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YIELD AND CHEMICAL COMPOSITION OF THE GRAIN OF NEW DWARF BREEDING LINES OF OAT (*Avena sativa* L.)

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Abstract. The work presents the results of a field experiment which was carried out in years 2007-2009 at the Didactic-Experimental Station of the University of Rzeszów in Krasne near Rzeszów. Economic value of six cultivated dwarf oat lines was assessed in comparison with the standard cultivar Krezus. It was shown that, among the studied oat forms, cultivar Krezus was characterized by the best usefulness for growth in the Subcarpathian region. It gave the highest grain yield and formed the greatest number of panicles per 1 m^2 before harvest and of spikelets and panicle grain mass. The studied dwarf lines gave on average one tone less yield per hectare than cultivar Krezus. The most raw fat was found in the grain of line STH 75, and total protein in the grain of line STH 5417.

Key words: *Avena sativa*, chemical composition of grain, dwarf lines, yield components

INTRODUCTION

Introduction of dwarf oat cultivars (*Avena sativa* L.) into growth makes it possible to obtain higher yields of this species. Cereal of this sort does not lodge, and therefore it is possible to apply intensive agrotechnics, including high nitrogen fertilization as a factor that maximalizes grain yield. Shoot shortening also causes physiological and morphological changes in plants. Some of the most important changes are increased tillering, greater number of formed and better filled grains per area unit, and growth period shortening [Nita *et al.* 1996, Nita 1999, Maciorowski *et al.* 2006]. Due to the utility features of the dwarf forms, research has been carried out on the possibility of introducing them into growth in different regions of Poland. Adding a new, original oat cultivar to the registry is being preceded by many-sided assessment of the agricultural value of the lines, carried out in diverse weather, soil, and agrotechnical conditions. Therefore, studies have been taken up on new dwarf oat lines, which compare them in regard to the yield and chemical composition of the grain with cultivar Krezus of medium height. Referring to breeding progress, the following scientific hypothesis was

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assumed: grain yield, components of yield structure, and the chemical composition of dwarf oat lines are at least similar or more favourable than the registered in 2005 cultivar Krezus. The studies were carried out in the Subcarpathian region, where the economic significance of oat is greater than in other regions of the country.

The aim of the study was the assessment of economic value of dwarf cultivated oat lines grown in the conditions of the Subcarpathian region.

MATERIAL AND METHODS

Field experiment was carried out in years 2007-2009 at the Didactic-Experimental Station in Krasne near Rzeszów (50^{o}03' N; 22^{o}06' E). The subject of the study was six dwarf oat lines (STH 71, STH 6106, STH 6108, STH 75, STH 5417, and STH 7105), which were compared with cultivar Krezus of average height. This cultivar is one that gives some of the highest yields in that region of Poland [Kozioł 2007]. Sowing material originated from the Plant Breeding Station Strzelce Ltd. Plant Breeding and Acclimatization Institute Group.

One-factor experiment was set up as a random block design in three repetitions on brown soil, with the mechanical composition of sandy silt and pH = 5.3. Soil was characterized by low magnesium content (3.8 mg per 100 g of soil) and average phosphorus (4.996 mg P per 100 g of soil) and potassium (14.53 mg K per 100 g of soil) content. Plot area for harvest was equal to 10 m^2, and planned plant density was 550 plants·m^{-2}. Forecrop in years 2007 and 2008 was triticale, and in 2009 winter rapeseed. Oat in the subsequent research years was sown on the following dates: April 2nd, 2007, April 10th, 2008 and April 4th, 2009. Nitrogen fertilization was applied in two doses of 40 kg·ha^{-1} pre-sowing and top-dressing at the stage of full tillering. Phosphorus and potassium fertilization in the amount of 35 kg·ha^{-1} P and 85 kg·ha^{-1} K in the form of 46% granulate superphosphate and 60% potassium salt was applied pre-sowing. Oat tending consisted of the application of spray Chwastox Turbo in the amount of 2 dm^3·ha^{-1} at the tillering stage. During growth, observations of the developmental stages of the plants were also carried out. Before harvest, 10 plants from every plot were collected in order to carry out morphological measurements and measure the composition elements of the yield, morphological and composition yield elements. The following traits were analyzed: blade height, panicle length, number and mass of panicle grain, mass of 1000 grains, and grain yield. Also panicle density per 1 m^2 was calculated before harvest. Grain harvest was conducted with the use of plot combine Seedmaster Universal on the following dates: August 7th, 2007, August 10th, 2008, and August 12th, 2009. Grain yield and mass of 1000 grains were presented in calculation per 15% humidity.

