

## **ASSESSMENT OF THE SUITABILITY OF OAT VARIETIES (*Avena sativa* L.) FOR CULTIVATION IN ORGANIC SYSTEM**

### *Summary*

*In the years 2014–2015 the study on the suitability of 7 oat varieties: 2 hulled (Bingo, Krezus) and 5 naked (Cacko, Maczo, Nagus, Polar, Siwek) for cultivation in organic farming was done. The experiments were conducted in two locations: Grabów (Mazowieckie province, organic farm of IUNG - PIB) and Chwałowice (Mazowieckie province, organic farm of CDR in Radom). In 2014 the yield of oats was on average by 2.0 t·ha<sup>-1</sup> lower than in 2015 due to adverse weather conditions (excess rainfall and low temperatures during sowing and emergence). Naked varieties responded by greater reduction in yields (yield in the range of 1.5–3.0 t·ha<sup>-1</sup>) compared to the hulled varieties (4.1–5.4 t·ha<sup>-1</sup>), which was a consequence of the weaker emergence and small density of canopy. In 2015 favorable distribution of rainfall during a critical period for the development of oats allowed to get a good compactness of crop canopy, which together with the lack of fungal diseases provided the high productivity of this species. In both years of research hulled varieties yielded higher than the naked varieties (on average by 66%). Among the naked varieties the highest yield was obtained for Maczo variety (average 3.76 t·ha<sup>-1</sup>) and Siwek in Grabów (3.84 t·ha<sup>-1</sup>) and the lowest for Cacko (2.94 t·ha<sup>-1</sup>), due to the smallest density of plants and ears. Differences in the intensity of oat infestation between the localizations of experiments and oat varieties were found. Hulled oat varieties: Bingo and Krezus were characterized by greater competitiveness in relation to the weeds compared to the naked oat varieties (13% fewer weeds and 40% less dry matter of weeds). The greater competitive ability against weeds of hulled oat varieties compared with naked was the result of bigger plant and ears density, a greater dry matter of underground parts and the height of plants. Assessment of leaf infection of examined oat varieties in milky-wax maturity stage in 2014 showed moderate intensity of corona rust and leaf spot as well as slight degree of Septoria diseases while in 2015 showed no symptoms. The symptoms of Fusarium disease in both years occurred sporadically and showed no statistically significant differences between varieties.*

**Key words:** varieties of oat, yield of oat, organic farming, weed infestation

## **OCENA PRZYDATNOŚCI ODMIAN OWSA (*Avena sativa* L.) DO UPRAWY W SYSTEMIE EKOLOGICZNYM**

### *Streszczenie*

*W latach 2014–2015 przeprowadzono badania przydatności do uprawy w rolnictwie ekologicznym 7 odmian owsa: 2 oplewionych (Bingo, Krezus) i 5 nagoziarnistych (Cacko, Maczo, Nagus, Polar, Siwek). Doświadczenia wykonano w 2 lokalizacjach: Grabów (woj. mazowieckie, gospodarstwo ekologiczne IUNG – PIB) oraz Chwałowice (woj. mazowieckie, gospodarstwo CDR Radom). W 2014 r. poziom plonowania owsa był średnio o 2,0 t/ha niższy niż w 2015 r., ze względu na niekorzystne warunki pogodowe (nadmiar opadów i niskie temperatury w okresie wysiewu i wschodów). Większą obniżką plonów zareagowały odmiany nagoziarniste (plon w zakresie 1.5–3.0 t·ha<sup>-1</sup>) w porównaniu do odmian oplewionych (4.1–5.4 t·ha<sup>-1</sup>), co było konsekwencją słabszych wschodów i małej zwartości lanów. W 2015 r. sprzyjający rozkład opadów w okresie krytycznym dla rozwoju owsa umożliwił otrzymanie dobrej zwartości lanu, co w powiązaniu z brakiem porażenia przez choroby grzybowe zapewniło wysoką wydajność tego gatunku. W obu latach badań odmiany oplewione plonowały wyżej niż odmiany nieoplewione (średnio o 66%). Spośród odmian nagoziarnistych najwyższe plony uzyskano dla odmiany Maczo (średnio 3,76 t/ha) oraz Siwek w Grabowie (3,84 t/ha), a najniższe dla odmiany Cacko (2,94 t/ha), ze względu na najmniejszą obsadę roślin i kłosów. Stwierdzono różnice w zachwaszczeniu lanów owsa między miejscowościami i odmianami. Odmiany oplewione owsa – Bingo i Krezus wyróżniały się większą konkurencyjnością w stosunku do chwastów w porównaniu do odmian nagoziarnistych (o 13% mniejsza liczba chwastów i o 40% mniejsza sucha masa chwastów). Większa konkurencyjność w stosunku do chwastów odmian oplewionych owsa w porównaniu z nieoplewionymi wynikała z większej obsady roślin i masy części nadziemnych oraz wysokości roślin. Ocena porażenia liści badanych odmian owsa w fazie dojrzałości mleczno-woskowej w 2014 r. wykazała umiarkowane nasilenie rdzy koronowej i plamistości liści oraz niewielki stopień porażenia septoriozą, natomiast w 2015 r. nie wykazała objawów chorobowych. Objawy fuzariozy w obu latach badań wystąpiły sporadycznie i nie wykazano statystycznie istotnych różnic między odmianami.*

