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EFFECT OF HERBICIDES AND HERBICIDE COMBINATIONS AND OF THE METHOD OF NITROGEN APPLICATION ON WINTER WHEAT YIELDING AND YIELD STRUCTURE

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A b s t r a c t. The study was aimed at determining the effect of selected herbicides and their combinations as well as of nitrogen fertilization and foliar supplementation of winter wheat on yielding and yield structure. A field experiment with cultivation of winter wheat var. Elena was carried out in the years 2000-2003 at the University of Warmia and Mazury in Olsztyn Experimental Station in Tomaszkowo. Wheat was cultivated annually after winter wheat, on class IIIa and IIIb heavy and medium-heavy brown soil, ranked as a good wheat complex. The first experimental factor were various methods of chemical weed control. The second experimental factor were variants of nitrogen fertilization (soil applied and soil-foliar applied). Herbicides and herbicide mixtures exerted a significant effect on the yielding of winter wheat. The best yield-protective results were obtained by using 2 mixtures: Granstar 75 WG + Chwastox Extra 300 SL (6.45 t ha^{-1} on average) and Granstar 75 WG + Starane 250 EC (6.43 t ha^{-1}). In turn, the worst results were observed in the case of Chwastox Extra 300 SL herbicide (6.20 t ha^{-1} on average). Variants of nitrogen fertilization did not diversify grain yield. Of the two factors examined, only the method of chemical weed control was found to significantly diversify spike density and 1000 kernel mass. The yield of wheat was affected to the greatest extent by the number of spikes per area size, followed by 1000 kernel mass, and to the least extent – by the number of kernels in a spike.

K e y w o r d s: winter wheat, herbicides, nitrogen application method, yield, yield structure

INTRODUCTION

The productivity of winter wheat depends on the yield structure of a single plant and on the crop field architecture, and thus it is the resultant of the number of plants and spikes per unit of field area, number of kernels per spike, and weight of 1000 kernels (Bavec and Bavec 1995, Ewert and Honermeier 1999, Podolska *et al.* 2002).

The production potential of winter wheat, resulting from field structure, is very high. However, obtainment of plentiful yields is only possible when the plants have suitable soil and climatic conditions (Daniel *et al.* 1998, Domitruk *et al.* 2001, Gooding and Smith 1998). The existing complex of habitat and cultivation conditions affects the features of winter wheat yield structure – number of spikes per field area unit, number of kernels per one spike, and weight of one thousand kernels (Kozłowska-Ptaszyńska 1997, Mazurek 1999). Improperly performed cultivation measures may cause deterioration in the biometric features and in the structure of yield, which in turn may reduce the quality and quantity of crop yield obtained. Therefore, it appears to be worthwhile to investigate the effect of selected herbicides, their compositions, and nitrogen fertilisation method on the level and structure of winter wheat yield.

MATERIAL AND METHODS

A field experiment with cultivation of winter wheat var. Elena was carried out in the years 2000-2003 at the University of Warmia and Mazury in Olsztyn Experimental Station in Tomaszkowo. Wheat was cultivated annually after winter wheat, on class IIIa and IIIb heavy and medium-heavy brown soil, ranked as a good wheat complex. The 2-factor field experiment was set up in the randomised block design with 4 replications. The first experimental factor were various methods of chemical weed control: 1. control treatment (no herbicides), 2. Granstar 75 WG (methyl tribenurone), 3. Granstar 75 WG + Starane 250 EC (fluoroxypyr), 4. Granstar 75 WG + Chwastox Extra 300 SL (MCPA), 5. Chwastox Extra 300 SL, 6. Chwastox Extra 300 SL + Starane 250 EC, 7. Aminopielik D 450 SL (2,4-D + dikamba), 8. Mustang 306 SE (florasulam+2,4-D). The herbicides and their combinations were applied at doses recommended by the Poznań Institute of Plant Protection (IOR). The second experimental factor was the method of nitrogen fertilisation application (total of 120 kg N ha^{-1}): 1) to the soil; urea was applied only in the form of granulate, at three times: 40.0 kg N ha^{-1} after restart of vegetation, 27.6 kg N ha^{-1} at the end of tillering, and 52.4 kg N ha^{-1} at the end of shooting phase, 2) to the soil and as foliar application; urea was applied two to the soil (40.0 kg N ha^{-1} after restart of vegetation and 35.8 kg N ha^{-1}at the end of shooting phase) and twice as foliar application: 27.6 kg N ha^{-1} at the end of tillering phase (20% solution of urea) and 16.6 kg N ha^{-1} at the end of shooting phase (12% solution of urea). In the objects with foliar application, in the first treatment herbicides were applied together with urea in a solution.