Chemical composition of grain was established with near infrared reflection spectroscopy using a device made by Bruker. Soil analysis was carried out at the Regional Chemical-Agricultural Station in Rzeszów according to the current methods. Meteorological data was processed on the basis of the records by the Meteorological Station in Jasionka.

Results of the experiment were statistically evaluated with the use of the following methods:

1) analysis of variance test or the Kruskal-Wallis test as its non-parametric equivalent in order to compare the mean values that relate to yield elements and

traits that determine oat grain quality [Jankowska and Majka 2009]; for the comparison of the mean values calculated for the analyzed lines and the oat cultivar, the Tukey's test was applied, whereas for the comparison of the mean values calculated for the particular lines with the mean for cultivar Krezus, the Dunnett's test was applied,
2) Pearson's linear correlation coefficients – assessment of the statistical significance of the determined correlation factors was carried out with the use of the t-Student significance test [Jóźwiak and Podgórski 2006],
3) multiple regression [Januszewicz and Puzio-Idźkowska 2002, Jóźwiak and Podgórski 2006],
4) descriptive statistics [Stanisz 2006].

Calculations were done with the use of the statistics program STATISTICA.PL. All tests were carried out at the significance level of P = 0.05.

RESULTS AND DISCUSSION

The greatest effect on oat growth, development, and yield was exerted by the weather course during growth, which was confirmed by other authors [Panek 1992, Gregorczyk 1999, Michalski *et al.* 1999, Kozera *et al.* 2006]. According to Witkowicz *et al.* [2007], weather course during growth is responsible in 50% for yield variability, panicle density per area unit, and mass of 1000 grains. In the present research, weather course in years 2007-2009 was more favourable for oat growth (Table 1). Particularly high precipitation in June and July of 2008 and 2009 contributed to good grain filling and high yields of the studied lines and the oat cultivar (Table 1).

Table 1. Weather conditions during the growth period of oat
Tabela 1. Warunki meteorologiczne w okresie wegetacji owsa

Year – Rok	Month – Miesiąc					Mean Średnia
	April kwiecień	May maj	June czerwiec	July lipiec	August sierpień	
	Temperature – Temperatura, °C					
2007	8.7	15.8	19.2	20.2	18.9	16.56
2008	9.1	13.6	18.1	18.9	18.8	15.70
2009	10.6	13.5	16.8	20.2	18.7	15.96
Long term – Wielolecie 1986-2009	8.7	13.9	17	20.1	18.1	15.56
	Precipitation – Opady, mm					Sum – Suma
2007	27.2	39.9	70.5	73.6	87.9	299.1
2008	45.5	105.3	86.7	117.6	55.3	410.4
2009	3.7	102.6	146.4	98	45.3	396
Long term – Wielolecie 1986-2009	50.5	80.7	82	88.1	69.7	371

Average oat yield obtained jointly in the three-year-long research period from all the assessed lines and the cultivar amounted to 4.76 $t \cdot ha^{-1}$. Cultivar Krezus gave the highest yield, which was over 1 tone per hectare higher than the yield of the remaining lines (Tables 2 and 3).

Table 2. Comparison of yield elements and traits that determine oat grain quality (mean in 2007--2009)
Tabela 2. Porównanie elementów plonowania oraz cech określających jakość ziarna owsa (średnio w latach 2007-2009)