**Słowa kluczowe:** odmiany owsa, plony owsa, rolnictwo ekologiczne, chwasty

### **1. Introduction**

In organic farming system limitation of pests, diseases and weeds is provided by agricultural practices which create a beneficial condition of canopy and soil, such as crop

rotation, tillage, organic fertilization, date and density of sowing as well as mechanical, biological and physical methods of plant protection. An appropriate variety choice is a crucial component of agricultural practices [7, 15]. Organic farming gives a reference to varieties of cereals which

are characterized by high competitive ability against weeds (growth rate, length of stem, tillering rate, surface and of leaf attachment), tolerance to fungal diseases, ability to uptake of nutrients and resistance to nutrients deficiency stress [1, 2, 4, 11, 13].

The study of oat varieties, including naked grain varieties, comes from the growing interest of organic producers in cultivation of that species. Oat and oat products are rich source of many valuable components of nutritional and biological importance, mainly proteins, fats, fiber, carbohydrates, minerals and vitamins. Oat is characterized by the high content of soluble fraction of dietary fiber with glucans as the most important component of this fraction [6]. The oat grain has a significant preventive and therapeutic activity, for example against cardiovascular disease, obesity and diet-related diseases.

Oat is a species consistently yielding under extensive systems of farming [14]. Therefore, it is preferred to sow in pure and mixed stands according to the principles of organic agriculture [3]. In addition, oat is a good forecrop for other cereals due to its phytosanitary properties which has a beneficial effect in conditions of increasing share of cereals in crop rotation. Oats emits specific organic substances of fungistatic activity against soil pathogens. Oat is very rarely attacked by soil borne diseases, while the rhizosphere is inhabited by a community of beneficial fungi. Oats is also highly competitive against weeds by producing extensive root system and the broad leaves [6]. It should be noted that in the literature there are not many papers on the reaction of oat varieties for cultivation in organic farming, especially naked varieties. The aim of the study was to evaluate the suitability of hulled and naked oat varieties for cultivation in organic farming.

## 2. Material and methods

The experiments were conducted in the years 2014-2015 in two locations: Grabów (Mazowieckie province, organic farm of IUNG - PIB) and Chwałowice (Mazowieckie province, organic farm of CDR in Radom) (Table 1).

The experiment with different oat varieties was established in a completely randomized blocks, in four replications. Five naked oat varieties: Cacko, Maczo, Nagus, Polar, Siwek and two hulled oat varieties: Bingo and Krezus were tested for cultivation in organic farming. The varieties were sown in an optimal date for region (25-30 March) at a rate of 500 grains·m<sup>-2</sup> for hulled oat varieties and 550 grains·m<sup>-2</sup> for naked oat varieties. According to organic agriculture rules, mineral nitrogen fertilizers and chemicals were not used. The harrowing of oat canopy was done twice in the period from the 4-leaves phase to the tillering stage.

