and cereal lodging was used on all plots. Protection program of a spring wheat canopy included: Aminopielik D 450 SL (2,4D + dicamba) –  $3.0 \text{ dm}^3 \cdot \text{ha}^{-1}$  (22-29 BBCH), Puma Uniwersal 069 EW (fenoxaprop-P-ethyl) –  $1.0 \text{ dm}^3 \cdot \text{ha}^{-1}$  (22-29 BBCH), Antywylegacz Płynny 675 SL (chlorocholine chloride) –  $1.5 \text{ dm}^3 \cdot \text{ha}^{-1}$  (31-32 BBCH), Tilt Plus 400 SC (propiconazole + fenpropidin) –  $1.0 \text{ dm}^3 \cdot \text{ha}^{-1}$  (30-37 BBCH), Decis 2.5 EC (deltamethrin) –  $0.25 \text{ dm}^3 \cdot \text{ha}^{-1}$  (32-59 BBCH).

Before harvest, the number of heads per  $1 \text{ m}^2$  was determined, as well as plant height, number and weight of grains per head, and 1000 grain weight. Grain yield from particular plots was calculated per  $\text{Mg} \cdot \text{ha}^{-1}$ . Obtained results were subjected to analysis of variance, while significance of differences was verified with Tukey's test with significance level of  $P = 0.05$ . Moreover, coefficients of variation (CV) were calculated for all analyzed traits.

Weather conditions in particular growing seasons (April-July) were rather diversified (Table 1). First three years of research may be considered as dry, rainfall in these years was lower than the mean from the long-term period. In 2006, rainfall slightly exceeded the mean from the years 1966-1995, as it was affected by a very intensive rainfall in August, being 202.5 mm. The mean air temperatures in particular years of research, except 2004, were higher than the means from the long-term period.

Table 1. Rainfall and air temperature from April to August compared to the means from the years 1966-1995, according to the Meteorological Station in Czesławice

Year	Month					Total
	April	May	June	July	August	
Rainfall, mm						
2003	16.0	66.3	36.7	109.7	23.9	252.6
2004	52.4	26.6	66.1	96.8	57.8	299.7
2005	21.2	146.9	48.0	55.8	46.2	318.1
2006	26.1	68.1	23.2	26.6	202.5	346.5
Mean from 1966-1995	44.5	59.5	80.2	79.4	68.6	332.2
Temperature, °C						
						Mean
2003	6.5	15.9	17.4	19.4	18.3	15.5
2004	7.7	11.6	15.5	17.8	18.4	14.2
2005	8.4	13.0	15.6	19.8	17.0	14.8
2006	8.5	13.3	16.9	21.1	17.4	15.4
Mean from 1966-1995	7.6	13.4	16.3	17.9	17.4	14.5

## RESULTS

Tests carried out in the second cycle of crop rotation: potato – spring wheat – field pea (edible form) – winter wheat, indicated that reduced tillage as well as diversified mineral fertilization had no significant effect on the yield of spring wheat. Differences in the grain yield in particular years of research were statistically proved (Table 2). The highest yields were obtained in 2004, while significantly lower ones in the first and last year of research. On average, in the four-year period, the highest grain yields were

obtained in case of conventional tillage (A), they amounted to  $5.18 \text{ Mg}\cdot\text{ha}^{-1}$ , lower by 4% from plots where pre-winter ploughing was replaced with cultivating, while the lowest ( $4.81 \text{ Mg}\cdot\text{ha}^{-1}$ ) in case of reducing autumn tillage to heavy harrowing (C). Higher level of mineral fertilization affected increase in the wheat yield on average by  $0.2 \text{ Mg}\cdot\text{ha}^{-1}$ . Significantly higher wheat yield under conditions of intensive fertilization in particular years of research was observed only in 2004. Coefficients of variation, being from  $\text{CV} = 19.2\%$  to  $\text{CV} = 22.3\%$ , testify to a low yield stability under conditions of diversified mineral fertilization and tillage systems.