Trait – Cecha	STH 71	STH 6106	STH 6108	STH 75	STH 5417	STH 7105	KREZUS
Grain yield, $t \cdot ha^{-1}$ Plon ziarna, $t \cdot ha^{-1}$ H = 12.509; p = 0.050	4.64^{A}	4.82^{A}	4.65^{A}	4.33^{A}	4.40^{A}	4.74^{A}	5.75^{B}
Mass of panicle grains, g Masa ziaren z wiechy, g F = 15.980; p = 0.000	1.51^{A}	1.49^{A}	1.52^{A}	1.36^{B}	1.38^{B}	1.37^{B}	1.69^{C}
Panicle density, $pcs. \cdot m^{-2}$ Obsada wiech, $szt. \cdot m^{-2}$ H = 6.163; p = 0.405	322.89	337.00	325.89	335.22	329.11	358.11	346.44
Number of panicle grains, pcs. Liczba ziaren z wiechy, szt. H = 18.703; p = 0.005	$45.39^{B, C}$	$46.04^{B, C}$	$46.40^{B, C}$	$43.80^{A, B}$	40.68^{A}	41.03^{A}	48.70^{C}
Mass of 1000 grains, g Masa tysiąca ziaren, g F = 2.980; p = 0.014	$34.44^{A, B}$	$34.47^{A, B}$	34.70^{B}	$34.50^{A, B}$	35.47^{B}	33.55^{A}	35.49^{B}
Number of spikes in panicle, pcs. Liczba kłosów w wiesze, szt. H = 4.559; p = 0.602	23.58	22.71	23.50	22.10	22.30	23.09	25.77
Main blade length, cm Długość źdźbła głównego, cm H = 26.163; p = 0.000	62.20^{A}	55.73^{A}	59.09^{A}	62.44^{A}	55.89^{A}	56.50^{A}	82.77^{B}
Panicle length, cm Długość wiechy, cm H = 24.447; p = 0.000	13.21^{A}	13.42^{A}	13.38^{A}	13.41^{A}	11.68^{B}	12.01^{B}	13.64^{A}
Total protein, % d.m. Białko ogólne, % s.m. H = 4.414; p = 0.621	13.07	13.70	13.30	13.21	13.89	13.39	13.52
Raw fat, % d.m. Tłuszcz surowy, % s.m. F = 2.329; p = 0.050	$4.51^{A, B}$	$4.80^{A, C}$	$4.43^{A, B}$	5.06^{C}	$4.82^{A, C}$	4.31^{B}	$4.65^{A, B, C}$
Raw fibre, % d.m. Włókno surowe, % s.m. H = 3.270; p = 0.774	9.41	10.21	10.10	10.14	9.52	9.51	10.29
Raw ash, % d.m. Popiół surowy, % s.m. H = 7.456; p = 0.281	2.56	2.62	2.69	2.29	2.48	2.06	2.74
Nitrogen-free extracts, % d.m. Bezazotowe wyciągowe, % s.m. H = 5.507; p = 0.481	70.47	68.76	69.53	69.53	69.36	70.68	68.76

$^{A, B, C}$ – homogenous groups distinguished with the Tukey's test – grupy jednorodne wyodrębnione testem Tukeya
H – statistical value of the Kruskal-Wallis test – wartość statystyki testowej testu Kruskala-Wallisa
F – statistical value of the analysis of variance – wartość statystyki testowej testu analizy wariancji

The conducted Kruskal-Wallis test showed that the grain yields of the studied lines and the oat cultivar were diversified. Also statistically significant differences were found in regard to yield structure and fat content (Table 2). Cultivar Krezus was characterized by the highest values of all the elements of the yield, which agreed with the data presented by Kozioł [2007]. The highest grain yield and the lowest panicle grain mass and spikelet number per panicle were found in line STH 75.

Table 3. Comparison of yield elements and traits that determine the oat grain yield of the studied lines with cultivar Krezus (mean for 2007-2009)
Tabela 3. Porównanie elementów plonowania oraz cech określających jakość ziarna owsa badanych rodów z odmianą Krezus (średnia za lata 2007-2009)