Table 1. Habitat conditions of research

Tab. 1. Warunki siedliskowe prowadzenia badań

Item	Location of organic farms	
	Chwałowice	Grabów
Complex of agricultural suitability of soils	good wheat (complex 2)	very good rye (complex 4)
Soil type	brown soil	luvisol soil
Soil textural group	dust clay	heavy loamy sand on a clay
Richness of the soil:		
- humus (%)	1.7	1.5
- P <sub>2</sub> O <sub>5</sub> (mg·100 g <sup>-1</sup> of soil)	23.4	6.8
- K <sub>2</sub> O	22.3	7.1
- Mg	13.1	5.8
- pH in KCl	6.2	5.8
Forecrop	potato	mixture of cereals and leguminous

Source: own work / Źródło: opracowanie własne

High differences in weather conditions between years and localities of research were observed (Table 2).

In 2014 in Chwałowice large excess of rainfalls in May, July and August was reported. Low yields of naked oat varieties were obtained probably due to a stronger reaction to these variations, compared to the hulled varieties, on the unfavorable weather conditions during the sowing and emergence (excess rainfall and low temperatures). As a result, the density of canopy was low, which influenced the level of crop yields.

In 2015 a shortage of rainfall already in May was observed in Chomentowo, while in other locations the rain exceeding the long-term average was found in this time. From June to August in all localities increasing drought occurred, especially in Chomentowo, with temperature values higher than the average temperature for the long-term period. This weather conditions during the growing season 2015 influenced the yield of crops and severity of agrophages (weeds, fungal pathogens) in different localities of research.

Grain yield and components of its structure were estimated in 25 m<sup>2</sup> plots in 4 replications. Stem and leaves were scored for infestation rate with fungal pathogens at milky-dough stage (BBCH 77-83). The number of weeds and their dry matter were assessed at dough stage of oat (BBCH 85-87), on an area of 0.5 m<sup>2</sup>, in four replications for each variety. From the same area the parameters of plant canopy, such as number of plants and their dry matter were evaluated. The results were calculated on the area of 1 m<sup>2</sup>. The biometric analysis of oat plants: plant height and overall tillering were estimated for 30 plants.

Table 2. Mean monthly temperature of air (°C) and sum of precipitation (mm) in the years 2014-2015

Tab. 2. Średnie miesięczne temperatury powietrza (°C) i sumy opadów (mm) w latach 2014-2015

Month	2014				2015			
	Temperature (°C)		Precipitation (mm)		Temperature (°C)		Precipitation (mm)	
	Chwałowice	Grabów	Chwałowice	Grabów	Chwałowice	Grabów	Chwałowice	Grabów
III	6.5	6.0	62	61	5.2	5.0	60	63
IV	10.2	10.0	57	55	8.6	8.1	50	35
V	14.0	13.6	181	170	13.0	12.7	139	107
VI	14.7	14.2	47	46	17.3	16.9	28	30
VII	20.7	20.1	158	150	20.1	19.7	32	52
VIII	18.0	17.8	198	190	22.4	22.1	14	6

Source: own work / Źródło: opracowanie własne

The results were analysed statistically. Analysis of variation for the completely randomized model was applied and the significance of differences between means was verified by Tukey test at  $\alpha = 0.05$ . Pearson's correlations between grain yield of oat varieties, morphological features and canopy parameters were performed. Cluster analysis using Furthest Neighbour method was done in order to divide varieties into groups with similar characteristics. Calculations were performed using Statgraphic Plus version 2.1.

### 3. Results and discussion

Differences in the intensity of oat infestation between the localizations of experiments and oat varieties were found. In both years, number of weeds was higher in Chwałowice than in Grabów (Table 3). Similarly, twice more the weight of weeds was found in Chwałowice (approximately  $53 \text{ g}\cdot\text{m}^{-2}$ ) in comparison to Grabów ( $24 \text{ g}\cdot\text{m}^{-2}$ ) (Table 4).