Table 2. Grain yield of spring wheat,  $\text{Mg}\cdot\text{ha}^{-1}$

Year	Tillage system			Fertilization level		Mean
	A	B	C	a	b	
2003	4.72	4.81	4.60	4.62	4.80	4.71
2004	6.02	5.53	5.73	5.36	6.16	5.76
2005	6.01	5.85	5.20	5.68	5.68	5.68
2006	3.95	3.64	3.71	3.84	3.69	3.77
Mean	5.18	4.96	4.81	4.88	5.08	–
CV, %	21.7	20.0	20.7	19.2	22.3	–
LSD <sub>0.05</sub> for:						
years		0.461				
tillage system		ns				
fertilization level		ns				
interaction:						
year × fertilization level		0.773				

A – conventional tillage

B – reduced tillage – cultivating

C – reduced tillage – harrowing

a – basic fertilization

b – increased fertilization

ns – non-significant differences

Experimental factors had no significant effect on the number of heads before harvest, however, this trait was significantly diversified throughout the years of research (Table 3). The highest number of heads per  $1 \text{ m}^2$  was observed in 2005, in other years of research the wheat produced a significantly sparser canopy. Analyzing the effect of diversified tillage on the number of heads, their similar number was observed in tillage variants A and B, while a lower one on plot with heavy harrowing. Under conditions of reduced tillage, lower variation of this trait was indicated, compared to conventional tillage. Mineral fertilization did not vary the number of heads before harvesting the wheat, while in variant B a higher variation of this trait was indicated ( $\text{CV} = 13.8\%$ ). Similarly, no significant effect of experimental factors was proved on the height of spring wheat (Table 4). While comparing tillage systems, the tallest plants were observed under conditions of conventional tillage, in which the number of heads per  $\text{m}^2$  was the lowest, whereas the shortest plants where the lowest number of heads was noted. Also, higher head density occurring on plots with increased fertilization, positively affected the plant height.

Table 3. Head number before harvesting spring wheat as head·m<sup>-2</sup>

Year	Tillage system			Fertilization level		Mean
	A*	B	C	a	b	
2003	458.8	444.5	457.1	451.8	455.2	453.5
2004	457.0	470.5	434.5	451.7	456.3	454.0
2005	527.0	526.0	508.0	508.7	532.0	520.3
2006	432.0	438.0	416.0	433.3	424.0	428.7
Mean	468.7	469.8	453.9	461.4	466.9	–
CV, %	12.8	12.2	11.6	10.5	13.8	–
LSD <sub>0.05</sub> for:						
year		36.20				
tillage system		ns				
fertilization level		ns				

\* explanations under Table 2

Table 4. Plant height in spring wheat, cm

Year	Tillage system			Fertilization level		Mean
	A*	B	C	a	b	
2003	76.4	78.1	77.1	77.1	77.3	77.2
2004	92.5	88.6	90.8	89.9	91.4	90.6
2005	77.3	77.6	73.7	75.9	76.5	76.2
2006	73.5	72.7	73.8	73.1	73.5	73.3
Mean	79.9	79.2	78.8	79.0	79.7	–
CV, %	10.4	8.2	10.2	9.2	9.9	–
LSD <sub>0.05</sub> for:						
year		2.98				
tillage system		ns				
fertilization level		ns				

\* explanations under Table 2

Replacing ploughing with cultivating or harrowing, as well as a higher dose of mineral fertilizers did not cause any significant differences in the weight and number of grains per head (Tables 5, 6). It can be observed that application of reduced tillage resulted in a slight deterioration of elements of the head structure. In the analyzed experiment, the grain number per head was characterized by a higher stability (CV = 8.6-10.6%) than their weight (CV = 20.2-16.9%).

The weight of 1000 grains was significantly dependant on weather conditions (Table 7). The plumpest grain, 1000 grain weight = 46.7 g, was produced by wheat in 2004. In other years of research, 1000 grain weight in wheat was significantly lower. Irrespective of the years of research, the analyzed tillage systems, as well as levels of mineral fertilization, did not vary significantly 1000 grain weight. Calculated values of the coefficient of variation of this trait for the experimental factors confirm a high diversity in grain plumpness. Replacing plough with tools not overturning the soil (variant B and C), caused an increase in the stability of 1000 grain weight. In both variants of mineral fertilization, diversity in the obtained values of 1000 grain weight was very similar.

