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Elżbieta PISULEWSKA[1], Ryszard PORADOWSKI[2]
and Robert WITKOWICZ[1]

EFFECT OF SOWING DENSITY ON THE YIELD AND CHEMICAL COMPOSITION OF OAT GRAINS

WPŁYW GĘSTOŚCI SIEWU NA PLON I SKŁAD CHEMICZNY ZIARNA OWSA

Abstract: The research were aimed at determining the effect of sowing density on the yield and chemical composition of grain of two common oat forms. Two-factorial field experiment was set up on brown alluvial soils in 1999–2001 in southern Poland. The first experimental factor included 2 forms of oat: husked oat (cv. Dukat) and naked oats (2 genotypes POB-W-481, POB-W-492 and cv. Akt). The second factor included two levels of sowing density: 450 grains per 1 m^2 and 550 grains per 1 m^2. The analyzed forms differed significantly in their grain yields. The husked cv. Dukat (average yield for 3 years 3.62 $Mg \cdot ha^{-1}$) in all years of the experiment yielded 16.7–30 % higher when compared with cv. Akt (average yield for 3 years 2.97 $Mg \cdot ha^{-1}$) and the naked genotypes (average yield for 3 years POB-W-481 3.02 $Mg \cdot ha^{-1}$, POB-W-492 2.99 $Mg \cdot ha^{-1}$). Higher sowing density favorably increased the number of panicles formed per area unit (450 grains per m^2 – 319, 550 grains per m^2 – 333 panicles per m^2) and therefore gave higher grain yields (450 grains per m^2 – 3.09 $Mg\ h^{-1}$, 550 grains per m^2 – 3.21 $Mg \cdot ha^{-1}$). The compared cultivars differed considerably in their content of K, P, Ca and Mg. The naked forms had higher concentrations of K, P and Ca but lower of Mg. The analyzed sowing quantities did not affect significantly the content of macroelements in oat grain. However, in the first year of the trial significantly higher P and Mg contents were noted at lower sowing density.

Keywords: naked oats, husked oats, sowing density, grain yield, chemical composition

One of the main determinants of grain yield and a basic element of oat yield structure is sowing density [1, 2]. In addition, sowing density is the main factor determining the number of panicles per area unit [2, 3]. Technology of oat cultivation in the COBORU

[1] Department of Crop Production, University of Agriculture in Krakow, al. A. Mickiewicza 21, 31–120 Kraków, Poland, phone: +48 12 662 43 85, fax: +48 12 662 43 82, email: elzbieta.pisulewska@ar.krakow.pl

[2] Agricultural College in Nawojowa, Nawojowa 348, 33–335 Nawojowa, Poland, phone: +48 18 445 70 76, email: secretariat@nawojowa.edu.pl

experiments assumes 500 germinating grains per area unit (m^2), irrespective of cultivar variety or habitat conditions. It results in elimination of too many experimental factors. However, in practice the sowing density should be adjusted to soil and climatic conditions, the sowing material used, the date of sowing and above all to the oat form and/or cultivar.

It has been assumed that in comparison with the other cereal species oat is particularly abundant in Ca, Fe, Zn and Mn, therefore it may be an important source of these minerals in human nutrition [4, 5].

The aim of the experiment was to assess grain yield and macroelement concentrations in grain of 2 oat forms: husked (cv. Dukat) and naked oats (2 genotypes POB-W-481, POB-W-492 and cv. Akt.), as affected by different sowing density.

Material and methods

The experiments were carried out over a 3-year period (1999–2001) using a split-plot design with 4 replications in Nawojowa near Nowy Sacz. The first experimental factor involved two forms of oat: husked cv. Dukat, and naked oats (genoptypes POB-W-481, POB-W-492 and cv. Akt). The second factor involved two sowing densities: lower 450 grains per m^2 and higher 550 grains per m^2. The forecrop for oat was winter wheat; after its harvesting first ploughing combined with harrowing was conducted, and subsequently winter ploughing in autumn. Soil loosening and harrowing were conducted in spring preceded by mineral fertilization. The soil abundance in P, K and Mg [mg/100 g] in the successive years of the experiment was as follows: 1999 – 30, 37, 15; 2000 – 18, 28.4, 11.9; 2001 – 6.5, 15.0, 11.5. Harrowing was made after sowing. Weed control was conducted at the tillering stage using Chwastox Turbo dosed at 2 dm^3/ha. The dates of sowing in the successive years differed greatly due to the weather conditions. (Table 1).

Table 1

Time of sowing of oat in the successive years of the experiment

Year	1999	2000	2001
Day and months	31 March	17 April	18 April

Prior to harvesting the number of grains per panicle and number of panicles per area unit were counted. Subsequently grain samples were collected, and the 1000 grain weight [g] was determined. Grain samples were analysed for macroelements (K, P, Ca, Mg, Na) using 989 Solar atomic absorption spectrophotometer (Unican). The data were subjected to ANOVA using STAT Skierniewice programme [6]. The significance of differences between means was detected using Tukey test at the level of $\alpha = 0.05$.

The course of weather condition in the successive years of the field experiment was presented in Figs. 1 and 2.