Table 3. Number of weeds in oat varieties in organic system ( $\text{plants}\cdot\text{m}^{-2}$ )

Tab. 3. Liczba chwastów w odmianach owsa w systemie ekologicznym ( $\text{szt.}\cdot\text{m}^{-2}$ )

Variety	Chwałowice			Grabów		
	2014	2015	mean	2014	2015	mean
Bingo	162	106	134	49	77	63
Krezus	143	99	121	65	96	80
Mean for hulled varieties	153	103	128	57	86	72
Cacko	191	114	152	104	71	87
Maczo	172	116	144	81	74	77
Nagus	185	110	148	87	88	87
Polar	185	100	142	94	71	83
Siwek	179	107	143	71	96	83
Mean for naked varieties	182	109	146	87	80	83
Mean for all varieties	174	107	141	78	82	80
LSD <sub>0.05</sub>	n.s.*	n.s.	n.s.	n.s.	n.s.	n.s.

\* n.s. – not significant differences

Source: own work / Źródło: opracowanie własne

In both localities of research hulled oats varieties: Bingo and Krezus were characterized by greater competitiveness

Table 5. Oat plants density and their dry matter

Tab. 5. Obsada roślin i sucha masa części nadziemnych owsa

Variety	Oat plant density ( $\text{plants}\cdot\text{m}^{-2}$ )			Dry matter of oat ( $\text{g}\cdot\text{m}^{-2}$ )		
	2014	2015	mean	2014	2015	mean
Bingo	453 b	270 ab	362 c	1132 c	1080 ab	1106 a
Krezus	364 b	265 ab	315 bc	1033 bc	1060 ab	1047 a
Mean for hulled varieties	409	268	339	1083	1070	1076
Cacko	223 a	251 ab	237 ab	738 ab	1004 ab	871 a
Maczo	436 b	300 b	368 c	1020 bc	1200 b	1110 a
Nagus	360 b	221 a	291 abc	846 abc	884 a	865 a
Polar	284 a	259 ab	272 ab	634 a	1036 ab	835 a
Siwek	310 a	229 a	270 a	790 abc	916 a	853 a
Mean for naked varieties	323	252	288	806	1008	907
Mean for all varieties	347	256	302	885	1026	955
LSD <sub>0.05</sub>	126	54	91	180	216	n.s.*

\* n.s. – not significant differences

Source: own work / Źródło: opracowanie własne

in relation to the weeds compared to the naked oat varieties (13% fewer weeds and 40% less dry weight of weeds) (Table 3-4). Observed level of weed infestation was not so big to affect the yield of oat. According to Gibiński et al. [6] morphological structure of the oat plant (the high, wide leaves, depth roots) favors the reduction of weed infestation.

Table 4. Weed dry matter in oat varieties in organic system ( $\text{g}\cdot\text{m}^{-2}$ )

Tab. 4. Sucha masa chwastów w odmianach owsa w systemie ekologicznym ( $\text{g}\cdot\text{m}^{-2}$ )

Variety	Chwałowice			Grabów		
	2014	2015	mean	2014	2015	mean
Bingo	29 a	36	33	9 a	17	13
Krezus	40 ab	46	43	13 a	22	17
Mean for hulled varieties	35	41	38	11	20	15
Cacko	78 c	52	65	57 b	14	36
Maczo	42 abc	61	51	11 a	33	22
Nagus	41 abc	91	66	22 ab	38	30
Polar	56 abc	57	57	51 b	15	33
Siwek	71 bc	45	58	13 a	27	20
Mean for naked varieties	58	61	59	31	25	28
Mean for all varieties	51	55	53	25	24	24
LSD <sub>0.05</sub>	18	n.s.*	n.s.	34	n.s.	n.s.

\* n.s. – not significant differences

Source: own work / Źródło: opracowanie własne

Studies showed that the competitive ability of oat varieties against weeds was related to plant density and their dry matter which were higher by 17% and 34% for hulled varieties in comparison with naked varieties (Table 5). A large competitiveness against weeds of Bingo variety resulted additionally from its height (Table 6). Among naked oat varieties Maczo was distinguished by the longest stem and at the same time by the biggest competitive ability against weeds and high yield (Table 3, 4, 6, 7). The most weedy were naked varieties: Cacko in 2014 and Nagus in 2015 which was associated with a small plant density of these varieties (Table 5). There were no significant differences between oat varieties in number of tillers (Table 6).