The area of a single experimental plot was 20 m^2 (2x10 m). The treatments of spraying with herbicides and with the herbicide-urea solution were performed with a knapsack sprayer, applying a 300 dm^3 ha^{-1} dose of the liquid.

The scope of the study comprised estimation of yielding and of elements of yield structure of winter wheat and of the strength of their relation with crop yielding under conditions of application of various herbicides and methods of nitrogen fertilisation.

RESULTS AND DISCUSSION

Winter wheat yielding. The three-year period of the study (2000-2003) was characterised by considerable differentiation of weather conditions (Tab. 1), which affected the level of yields obtained.

Table 1. Air temperatures and rainfall in the vegetation period of winter wheat in the years 2001-2003 according to Meteorological Station in Tomaszkowo

Month	Air temperature (^oC)				Rainfall (mm)			
	Multi-year average	Mean of month			Multi-year average sum	Sum in months		
	1961-2000	2001	2002	2003	1961-2000	2001	2002	2003
IV	6.9	7.2	4.0	6.0	36.1	54.9	14.2	35.5
V	12.7	12.8	8.1	14.0	51.9	33.2	26.9	30.2
VI	15.9	13.9	16.5	16.6	79.3	77.9	48.6	72.0
VII	17.7	20.0	20.2	19.1	73.8	148.6	27.5	79.2
VIII	17.2	18.1	19.8	17.4	67.1	53	61.0	56.5
Mean		13.5	12.2	13.9	Sum	367.6	178.2	273.4

The highest yield was obtained in 2002 (average of 7.38 t ha^{-1}), slightly lower in 2003 (7.27 t ha^{-1}), and definitely the lowest in 2001 – 4.03 t per ha (Tab. 2). The cause of the low crop yield in 2001 was unfavourable weather conditions during the period of emergence and initial growth of wheat (rainfall deficit) and during the spring-summer vegetation season. Lowered temperature and rainfall deficit in the 1st decade of May limited tillering of the plants and the effectiveness of the herbicides applied. In the second and third seasons of the study the weather conditions were more favourable for wheat growth, and the herbicides were more effective in eliminating weed infestation. Rainfall deficits occurring in the second year of the study, in the spring-summer vegetation season (April-July), did not have too negative an effect on the growth of inter wheat as they were relatively uniformly spread in time and, moreover, the preceding winter season was characterized by plentiful precipitations.

In all the years of the study and for the average results for three years the application of the herbicides and their combinations caused a significant increase in winter wheat yielding. The highest increase was observed after the application of 2 herbicide combinations: Granstar 75 WG + Starane 250 EC (9.7%) and Granstar 75 WG + Chwastox Extra 300 SL (9.3%). Among the herbicides that were applied individually, the highest crop yield was obtained after the application of the Mustang 306 SE herbicide (increase by 7.1% with relation to the wheat with no weed control).

Nevertheless, in the conditions of rainfall deficit in the second year of the study, the yielding of wheat after the application of that herbicide was similar to that obtained on the control object (7.12 $t \cdot ha^{-1}$ compared to 7.10 $t \cdot ha^{-1}$). It should be pointed out that none of the herbicides, applied individually as well as in combinations, caused a reduction in grain yield. The lowest increase in yield in all the years was recorded in the case of the Chwastox Extra 300 SL herbicide (average for 3 years 3.2%). The differences observed in crop yield after the application of seven combinations of chemical weed control in winter wheat could have been due to varied effectiveness in weed elimination (Tab. 3).