Trait – Cecha	STH 71	STH 6106	STH 6108	STH 75	STH 5417	STH 7105	KREZUS
Grain yield, $t{\cdot}ha^{-1}$ Plon ziarna, $t{\cdot}ha^{-1}$	4.64* p = 0.004	4.82* p = 0.019	4.65* p = 0.004	4.33* p = 0.000	4.40* p = 0.000	4.74* p = 0.009	5.75
Mass of panicle grains, g Masa ziaren z wiechy, g	1.51* p = 0.000	1.49* p = 0.000	1.52* p = 0.001	1.36* p = 0.000	1.38* p = 0.000	1.37* p = 0.000	1.69
Panicle density, $pcs.{\cdot}m^{-2}$ Obsada wiech, $szt.{\cdot}m^{-2}$	322.89 p = 0.543	337.00 p = 0.985	325.89 p = 0.671	335.22 p = 0.965	329.11 p = 0.802	358.11 p = 0.958	346.44
Number of panicle grains, pcs. Liczba ziaren z wiechy, szt.	45.39 p = 0.390	46.04 p = 0.609	46.40 p = 0.734	43.80 p = 0.087	40.68* p = 0.001	41.03* p = 0.002	48.70
Mass of 1000 grains, g Masa tysiąca ziaren, g	34.44 p = 0.245	34.47 p = 0.265	34.70 p = 0.518	34.50 p = 0.297	35.47 p = 1.000	33.55* p = 0.004	35.49
Number of spikes in panicle, pcs. Liczba kłosów w wiesze, szt.	23.58 p = 0.663	22.71 p = 0.333	23.50 p = 0627	22.10 p = 0.178	22.30 p = 0.221	23.09 p = 0.464	25.77
Main blade length, cm Długość źdźbła głównego, cm	62.20* p = 0.000	55.73* p = 0.000	59.09* p = 0.000	62.44* p = 0.000	55.89* p = 0.000	56.50* p = 0.000	82.77
Panicle length, cm Długość wiechy, cm	13.21 p = 0.874	13.42 p = 0.994	13.38 p = 0.985	13.41* p = 0.992	11.68* p = 0.001	12.01* p = 0.005	13.64
Total protein, % d.m. Białko ogólne, % s.m.	13.07 p = 0.964	13.70 p = 0.999	13.30 p = 0.999	13.21 p = 0.995	13.89 p = 0.986	13.39 p = 1.000	13.52
Raw fat, % d.m. Tłuszcz surowy, % s.m.	4.51 p = 0.985	4.80 p = 0.972	4.43 p = 0.886	5.06 p = 0.367	4.82 p = 0.956	4.31 p = 0.551	4.65
Raw fibre, % d.m. Włókno surowe, % s.m.	9.41 p = 0.831	10.21 p = 1.000	10.10 p = 1.000	10.14 p = 1.000	9.52 p = 0.897	9.51 p = 891	10.29
Raw ash Popiół surowy, % s.m.	2.56 p = 1.000	2.62 p = 1.000	2.69 p = 1.000	2.29 p = 0.972	2.48 p = 0.998	2.06 p = 0.840	2.74
Nitrogen-free extracts, % d.m. Bezazotowe wyciągowe, % s.m.	70.47 p = 0.448	68.76 p = 1.000	69.53 p = 0.958	69.53 p = 0.986	69.36 p = 0.986	70.68 p = 0.333	68.76

* marked are the mean values form the particular lines which differed from the mean values of cultivar Krezus at the significance level of $P \leq 0.05$ – zaznaczono średnie poszczególnych rodów różniące się od średnich odmianyKrezus na poziomie istotności $P \leq 0,05$

The lowest number of panicle grains and the shortest panicles were formed by the plants from line STH 5417. Grain with the lowest mass was obtained by line STH 7105. The shortest blades were formed by the plants from line STH 6106.

The analysis of the chemical composition of grain showed that the highest content of raw fat was characteristic for line STH 75 grain, total protein for line STH 5417 grain, and the greatest amount of fibre and ash was found in the grain of cultivar Krezus. Line STH 71 was characterized by the lowest protein and fibre content. The lowest fat and ash content occurred in line STH 7105, and of nitrogen-free extracts in line STH 6108 and cultivar Krezus. The results indicate that in cereals, the chemical composition is determined to a high degree by plant genotype, which was also confirmed in the studies by other authors [Panek 1992, Subda *et al.* 1998, Petkov and Piech 2001, Lutowska *et al.* 2008].

The conducted Dunnett's test, on the basis of which the mean values of the yield and yield elements of the studied lines with cultivar Krezus were compared showed that:

– the studied lines gave significantly lower yield than the standard cultivar,
– mass of panicle grains in all the lines was significantly lower than in cultivar Krezus,
– lines STH 5417 and STH 7105 were characterized by a significantly lower than the other lines number of grains in the panicle,
– line STH 7105 formed grains with a significantly lower mass of 1000 grains in comparison with the standard cultivar,
– in all the studied lines, blade length was significantly lower than in cultivar Krezus,
– panicle length of lines STH 5417 and STH 7105 was significantly shorter in relation to cultivar Krezus.

The results of the Dunnett's test did not show, however, significant differences in the contents of protein, fat, ash, fibre, and nitrogen-free extracts between cultivar Krezus and the studied oat lines (Table 3).

Basic descriptive statistics were calculated in order to characterize more fully the distribution of the studied oat traits (Table 4).