Table 6. Number of tillers and the height of oat varieties

Tab. 6. Rozkrzewienie i wysokość odmian owsa

Variety	Number of tillers per plant			Height (cm)		
	2014	2015	mean	2014	2015	mean
Bingo	1.28	1.38	1.33	92.6 a	97.7 a	95.1 a
Krezus	1.23	1.41	1.32	79.7 b	87.7 b	83.7 d
Mean for hulled varieties	1.26	1.40	1.33	86.2	92.7	89.4
Cacko	1.32	1.41	1.37	87.5 ab	89.2 b	88.3 bcd
Maczo	1.13	1.47	1.30	84.7 ab	84.8 b	84.7 cd
Nagus	1.21	1.63	1.42	86.4 ab	98.1 a	92.2 ab
Polar	1.38	1.54	1.46	84.8 ab	96.2 a	90.5 abc
Siwek	1.16	1.42	1.29	84.4 ab	87.9 b	86.1 bcd
Mean for naked varieties	1.24	1.49	1.37	85.5	91.2	88.4
Mean for all varieties	1.24	1.47	1.36	85.7	91.7	88.7
LSD <sub>0.05</sub>	n.s.*	n.s.	n.s.	10.6	5.7	6.6

\* n.s. – not significant differences

Source: own work / Źródło: opracowanie własne

Assessment of leaf infection of examined oat varieties in milky-wax maturity stage in 2014 showed moderate intensity of corona rust and leaf spot as well as slight degree of *Septoria* diseases while in 2015 showed no symptoms. The symptoms of *Fusarium* disease in both years occurred sporadically and showed no statistically significant differences between varieties.

In 2014 the yield of oats was lower on average by 2.0 t·ha<sup>-1</sup> than in 2015 due to adverse weather conditions (excess rainfall and low temperatures during sowing and emergence) (Table 7). Naked varieties responded by greater reduction in yields (yield in the range of 1.5-3.0 t·ha<sup>-1</sup>) compared to the hulled varieties (4.1-5.4 t·ha<sup>-1</sup>), which was a consequence of the weaker emergence and small density of canopy (Table 5, 8). In 2015 favorable distribution of rainfall during a critical period for the development of oats allowed to get a good compactness of crop canopy, which together with the lack of fungal diseases provided the high productivity of this species. In both years of research hulled varieties yielded higher than the naked varieties (on average by 66%). Among the naked varieties the highest yields were obtained for Maczo variety (average 3.76 t·ha<sup>-1</sup>) and Siwek in Grabów (3.84 t·ha<sup>-1</sup>) and the lowest for Cacko (2.94 t·ha<sup>-1</sup>), due to the smallest density of plants and ears.

Thousand grain weight was higher for hulled oat varieties than for naked ones (Table 9).

Other studies confirm the impact of weather conditions on the variability of the yield of oats [10]. Analysis of variance for 123 oat lines in the years 2009-2011 showed that years influenced significantly the growth and development of oat as well as the quality and quantity of yield [10]. Oat is a cereal with high water demands [9, 12], so the amount of rainfall in the years can affect significantly the yields. According to Klima and Łabza [8] the yield of oat and its mixture with other cereals in organic system were lower by 12% compared to conventional system, but at the same time abandonment of the use of fertilizers and pesticides resulted in nearly 5 times decrease in the value of direct costs and the 4 times increase in the personal income compared to the crops grown in the conventional system.

Studies showed a negative correlation between the weeds and oat dry matter, tillering and the height (Table 10). Oat yield was negatively correlated with the number and dry matter of weeds ( $r = -0.650$  and  $-0.583$ ). Similar results were obtained in the previous study on the competitiveness of the winter wheat and spring wheat against weeds [4, 5].