Table 2. Yields of winter wheat grain depending on the herbicides applied and nitrogen application method ($t\ ha^{-1}$)

Specification	Year of research			Mean
	2001	2002	2003	
Herbicides				
Without herbicides (Control object)	3.76	7.10	6.80	5.89
Granstar 75 WG	4.03	7.41	7.25	6.23
Granstar 75 WG + Starane 250 EC	4.33	7.52	7.42	6.42
Granstar 75 WG + Chwastox Extra 300 SL	4.35	7.63	7.35	6.44
Chwastox Extra 300 SL	3.61	7.35	7.24	6.07
Chwastox Extra 300 SL + Starane 250 EC	3.75	7.51	7.33	6.20
Aminopielik D 450 SL	4.05	7.39	7.28	6.24
Mustang 306 SE	4.38	7.12	7.42	6.31
Mean	4.03	7.38	7.26	6.23
$LSD_{(0.05)}$	0.48	0.22	0.20	0.18
Nitrogen application method				
applied to the soil	3.97	7.33	7.22	6.17
to the soil + foliar	4.09	7.42	7.31	6.27
Mean	4.03	7.38	7.27	6.22
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	n.s.

$LSD_{(0.05)}$ for years – 1.1, $LSD_{(0.05)}$ years x herbicides – 3.2, Other interactions – n.s.

Klimont and Osińska (2004) demonstrated that Granstar 75 DF and Aminopielik D, applied in winter wheat protection against weed infestation, were significantly conducive to increased yielding, while Chwastox D caused only a tendency for crop yield to increase.

In the present experiment, the method of urea application (to the soil and to the soil + foliar application) did not have any significant effect on crop yielding. However, in all the years of the study a favourable tendency was observed, of increased yield of wheat for which nitrogen fertilisation was applied to the soil and supplemented with foliar application (6.27 t, compared to fertilisation application only to the soil – 6.17, average for 3 years).

Table 3. Effectiveness of herbicides and herbicide-urea mixtures in the cultivation of winter wheat, 8 weeks after treatment application (%)

Specification	Year of research			Mean
	2001	2002	2003	
Herbicides				
Granstar 75 WG	75.2	78.1	76.1	76.5
Granstar 75 WG + Starane 250 EC	80.5	92.1	83.9	85.5
Granstar 75 WG + Chwastox Extra 300 SL	78.7	76.5	77.2	77.5
Chwastox Extra 300 SL	61.4	52.6	72.1	62.0
Chwastox Extra 300 SL + Starane 250 EC	76.7	72.5	80.6	76.6
Aminopielik D 450 SL	83.4	94.1	89.4	89.0
Mustang 306 SE	69.8	83.2	83.8	78.9
Mean	75.1	78.4	80.5	78.0
$LSD_{(0.05)}$	10.1	14.0	5.4	6.2
Nitrogen application method				
applied to the soil	72.2	82.5	79.6	78.1
to the soil + foliar	77.9	74.3	81.3	77.8
Mean	75.1	78.4	80.5	78.0
$LSD_{(0.05)}$	5.4	7.5	n.s.	n.s.

Explanations as in Table 1, $LSD_{(0.05)}$ for years – 2.7, $LSD_{(0.05)}$ years x herbicides – 8.9, $LSD_{(0.05)}$ years x urea application method – 4.8.

On average for the 3 years of the study, the method of nitrogen application, as in the one-year experiments, did not have any significant effect on the yielding of wheat. Nevertheless, in all the years of the study a favourable tendency was observed, for the yield of wheat fertilised with nitrogen to the soil and supplemented with foliar application to increase as compared to that fertilised only to the soil (average for the 3 years by 0.1 t per ha). In studies by Sobiech et al. (1993) and by Kuś and Jończyk (1997), the method of nitrogen application (to the soil or foliar) did not differentiate the yielding of winter wheat. Other studies demonstrated that foliar feeding with a water solution of urea usually caused a smaller or greater increase in grain crop, depending on a variety of factors and on the conditions of application (Brzozowska 2003, Brzozowski et al. 2001, Czuba 1993, Rogalski 1993). The grain yield of cereals is determined by the values of the elements of its structure. The primary determinant is the habitat conditions and human influence through tillage techniques (Mazurek 1999, Podolska *et al*. 2002, Sobiech *et al*. 1993, Weber and Zalewski 2004).