Table 5. Grain number per spring wheat head

Year	Tillage system			Fertilization level		Mean
	A*	B	C	a	b	
2003	31.3	32.7	30.7	30.7	32.3	31.5
2004	30.8	29.7	31.8	30.7	30.9	30.8
2005	33.1	32.6	31.6	32.9	31.9	32.4
2006	32.7	32.2	32.3	32.4	32.4	32.4
Mean	31.9	31.8	31.6	31.7	31.9	–
CV, %	10.4	9.9	8.9	8.6	10.6	
LSD <sub>0.05</sub> for:						
year			ns			
tillage system			ns			
fertilization level			ns			

\* explanations under Table 2

Table 6. Grain weight per spring wheat head, g

Year	Tillage system			Fertilization level		Mean
	A*	B	C	a	b	
2003	1.06	1.08	1.06	1.03	1.10	1.07
2004	1.47	1.38	1.46	1.43	1.44	1.44
2005	1.27	1.19	1.18	1.24	1.18	1.21
2006	0.99	0.90	1.06	1.00	0.96	0.98
Mean	1.20	1.14	1.12	1.18	1.17	–
CV, %	20.2	17.0	16.9	18.1	18.2	–
LSD <sub>0.05</sub> for:						
year			0.115			
tillage system			ns			
fertilization level			ns			

\* explanations under Table 2

Table 7. 1000 grain weight of spring wheat, g

Year	Tillage system			Fertilization level		Mean
	A*	B	C	a	b	
2003	33.8	38.9	35.7	34.2	35.4	34.8
2004	47.6	46.5	46.1	46.7	46.7	46.7
2005	38.4	36.6	37.5	37.8	37.2	37.5
2006	30.4	30.2	32.8	30.9	31.4	31.1
Mean	37.5	37.0	38.0	37.4	37.7	–
CV, %	18.3	17.5	14.8	16.9	16.8	–
LSD <sub>0.05</sub> for:						
year			1.94			
tillage system			ns			
fertilization level			ns			

\* explanations under Table 2

In the second cycle of crop rotation, on all experimental plots, a higher grain yield in spring wheat was observed, compared to the one obtained in the first cycle (Table 8). This increase was most visible on plots with heavy harrowing. In the years 2003-2006,

increase in the number of heads per area unit occurred only under conditions of reduced tillage C, as well as with a decreased fertilization level. On plots with a reduced tillage B, head density in the first and second cycle of crop rotation was similar, whereas a lower number of heads in the years 2003-2006 was observed under conditions of conventional tillage with an increased mineral fertilization. Long-term application of reduced tillage favorably affected plant height, 1000 grain weight, as well as the number and weight of grains per head of spring wheat. However, in case of 1000 grain weight, number and weight of grains per head, the highest increase in parameters, compared to the mean from the years 1999-2002, occurred on plots with heavy harrowing. In the evaluated fertilization levels, higher proportional variations in the elements of head structure, compared to the first cycle, were observed under conditions of basic mineral fertilization.

Table 8. Proportional variations in grain yield and in particular components of yield structure and spring wheat canopy obtained in the years 2003-2006, compared to the first cycle of crop rotation (1999-2002) – values obtained in the first rotation were taken as 100%

Specification	Tillage system			Fertilization level	
	A*	B	C	a	b
Grain yield	11.9%	16.7%	17.9%	15.1%	15.4%
Head number before harvest	-1.5%	0.4%	2.2%	3.2%	-2.3%
Plant height	12.7%	12.8%	12.4%	14.2%	11.3%
Grain number per head	16.0%	17.8%	19.7%	19.2%	16.9%
Grain weight per head	22.5%	20.0%	23.1%	25.5%	23.2%
1000 grain weight	4.2%	4.5%	8.9%	3.9%	7.7%

\* explanations under Table 2

## DISCUSSION

The research proved that the applied reduced tillage had no significant effect on the grain yield of spring wheat or on its components. In the second cycle of crop rotation, replacing pre-winter ploughing with cultivating (B) or heavy harrowing (C) resulted in a slight decrease in the yield, by 4.3% and 7.1%, respectively. In the first cycle of this crop rotation, Frant and Bujak [2007] indicated a significantly higher and statistically proved effect of tillage on the spring wheat yield. Reducing autumn cultivation treatments to cultivating and heavy harrowing decreased the yield by 8.2% and 11.9%, respectively, compared to the one obtained after conventional tillage. In the research of Kraska [2011], the yield of spring wheat grown on rendzina soil, in the conventional system was by 8.8-9.7% higher than on plots with conservation tillage. Other authors also indicate that reduced tillage, and especially the use of direct sowing, caused a decrease in the cereal grain yield [Dzienia *et al.* 1998, Blecharczyk *et al.* 1999, Diaz-Zorita 2000, Lal and Ahmadi 2000, López-Bellido *et al.* 2000, Orzech *et al.* 2002, Camara *et al.* 2003, Woźniak and Gontarz 2009].