Table 7. The yield of oat varieties cultivated in organic system (t·ha<sup>-1</sup>)Tab. 7. Plon ziarna odmian owsa uprawianych w systemie ekologicznym (t·ha<sup>-1</sup>)

Variety	Chwałowice			Grabów		
	2014	2015	mean	2014	2015	mean
Bingo	4.07	7.28	5.68	5.44	6.42	5.93
Krezus	4.59	6.88	5.74	4.79	5.92	5.36
Mean for hulled varieties	4.33	7.08	5.71	5.12	6.17	5.65
Cacko	1.50	3.90	2.70	2.02	4.33	3.18
Maczo	2.76	4.76	3.76	3.20	4.33	3.77
Nagus	2.39	4.13	3.26	2.94	4.25	3.60
Polar	1.71	4.42	3.07	2.59	4.76	3.68
Siwek	2.28	4.40	3.34	2.99	4.69	3.84
Mean for naked varieties	2.13	4.32	3.23	2.75	4.47	3.61
Mean for all varieties	2.76	5.11	3.94	3.42	4.96	4.19
LSD <sub>0.05</sub>	0.48	0.49	-	0.34	0.67	-

Source: own work / Źródło: opracowanie własne

Table 8. The ears density of oat varieties cultivated in organic system (ears·m<sup>-2</sup>)

Tab. 8. Obsada kłosów w odmianach owsa uprawianych w systemie ekologicznym (szt.·m<sup>-2</sup>)

Variety	Chwałowice			Grabów		
	2014	2015	mean	2014	2015	mean
Bingo	532	293	413	437	376	407
Krezus	397	310	354	444	334	389
Mean for hulled varieties	465	301	383	441	355	398
Cacko	253	299	276	154	409	282
Maczo	412	265	339	419	421	420
Nagus	403	276	340	331	295	313
Polar	261	302	282	212	400	306
Siwek	245	293	269	310	333	322
Mean for naked varieties	315	287	301	286	372	329
Mean for all varieties	357	291	324	329	367	348
LSD <sub>0.05</sub>	102	53	-	78	67	-

Source: own work / Źródło: opracowanie własne

Table 9. Thousand grain weight (g) in oat varieties cultivated in organic system

Tab. 9. Masa tysiąca ziaren (g) w odmianach owsa uprawianych w systemie ekologicznym

Variety	Chwałowice			Grabów		
	2014	2015	mean	2014	2015	mean
Bingo	38.7	36.5	37.6	47.6	41.5	44.6
Krezus	33.7	30.5	32.1	32.6	34.8	33.7
Mean for hulled varieties	36.2	33.5	34.9	40.1	38.1	39.1
Cacko	23.2	25.7	24.5	23.8	25.5	24.7
Maczo	22.1	24.0	23.1	24.2	26.6	25.4
Nagus	21.3	21.7	21.5	22.9	26.0	24.5
Polar	23.1	24.7	23.9	24.2	26.2	25.2
Siwek	21.7	20.9	21.3	24.1	25.2	24.7
Mean for naked varieties	22.3	23.4	22.9	23.8	25.9	24.9
Mean for all varieties	26.3	26.3	26.3	28.5	29.4	29.0
LSD <sub>0.05</sub>	1.8	2.1	-	0.3	3.3	-

Source: own work / Źródło: opracowanie własne

Table 10. Correlation coefficients between the parameters of weed infestation, morphological features and canopy parameters of oat

Tab. 10. Współczynniki korelacji pomiędzy parametrami zachwaszczenia a cechami morfologicznymi i struktury łanu owsa

	No of weeds (plants·m <sup>-2</sup> )	Weed dry matter (g·m <sup>-2</sup> )	Number of tillers	Height (cm)	Plant density (no·m <sup>-2</sup> )	Oat dry matter (g·m <sup>-2</sup> )	Yield (t·ha <sup>-1</sup> )	Ears density (no·m <sup>-2</sup> )	Thousand grain weight (g)
No of weeds (plants·m <sup>-2</sup> )	<b>X</b>	0.672*	-0.466*	-0.301*	0.270*	-0.738*	-0.650*	-0.188*	-0.257
Weed dry matter (g·m <sup>-2</sup> )		<b>X</b>	-0.382*	-0.247	-0.036	-0.547*	-0.583*	-0.441*	-0.281*
Number of tillers			<b>X</b>	0.359*	-0.178	0.296	0.207	0.096	0.059
Height (cm)				<b>X</b>	-0.155	0.428*	0.341*	0.103	0.248
Plant density (no·m <sup>-2</sup> )					<b>X</b>	-0.195	-0.096	0.742	0.213
Oat weight (g·m <sup>-2</sup> )						<b>X</b>	0.745*	0.253	0.352*
Yield (t·ha <sup>-1</sup> )							<b>X</b>	0.330*	0.700*
Ears density (no·m <sup>-2</sup> )								<b>X</b>	0.371*
Thousand grain weight (g)									<b>X</b>