Distribution of almost all the analyzed variables showed a high concentration of empirical values around the mean. Exceptions were the mass of 1000 grains and the content of nitrogen-free extracts, which may be assumed as almost constant since the value of the coefficient of variation was lower than 10% and amounted to slightly more than 3%. Ash content was characterized, on the other hand, by strong dispersion of values around the mean (standard deviation was as high as 57.7% of the mean value).

In order to determine the direction and strength of relations between the studied oat yield elements, linear correlation coefficients were set (Table 5).

Oat grain yield correlated in a statistically significant way with all the yield components except the mass of 1000 grains. In all the cases, the correlation was moderate, positive, and statistically significant. The results confirm the opinion that in oat, an important yield element is panicle distribution per 1 m^2, mass of panicle grains, spikelet number, and the number of panicle caryopses [Podolska *et al.* 2006, Leszczyńska and Noworolnik 2010].

Similar analysis of variance was carried out also for the traits that determine the quality of oat grain (Table 6). Total protein content correlated positively and significantly with the contents of raw fat and ash and negatively correlated with the content of nitrogen-free extracts. The strength of this correlation was, respectively: weak, moderate, and strong. Negative, also statistically significant correlation occurred between the contents of nitrogen-free extracts and protein (strong correlation), fat (moderate correlation), and ash content (weak correlation).

Table 4. Basic descriptive characteristics for yield elements and traits that determine oat grain quality
Tabela 4. Podstawowe charakterystyki opisowe dla elementów plonowania oraz cech określających jakość ziarna owsa

Variables Zmienne	Range Zakres	Arithmetic mean Średnia arytmetyczna	Standard deviation Odchylenie standardowe	Coefficient of variation Współczynnik zmienności	Slant Skośność
Grain yield, $t \cdot ha^{-1}$ Plon ziarna, $t \cdot ha^{-1}$	3.6-6.8	4.76	0.76	15.9%	0.94
Mass of panicle grains, g Masa ziarniaków z wiechy, g	1.2-1.9	1.47	0.14	9.6%	0.59
Panicle density, $pcs. \cdot m^{-2}$ Obsada wiech, $szt. \cdot m^{-2}$	263-402	336.38	35.86	10.7%	-0.23
Number of panicle grains, pcs. Liczba ziaren z wiechy, szt.	33.1-59.8	44.58	4.92	11.0%	0.40
Mass of 1000 grains, g Masa tysiąca nasion, g	31.6-36.9	34.66	1.27	3.7%	0.00
Number of spikes in panicle, pcs. Liczba kłosów w wiesze, szt.	15.9-30.8	23.29	3.74	16.1%	0.12
Main blade length, cm Długość źdźbła głównego, cm	43.1-99.8	62.12	12.39	20.0%	1.08
Panicle length, cm Długość wiechy, cm	10.7-15.6	12.96	1.20	9.2%	0.16
Total protein, % d.m. Białko ogólne, % s.m.	10.8-16.4	13.44	1.38	10.3%	-0.14
Raw fat, % d.m. Tłuszcz surowy, % s.m.	3.6-6.1	4.65	0.55	11.8%	0.24
Raw fibre, % d.m. Włókno surowe, % s.m.	6.5-13.6	9.88	1.85	18.7%	-0.05
Raw ash, % d.m. Popiół surowy, % s.m.	1.1-5.4	2.49	1.44	57.7%	0.81
Nitrogen-free extracts, % d.m. Bezazotowe wyciągowe, % s.m.	65.1-73.6	69.56	2.35	3.38%	-0.03

For the description of the correlations between the variables, also regression analysis was used. Multiple regression equation from the sample for oat yield size in relation to yield elements assumed the following form:

$$Y = -6.645 + 2.929 \quad X_1 + 0.013 \cdot X_2 + e_i \qquad R^2 = 82.7\%$$

$$(1.553) \quad (0.500) \quad (0.002) \quad (0.332)$$

$$p = 0.000 \quad p = 0.000 \quad p = 0.000$$

where:

Y – oat yield size,
X_1 – mass of panicle caryopses,
X_2 – panicle density.

The estimated multiple regression coefficients inform that if a given mass of panicle grain increases by 1 g, oat yield increases on average by 2.929 $t \cdot ha^{-1}$, assuming that panicle density remains at a constant, average level. On the other hand, if panicle density increase amounts to 1 $panicle \cdot m^{-1}$, oat yield increases on average by 0.013 $t \cdot ha^{-1}$, assuming that grain mass does not change. Empirical values of the dependent value (yield) may differ from the theoretical values set on the basis of the assumed regression function on average by +/- 0.334 $t \cdot ha^{-1}$. Set function was adjusted in 82.7% to the empirical data.