Ciesielska and Rzeźnicki [2007] found the highest difference in the spring wheat yield between conventional tillage and direct sowing in the first year of using no-tillage system. In the following years of experiment, differences were significantly smaller. Similar tendencies to variations were observed in the conducted experiment. The greatest differences in the wheat yield obtained from plots with conventional tillage and

with reduced tillage were found in the first year of crop rotation cycle [Frant and Bujak 2007], while in the following years such great differences were not observed. Similar correlations were also proved by Vegeler *et al.* [2009].

According to Filipovic *et al.* [2006], winter wheat from among all cereals, best adapts to reduced tillage. While comparing conventional tillage and no-tillage, the authors obtained the highest yields of this species from plots with conservation tillage. Anken *et al.* [2004], also confirmed high tolerance of wheat to conservation tillage. After using reduced tillage, they obtained higher average yields than in the conventional tillage, while after direct sowing they usually observed decrease in the winter wheat yield. Increase in the yield of spring wheat under conservation tillage and direct sowing into stubble-field, compared to conventional tillage, was also obtained by Ciha [1982]. He proved that reduced tillage favorably affects grain plumpness, whereas the number of heads or the number of grains per head was not varied by tillage systems.

In the conducted experiment, decrease in the spring wheat yield in variants with reduced tillage occurred as a result of a lower number of heads per m<sup>2</sup>, and their lower productivity. Kraska [2011] and Weber [2012] proved that wheat yield was most strongly connected with the number of heads per area unit. This correlation is unfavorable from the point of view of applying reduced tillage. Many authors indicated that reduced tillage as well as zero-tillage to a great extent decreased the number of heads or plants per area unit [Blecharczyk *et al.* 1999, Lal and Ahmadi 2000, Malicki *et al.* 1998]. In the first cycle of the evaluated crop rotation, Frant and Bujak [2007] proved a significant effect of a tillage system on the number of heads per 1 m<sup>2</sup>, however in the following years of the conducted experiment, no such significant effect was found. Similar tendencies were proved by Ciesielska and Rzeźnicki [2007]. In the studies of these authors, only in the first year of applying reduced tillage, there was a significantly lower number of heads per area unit, compared to conventional tillage. In the first cycle of the experiment, a significant effect of reduced tillage on the structure of head was only visible in the weight of grains per head in variant C [Frant and Bujak 2007]. In the years 2003-2006, no significant differences between head components were observed. Replacing ploughs with other cultivation tools affected a slight decrease in the number and weight of grains per head, however it did not negatively affect plumpness of grains. The obtained results are partly confirmed in the research of Kraska [2011], who indicated that reduced tillage used under spring wheat only slightly modified elements of head structure.

In the conducted research, higher NPK fertilization influenced an increase in the yield of spring wheat. Similar correlations were also indicated by Kołodziejczyk *et al.* [2007], Stępień [2004], Borkowska *et al.* [2002], as well as Biskupski *et al.* [2006]. The studies of Kołodziejczyk *et al.* [2012] proved that increasing nitrogen fertilization does not result in a relatively high yield. The factor limiting effectiveness of fertilization doses is natural soil fertility. In Czesławice, on lessive soil formed from loess, increase in a nitrogen dose by 50% resulted in an increase in the yield of wheat grain only by 4.1%. A decreasing yield-producing effectiveness of increasing nitrogen doses in wheat cultivation was also indicated by López-Bellido *et al.* [1998], López-Bellido and López-Bellido [2001], Lloveras *et al.* [2001], Kołodziejczyk *et al.* [2007], and Camara *et al.* [2003].