Number of spikes. Analysing the three-year period of the study notable variation was observed in the numbers of spikes between the years of the experiments (Tab. 4).

Table 4. Number of winter wheat spikes per $1m^2$

Specification	Year of research			Mean
	2001	2002	2003	
Herbicides				
Without herbicides (Control object)	449	578	551	526.0
Granstar 75 WG	458	567	576	533.7
Granstar 75 WG + Starane 250 EC	477	597	613	562.3
Granstar 75 WG + Chwastox Extra 300 SL	482	591	606	559.7
Chwastox Extra 300 SL	470	597	576	547.7
Chwastox Extra 300 SL + Starane 250 EC	475	586	587	549.3
Aminopielik D 450 SL	491	593	596	560.0
Mustang 306 SE	488	585	623	565.3
Mean	473.8	586.8	591.0	550.5
$LSD_{(0.05)}$	n.s.	n.s.	31.0	19.0
Nitrogen application method				
applied to the soil	470	587	590	549.0
to the soil + foliar	477	586	592	551.7
Mean	473.5	586.5	591.0	550.4
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	n.s.

Other interactions – n.s. (not significant).

The greatest number of spikes per square meter was recorded in 2003 (average of 591 per 1 m^2), slightly lower in 2002 (average of 587), and the lowest in the season characterized by unfavourable weather conditions – 2000/2001 (average of 474).

On average for the results of the three years of the study, the applied preparations – with the exception of the Granstar 75 WG herbicide (534 pcs. m^{-2}) – caused a significant increase in the density of wheat stems with spikes, as was the case with the third year of the study. Among the 7 experimental objects with herbicide protection, the highest number of spikes per square meter was observed in the case of wheat protected with the Mustang 306 SE herbicide – average of 565 pcs. m^{-2}, but the difference was significant only in comparison to the Granstar 75 WG herbicide (534 pcs. m^{-2}), with no significant differentiation with relation to the other herbicide variants (548-560 pcs. m^{-2}). The method of nitrogen application, as in the case of individual years of the study also for data averaged for the 3 years did not have any significant effect on the crop yield structure under analysis. No interaction of the experimental factors was found in differentiation of the number of spikes per square meter.

Table 5. Number of kernels per 1 spike of winter wheat

Specification	Year of research			Mean
	2001	2002	2003	
Herbicides				
Without herbicides (Control object)	29.5	33.8	29.7	31.0
Granstar 75 WG	30.4	34.0	30.0	31.5
Granstar 75 WG + Starane 250 EC	29.0	33.4	32.2	31.5
Granstar 75 WG + Chwastox Extra 300 SL	31.0	34.8	31.2	32.3
Chwastox Extra 300 SL	30.6	34.2	30.4	31.7
Chwastox Extra 300 SL + Starane 250 EC	30.5	34.4	30.4	31.8
Aminopielik D 450 SL	30.3	33.9	31.1	31.8
Mustang 306 SE	31.8	33.5	30.1	31.8
Mean	30.4	34.0	30.6	31.7
$LSD_{(0.05)}$	n.s.	1.1	n.s.	n.s.
Nitrogen application method				
applied to the soil	30.0	34.0	30.5	31.5
to the soil + foliar	30.7	34.0	30.7	31.8
Mean	30.4	34.0	30.6	31.7
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	n.s.

$NIR_{(0,05)}$ for years – 0,6 – $LSD_{(0.05)}$ for years – 0,6 , Other interactions – n.s. (not significant).