Table 5. Linear correlation coefficients between oat yield elements
Tabela 5. Współczynniki korelacji prostej pomiędzy elementami plonowania owsa

Trait Cecha	Grain yield Plon ziarna	Mass of panicle grains Masa ziarniaków z wiechy	Panicle density Obsada wiech	Number of panicle grains Liczba ziaren z wiechy	Mass of 1000 grains Masa tysiąca nasion	Number of spikes in panicle Liczba kłosów w wiesze	Main blade length Długość źdźbła głównego	Panicle length Długość wiechy
Grain yield Y Plon ziarna Y	1	0.60* p = 0.000	0.68* p = 0.000	0.67* p = 0.000	-0.08 p = 0.534	0.73* p = 0.000	0.63* p = 0.000	0.38* p = 0.002
Mass of panicle grains X_1 Masa ziarniaków z wiechy X_1	0.60* p = 0.000	1	0.02 p = 0.880	0.69* p = 0.000	0.15 p = 0.248	0.42* p = 0.001	0.62* p = 0.000	0.47* p = 0.000
Panicle density X_2 Obsada wiech X_2	0.68* p =0.001	0.02 p = 0.880	1	0.37 p = 0.003	-0.36* p = 0.003	0.65* p = 0.000	0.39* p = 0.001	0.13 p = 0.308
Number of panicle grains X_3 Liczba ziaren z wiechy X_3	0.67* p = 0.000	0.69* p = 0.000	0.37* p = 0.003	1	-0.07 p = 0.569	0.70* p = 0.000	0.63* p = 0.000	0.63* p = 0.000
Mass of 1000 grains X_4 Masa tysiąca ziaren X_4	-0.08 p = 0.534	0.15 p = 0.248	-0.36* p = 0.003	-0.07 p = 0.569	1	-0.23 p = 0.072	-0.07 p = 0.601	-0.03 p = 0.819
Number of spikes in panicle X_5 Liczba kłosków w wiesze X_5	0.73* p = 0.000	0.42* p = 0.001	0.65* p = 0.000	0.70* p = 0.000	-0.23 p = 0.072	1	0.65* p = 0.000	0.43* p = 0.000
Main blade length X_6 Długość źdźbła głównego X_6	0.63* p = 0.000	0.62* p = 0.000	0.39* p = 0.001	0.63* p = 0.000	-0.07 p = 0.601	0.65* p = 0.000	1	0.46* p = 0.000
Paniclelength X_7 Długość wiechy X_7	0.38* p = 0.002	0.47* p = 0.000	0.13 p = 0.308	0.63* p = 0.000	-0.03 p = 0.819	0.43* p = 0.000	0.46* p = 0.000	1

* marked are statistically significant coefficients at the significance level of $P \leq 0.05$ – zaznaczono współczynniki istotne statystycznie na poziomie istotności $P \leq 0,05$

Multiple correlation coefficient 0.91 indicated very high correlation between yield size (Y) and yield-forming qualities jointly (X_1, X_2). The value of the statistics F = 37.683 (p = 0.000) means that the entire model was statistically significant.

On the basis of the values of the standardized variability coefficients it may be stated that the lowest degree of co-variability with oat yield size was characteristic for panicle density, and then for the mass of panicle caryopses (Table 7, Figure 1).

The results are in agreement with the studies by other authors, according to whom oat yield size depends on panicle density before harvest and the mass and number of panicle grains [Kozłowska-Ptaszyńska 1999, Szempliński 2003, Maciorowski *et al.* 2006, Podolska *et al.* 2006].

Table 6. Linear correlation coefficients between traits that determine oat grain quality (mean for 2007-2009)
Tabela 6. Współczynniki korelacji prostej pomiędzy cechami określającymi jakość ziarna owsa (średnie za lata 2007-2009)