Spring wheat is characterized by high oscillations in the yield in particular growing seasons. It is connected with a significant effect of weather conditions, especially of the rainfall on plant development in phenophases which significantly determine plant's



yield [Kołodziejczyk *et al.* 2007]. The research indicated a close correlation between the grain yield quantity and rainfall in May and June, as well as the rainfall total in the period from April to July [Jaskulski 1999]. In the conducted research, the lowest yield was obtained in the last year of experiments ( $3.77 \text{ Mg} \cdot \text{ha}^{-1}$ ), in which in April, June and July there was water deficiency, while in August, the rainfall exceeded the mean rainfall from the long-term period by 195%. Weather conditions also affect components of the yield structure. Weber and Hryńczuk [1999] proved that deficiency of water at the stage of full tillering as well as inflorescence in spring wheat significantly affects the productive tillering, head length, as well as a number and weight of grains per head. In 2006, which was unfavorable for wheat, rainfall deficiency negatively affected the head number per  $\text{m}^2$ , plant height of wheat, grain weight per head, as well as 1000 grain weight.

## CONCLUSIONS

1. Statistical analysis did not indicate any significant effect of the applied tillage systems on the yield quantity of spring wheat grain or its structural components. Only weather conditions in particular years of research had a significant effect on the yield of spring wheat.

2. On lessive soil formed from loess, increasing doses of NPK fertilizers by 50% did not significantly vary the spring wheat yield or its components. Under conditions of higher fertilization level, the yield increased by 4.1%, head density by 1.2%, grain number per head by 0.6%, while 1000 grain weight by 0.8%.

3. In the second cycle of crop rotation in all experimental variants, an increase in the yield and its structural components was observed, compared to the studies from the years 1999-2002. The highest increase in the grain yield was observed on plots with heavy harrowing (variant C).

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## REAKCJA PSZENICY JAREJ NA UPROSZCZENIA W UPRAWIE ROLI I ZRÓŻNICOWANY POZIOM NAWOŻENIA MINERALNEGO

**Streszczenie.** Ograniczenie kosztów produkcji roślinnej oraz względy ekologiczne zmuszają rolników do licznych modyfikacji w uprawie roli. Najczęściej polegają one na spłycaaniu orok oraz zastępowaniu ich uprawkami nieodwracającymi roli. Celem badań było określenie wpływu płuznego i bezorkowego systemu uprawy roli oraz dwóch poziomów nawożenia mineralnego na plonowanie pszenicy jarej w drugiej rotacji płodozmianu ziemniak – pszenica jara – groch siewny forma jadalna – pszenica ozima. Badania przeprowadzono w latach 2003-2006 na glebie płowej wytworzonej z lessu, zaliczanej do kompleksu przydatności rolniczej pszennej dobrej. Jesienna uprawa roli pod pszenicę jarą odmiany Helia obejmowała następujące zabiegi uprawowe: A – orka przedzimowa (18-22 cm), B – kultywatorowanie (10-15 cm), C – bronowanie broną ciężką (8-10 cm). Wiosną na wszystkich obiektach wykonywano bronowanie, kultywatorowanie, bronowanie, siew i bronowanie. Drugim czynnikiem badawczym było nawożenie mineralne, występujące na dwu poziomach: 117,3 kg NPK (50 kg N, 17,5 kg P, 49,8 kg K) i 175,9 kg NPK (75 kg N, 26,2 kg P, 74,7 kg K). Przeprowadzone badania wykazały, iż zastąpienie orki przedzimowej kultywatorowaniem (B) lub bronowaniem roli broną ciężką (C) skutkowało nieistotnym statystycznie obniżeniem plonu – odpowiednio o 4,3% i 7,1% – oraz pogorszeniem elementów jego struktury. Na glebie płowej wytworzonej z lessu zwiększenie nawożenia azotowego, potasowego i fosforowego o 50% nie różnicowało istotnie plonu pszenicy jarej oraz jego składowych. W warunkach wyższego poziomu nawożenia plon zwiększył się o 4,1%. Plonowanie pszenicy jarej istotnie modyfikowały tylko warunki pogodowe w poszczególnych latach badań. W drugiej rotacji płodozmianu we wszystkich wariantach doświadczenia wykazano wzrost plonu oraz elementów jego struktury w porównaniu z wynikami badań z lat 1999-2002. W związku z powyższym można wnioskować, iż pszenica jara dobrze toleruje uproszczenia w uprawie roli polegające na wykonaniu płytkich uprawek nieodwracających roli.

**Słowa kluczowe:** potrzeby nawozowe, produktywność, pszenica jara, uprawa konserwująca

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