Number of kernels in a spike. In 2002 the wheat produced significantly more kernels per spike (average of 34.0 pcs.) compared to the two remaining years of the study, i.e. 2001 and 2003 (average of 30.4 and 30.6) – Tab. 5. Analysis of mean data for the three-year period shows that the herbicides and the method of nitrogen application did not differentiate the number of kernels per spike. Only in the second year of the study the number of kernels per spike of wheat protected with the herbicide combination of Granstar 75 WG + Chwastox Extra 300 SL was significantly higher compared to the combination of Granstar 75 WG + Starane 250 EC and the preparation Mustang 306 SE. Also, a slight tendency was noted for increase in the numbers of kernels per spike in objects with dual-method nitrogen application (to the soil and foliar), as was the case in the first and third year of the study.

Weight of 1000 kernels. In the experiment under analysis, the weight of 1000 kernels of winter wheat was significantly varied between the particular years of the study. The best-quality grain was obtained in 2002 (mean *TKW* of 47.9 g), and the smallest in 2001(mean *TKW* of 38.9 g) – Table 6.

Table 6. Weight of 1000 kernels of winter wheat (g)

Specification	Year of research			Mean
	2001	2002	2003	
Herbicides				
Without herbicides (Control object)	39.9	46.8	44.0	43.6
Granstar 75 WG	39.1	46.9	43.9	43.3
Granstar 75 WG + Starane 250 EC	40.7	47.4	43.9	44.0
Granstar 75 WG + Chwastox Extra 300 SL	38.8	48.2	43.0	43.3
Chwastox Extra 300 SL	35.6	48.1	43.8	42.5
Chwastox Extra 300 SL + Starane 250 EC	39.0	49.1	43.9	44.0
Aminopielik D 450 SL	38.8	48.5	44.2	43.8
Mustang 306 SE	39.6	48.1	44.2	44.0
Mean	38.9	47.9	43.9	43.6
$LSD_{(0.05)}$	2.3	1.6	n.s.	0.9
Nitrogen application method				
applied to the soil	39.4	47.7	43.5	43.5
to the soil + foliar	38.4	48.0	44.2	43.5
Mean	38.9	47.9	43.9	43.5
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	n.s.

$LSD_{(0.05)}$ for years – 0.6, $LSD_{(0.05)}$ years x nitrogen application method – 0.8, Other interactions – n.s. (not significant).

On average for the three year of the study, the highest *TKW* values were obtained for grain of wheat protected with herbicide combinations of Granstar 75 WG + Starane 250 EC (44.0 g) and Chwastox Extra 300 SL + Starane 250 EC (44.0 g), and with individual herbicides: Mustang 306 SE (44.0 g) and Aminopielik D 450 SL (43.8 g), but the values were significantly higher only in relation to the Chwastox Extra 300 SL herbicide (42.5 g). Variation of the weight of 1000 kernels with relation to the herbicides applied was not explicit in the successive years. Nevertheless, in two years the best-quality grain was obtained for wheat protected with the Aminopielik D 450 SL herbicide. The method of nitrogen application did not have any significant effect on the size of kernels. In 2002 and 2003 there only appeared a tendency for the weight of 1000 kernels to increase in objects with the soil-and-foliar nitrogen application. Moreover, significance was noted for the interaction between years and herbicides, and also between the method of nitrogen application and the value of *TKW*.

Yielding and yield structure. Analysis of linear correlation coefficients between winter wheat grain yield and the elements of its structure (x_1, x_2, x_3) showed that the strongest effect on the wheat grain yields was that of the number of spikes per square meter (r = 0.861**), followed by that of the weight of 1000 kernels (r = 0.838**), and the least – that of the number of kernels per spike (r = 0.419**) – Table 7.