Trait – Cecha	Total protein content Zawartość białka ogólnego	Raw fat content Zawartość tłuszczu surowego	Raw fibre content Zawartość włókna surowego	Raw ash content Zawartość popiołu surowego	Nitrogen-free extract content Zawartość związków bezazotowych wyciagowych
Total protein content Zawartość białka ogólnego	1	0.32* p = 0.010	-0.23 p = 0.069	0.59* p = 0.000	-0.83* p = 0.000
Raw fat content Zawartość tłuszczu surowego	0.32* p = 0.010	1	0.22 p = 0.076	-0.06 p = 0.963	-0.59* p = 0.000
Raw fibre content Zawartość włókna surowego	-0.23 p = 0.069	0.22 p = 0.076	1	-0.79* p = 0.000	-0.23 p = 0.067
Raw ash content Zawartość popiołu surowego	0.59* p = 0.000	-0.06 p = 0.963	-0.79* p = 0.000	1	-0.32* p = 0.011
Nitrogen-free extract content Zawartość związków bezazotowych wyciągowych	-0.83* p = 0.000	-0.59* p = 0.000	-0.23 p = 0.067	-0.32* p = 0.011	1

* marked are statistically significant coefficients at the significance level of P ≤ 0.05 – zaznaczono współczynniki istotne statystycznie na poziomie istotności P ≤ 0,05

Table 7. Assessment of multiple regression coefficients (track coefficients) and regression coefficients for standardized variables
Tabela 7. Oceny współczynników regresji wielokrotnej (współczynników ścieżek) oraz współczynników regresji dla standaryzowanych zmiennych

Variables Zmienne	Multiple regression coefficients Współczynniki regresji wielokrotnej	Standardized regression coefficients Standaryzowane współczynniki regresji
Mass of panicle caryopses Masa ziaren z wiechy	2.929	0.544
Panicle density Obsada wiech	0.013	0.638

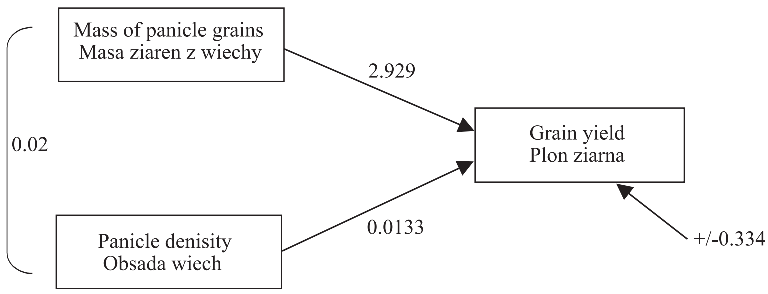

Fig. 1. Diagram which presents the effect of yield elements on oat grain yield (mean from 2007-2009)
Rys. 1. Diagram obrazujący wpływ elementów plonowania na plon ziarna owsa (średnia z lat 2007-2009)

CONCLUSIONS

1. Cultivar Krezus was characterized by the greatest usefulness for growth in the Subcarpathian region. It formed the greatest number of spikelets and mass of panicle grain, it had a high panicle density per 1 m^2 before the harvest, and it gave the highest grain yield.
2. The yields of dwarf lineswere by about 1 $t \cdot ha^{-1}$ lower than the yields of cultivar Krezus. Among the dwarf lines, the most promising ones are STH 6106 and STH 7105.
3. Grain of line STH 75 contained the greatest amount of raw fat, and grain of line STH 5417 contained the greatest amount of total protein.
4. Oat grain yield, regardless of the genotype, was determined mostly by the mass of panicle grain and panicle density per 1 m^2.

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PLONOWANIE I SKŁAD CHEMICZNY ZIARNA NOWYCH KRÓTKOSŁOMYCH RODÓW HODOWLANYCH OWSA SIEWNEGO (*Avena sativa* L.)

Streszczenie. W pracy przedstawiono wyniki doświadczenia polowego przeprowadzonego w latach 2007-2009 w Stacji Dydaktyczno-Badawczej Uniwersytetu Rzeszowskiego w Krasnem koło Rzeszowa. Oceniano wartość gospodarczą 6 krótkosłomych rodów hodowlanych owsa w porównaniu z odmianą wzorcową Krezus. Wykazano, że z spośród badanych form owsa odmiana Krezus charakteryzowała się najlepszą przydatnością do uprawy w rejonie Podkarpacia. Wydała najwyższy plon ziarna, wytworzyła największą liczbę wiech na 1 m^2 przed zbiorem oraz liczbę kłosków i masę ziarna z wiechy. Badane rody krótkosłome plonowały średnio o 1 tonę z hektara niżej niż odmiana Krezus. Najwięcej tłuszczu surowego zawierało ziarno rodu STH 75, a białka ogólnego – ziarno rodu STH 5417.

Słowa kluczowe: *Avena sativa*, komponenty plonu owsa, rody krótkosłome, skład chemiczny ziarna

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