\* significant correlation at P<0.05

Source: own work / Źródło: opracowanie własne

Cluster analysis showed that separate group was created by hulled variety Bingo from two years of research (Table 11). This variety was characterized by high yield in both years and showed no negative reaction to the weather conditions of 2014. It was characterized by the most favorable morphological and canopy parameters due to the competition with weeds. In a separate cluster

ter naked oat varieties from 2014, like Cacko, Polar and Siwek, were grouped. They reacted negatively to the adverse weather conditions of 2014 year and they were characterized by a small plants and ears density, dry matter of the oat canopy, large weed infestation and low yield. In the good conditions of 2015 all the varieties with the exception of Bingo were located in one cluster.

Table 11. Cluster analysis for oat varieties

Tab. 11. Analiza skupień dla odmian owsa

Cluster	No of weeds (plants·m <sup>-2</sup> )	Weed dry matter (g·m <sup>-2</sup> )	Number of tillers	Height (cm)	Ears density (no·m <sup>-2</sup> )	Oat dry matter (g·m <sup>-2</sup> )	Yield (t·ha <sup>-1</sup> )	Thousand grain weight (g)	Objects
1	120	23	1.33	95.1	454	1105	5.25	40.1	Bingo 2014, Bingo 2015
2	185	68	1.28	85.6	253	720	1.83	22.7	Cacko, Polar, Siwek 2014
3	167	41	1.19	83.6	404	966	3.25	25.7	Krezus, Maczo, Nagus 2014
4	82	25	1.48	90.7	365	1017	4.71	27.4	All varieties from 2015 except Bingo

Source: own work / Źródło: opracowanie własne

The results of research indicated the strong influence of weather conditions of year, especially rainfall distribution, on the structure of oat canopy, some morphological features, weed infestation and yield which was confirmed in the study of Kordulasińska and Bulińska-Radomska [10].

#### 4. Conclusions

1. In 2014 the yield of oat was lower on average by 2.0 t·ha<sup>-1</sup> than in 2015 due to adverse weather conditions (excess rainfall and low temperatures during sowing and emergence). Naked varieties responded by greater reduction in yields (yield in the range of 1.5-3.0 t·ha<sup>-1</sup>) compared to the hulled varieties (4.1-5.4 t·ha<sup>-1</sup>), which was a consequence of the weaker emergence and small density of canopy. In 2015 favorable distribution of rainfall during a critical period for the development of oats allowed to get a good compactness of crop canopy, which together with the lack of fungal diseases provided the high productivity of this species.

2. In both years of research hulled varieties yielded higher than the naked varieties (on average by 66%). Among the naked varieties the highest yield was obtained for Maczo variety (average 3.76 t·ha<sup>-1</sup>) and Siwek in Grabow (3.84 t·ha<sup>-1</sup>) and the lowest for Cacko (2.94 t·ha<sup>-1</sup>), due to the smallest density of plants and ears.

3. Differences in the intensity of oat infestation between the localizations of experiments and oat varieties were found. Hulled oat varieties: Bingo and Krezus were characterized by greater competitiveness against weeds compared to the naked varieties (13% fewer weeds and 40% less dry weight of weeds).

4. The greater competitive ability against weeds of hulled oat varieties compared to the naked varieties was the result of bigger plant and ears density, greater dry matter of underground parts and the height of plants.

5. Studies have shown a negative correlation between weeds and oat dry matter, tillering and the height. Oat yield was negatively correlated with the number and dry matter of weeds ( $r = -0.650$  and  $-0.583$ ).

6. Assessment of leaf infection of examined oat varieties in milky-wax maturity stage in 2014 showed moderate intensity of corona rust and leaf spot as well as slight degree of *Septoria* diseases while in 2015 showed no symptoms. The symptoms of *Fusarium* disease in both years occurred sporadically and showed no statistically significant differences between varieties.

#### 5. References

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