Table 7. Coefficients of linear correlation between yield structure elements (x_1,x_2,x_3) and grain yield of winter wheat (y), mean for the years 2001-2003

Specification[x]		Yield of grain (t per ha)	Number of spikes per 1 m^2	Number of kernels in spike (number)	1000 kernels weight (g)
		y	x_1	x_2	x_3
Herbicides	1	5.89	0.879**	0.557**	0,530**
	2	6.23	0.868**	0.336	0,870**
	3	6.42	0.919**	0.778**	0,818**
	4	6.44	0.873**	0.450*	0,823**
	5	6.07	0.871**	0.310	0,908**
	6	6.20	0.827**	0.413*	0,863**
	7	6.24	0.911**	0.488**	0,864**
	8	6.31	0.849**	-0.108	0,793
Nitrogen application method	A	6.17	0.859**	0.456**	0,817**
	B	6.27	0.865**	0.377	0,861**
In general		6,22	0.861**	0.419**	0.838**

[x]/explanations as in Methods, Significance of correlation coefficient r: * – p = 0.05; ** – p = 0.01.

The dependence of the level of grain yield on the elements of its structure finds confirmation in the results of multi-variable relation analysis. The calculated equations of multiple regression, averaged for the years 2000-2003, indicate a significant effect of the number of spikes per 1 m^2 and of the weight of 1000 grains on the yield, and a low effect of the number of kernels per spike (Tab. 8).

The normalized coefficient of regression (b) for the analysed elements of yield structure was 0.520, 0.437 and 0.023, respectively, and the dependence of wheat grain yield on the elements of the yield structure (considered jointly), under the conditions of application of different herbicide variants, was highly significant ($R^2 \cdot 100\%$ within the range from 85.1** to 90.2**). The lowest of the relationships was found for the control object – without herbicides ($R^2 \cdot 100\%$ = 81.7**). Coefficients of correlation between the yield and the elements of winter wheat yield structure, calculated for the particular experimental factors, indicate low differentiation and generally support the relations for the whole crop yield. Under the conditions of nitrogen fertilisation applied to soil and supplemented with foliar feeding, compared to application to the soil alone, the weight of 1000 kernels gained greater importance for the level of yielding. The normalized coefficient of regression for those features was 0.505 and 0.381, respectively (Tab. 8). Foliar feeding, especially under conditions of rainfall deficit, causes that plants utilise nitrogen more effectively than from granulated urea, which helps maintain the physiological activity of the assimilative surfaces of plants (Brzozowska 2003).

Table 8. Effect of yield structure elements (x_1,x_2,x_3) on grain yield of winter wheat (y), mean for the years 2001-2003

Specification [x]		Regression equation $y= b_0+b_1x_1+b_2x_2+b_3x_3$	Normalized coefficient of multiple regression (b)	Coefficient of determination $R^2\cdot100$ %
Herbicides	1	$y = -8.993+0.156x_1+0.069x_2 + 0.104x_3$	$b_1 = 0.638$ $b_2 = 0.121$ $b_3 = 0.231$	81.7**
	2	$y = -914+ 0.012x_1+ 0.010x_2 + 0.227x_3$	$b_1 = 0.460$ $b_2 = 0.015$ $b_3 = 0.508$	85.1**
	3	$y = -10.049 + 0.015_1+ 0.045x_2 + 0.149x_3$	$b_1 = 0.643$ $b_2 = 0.070$ $b_3 = 0.305$	90.2**
	4	$y = -9.362+0.015x_1 + 0.016x_2 + 0.162x_3$	$b_1 = 0.600$ $b_2 = 0.025$ $b_3 = 0.438$	88.8**
	5	$y = -5.953+0.008x_1+ 0.072x_2 + 0.229x_3$	$b_1 = 0.286$ $b_2 = 0.116$ $b_1 = 0.708$	86.7**
	6	$y = -10.584+0.012x_1+ 0.011x_2 + 0.219x_3$	$b_1 = 0.434$ $b_2 = 0.015$ $b_3 = 0.546$	84.8**
	7	$y = -12.223+0.021x_1+ 0.124x_2 + 0.065x_3$	$b_1 = 0.714$ $b_2 = 0.171$ $b_3 = 0.173$	87.9**
	8	$y = -2.599+0.009x_1+ 0.182x_2 + 0.215x_3$	$b_1 = 0.441$ $b_2 = 0.241$ $b_3 = 0.571$	86.3**
Nitrogen application method	A	$y = -9.736+0.014x_1+0.041x_2+0.162x_3$	$b_1 = 0.581$ $b_2 = 0.065$ $b_3 = 0.381$	83.3**
	B	$y = -8.165+0.013\ x_1+0.020x_2+0.184x_3$	$b_1 = 0.501$ $b_2 = 0.029$ $b_3 = 0.505$	85.1**
In general		$y = -9{,}117+0{,}013x_1 + 0{,}015_2 + 0{,}171x_3$	$b_1 = 0.520$ $b_2 = 0.023$ $b_3 = 0.437$	84.0**

[x]/ explanations as in Methods,
Significance of the multiple regression: * – p = 0.05; ** – p = 0.01; x_1 – number of spikes per 1 m^2; x_2 – number of grains in spike (number); x_3 – 1000 grains weight (g); y – yield of grain (t per ha).

CONCLUSIONS

1. The herbicides and herbicide combinations had a significant effect on the level of winter wheat yielding. The best results were obtained with the application of two combinations: Granstar 75 WG + Chwastox Extra 300 SL (average of 6.45 t ha^{-1}) and Granstar 75 WG + Starane 250 EC (6.43 t ha^{-1}), and the poorest with the Chwastox Extra 300 SL herbicide (6.20 t ha^{-1}) that was characterised by low effectiveness. The method of nitrogen application did not differentiate the levels of grain yield.

2. Among the yield structure elements, the strongest effect on the level of grain yield was that of the number of spikes per area unit, followed by the weight of 1000 kernels, and the least – of the number of kernels per spike.

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WPŁYW HERBICYDÓW I MIESZANIN HERBICYDOWYCH ORAZ SPOSOBU STOSOWANIA AZOTU NA PLONOWANIE I STRUKTURĘ PLONU PSZENICY OZIMEJ

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S t r e s z c z e n i e. Celem pracy była ocena wpływu wybranych herbicydów, ich mieszanin oraz nawożenia i dokarmiania dolistnego pszenicy ozimej azotem na wielkość plonu i jego strukturę. Eksperyment polowy z uprawą pszenicy ozimej odmiany Elena przeprowadzono w latach 2000-2003 w Zakładzie Dydaktyczno-Doświadczalnym w Tomaszkowie, należącym do Uniwersytetu Warmińsko-Mazurskiego w Olsztynie. Pszenicę corocznie uprawiano po pszenicy ozimej, na glebie brunatnej właściwej średniej i ciężkiej, klasy IIIa i IIIb, zaliczonej do kompleksu pszennego dobrego. Czynnikiem pierwszego rzędu były różne sposoby odchwaszczania chemicznego. Drugim czynnikiem był sposób nawożenia azotem (doglebowy i doglebowo-dolistny).

Herbicydy i mieszaniny herbicydowe wywierały istotny wpływ na plonowanie pszenicy ozimej. Najlepsze rezultaty plonochronne zapewniały 2 mieszaniny: Granstar 75 WG + Chwastox Extra 300 SL (średnio 6,45 $t \cdot ha^{-1}$) oraz Granstar 75 WG + Starane 250 EC (6,43 $t \cdot ha^{-1}$), a najgorsze herbicyd Chwastox Extra 300 SL (średnio 6,20 $t \cdot ha^{-1}$). Sposób nawożenia azotem nie różnicował plonów ziarna. Z dwóch badanych czynników, jedynie sposób odchwaszczania chemicznego zmieniał istotnie obsadę kłosów oraz masę 1000 ziaren. Największy wpływ na kształtowanie się wielkości plonów ziarna miały: liczba kłosów na jednostce powierzchni, następnie masa 1000 ziaren, a najmniejszy liczba ziaren w kłosie.

S ł o w a k l u c z o w e: pszenica ozima, herbicydy, sposób nawożenia azotem, plon, struktura plonu