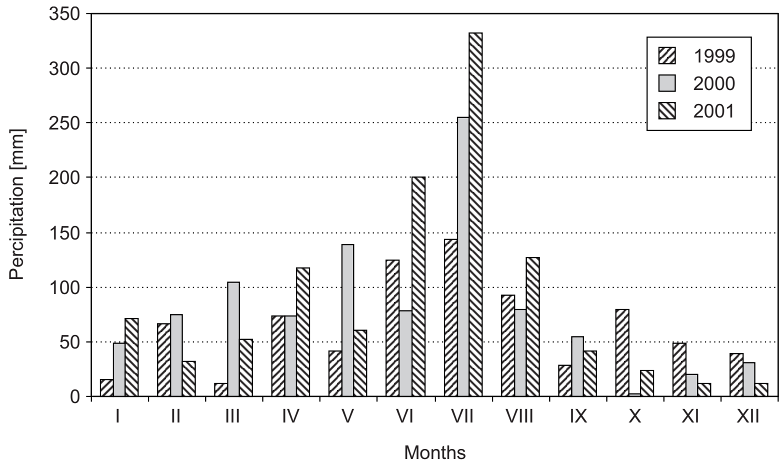

Fig. 1. Precipitations during the vegetation seasons 1999–2001

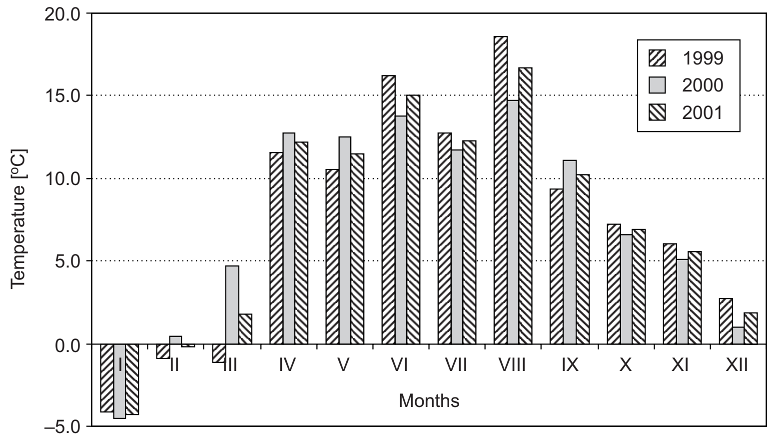

Fig. 2. Temperatures during the successive vegetation seasons 1999–2001

Results and discussion

The analyzed oat forms differed significantly in their grain yields. In all years of the experiment husked oat cv. Dukat gave 16.7 to 30 % higher yields than cv. Akt. and naked oat genotypes (Table 2). The course of the weather conditions was different in successive seasons. Notably, the first year of field experiments (1999) with lower precipitations and higher average air temperatures than in the years 2000 and 2001,

Table 2

Effect of years of the experiment and forms of oat on grain yield and its components

Years	Oat forms	Grain yield [Mg ha^{-1}]	Number of panicles per sq. meter	Number of grains per panicle	Mass of 1000 seeds [g]
1999	Dukat	4.02	356.4	34.5	28.6
	Akt	3.41	389.7	38.3	25.5
	POB-W-481	3.32	332.9	34.9	24.9
	POB-W-492	3.49	344.1	38.5	26.5
LSD for oat forms		0.36	35.4	3.3	2.8
2000	Dukat	3.64	363.4	34.6	39.7
	Akt	3.29	343.2	34.6	27.3
	POB-W-481	3.13	396.3	31.4	28.3
	POB-W-492	3.03	341.9	33.5	29.3
LSD for oat forms		0.30	56.1	ns	2.3
2001	Dukat	3.19	260.4	36.3	36.9
	Akt	2.21	276.5	36.9	27.7
	POB-W-481	2.65	270.3	37.7	25.9
	POB-W-492	2.45	235.8	36.6	27.6
LSD for oat forms		0.28	29.9	ns	3.7
Means for years 1999–2001	Dukat	3.62	326.7	35.1	35.1
	Akt	2.97	336.4	36.6	26.8
	POB-W-481	3.02	333.2	34.6	26.3
	POB-W-492	2.99	307.5	36.2	27.8
LSD for oat forms		0.16	23.5	1.9	1.4

n.s. – non significant

favorably affected the obtained yields (Figs. 1 and 2). From among the compared yield structure components, the number of panicles formed per area unit and *thousand grain weight* (TGW) proved statistically significant. High weight of a thousand grains of husked oat cv. Dukat had a significant influence on higher yields of this variety in all years of the experiment. Despite the largest number of panicles formed and number of grains per panicle, but very small TGW, cv. Akt gave the smallest yields among the compared cultivars and genotypes. Taking into account soil and adverse climatic conditions of the experimental site (Nawojowa), grain yields obtained in the present experiment can be considered good as compared with the yields commonly generated under sub-mountain conditions [7].

Greater sowing density (550 grains per m^2) favorably affected grain yields resulting in an increase in the number of panicles formed per area unit and subsequently greater grain yields (Table 3). On the other hand, different sowing densities had no effect on other components of yield structure: number of grains per panicle and TGW. Latest literature data concerning the influence of oat sowing density on grain yields are greatly diversified. Walens [8] who investigated the effect of nitrogen fertilization and sowing density on the amount and quality of husked and naked oats grain yield showed that increasing sowing density (400, 500 and 600 grains/m^2) had no effect on the yield of either husked cv. Deresz or naked cv. Akt. On the other hand, Dubis and Budzynski [9] demonstrated a significant increase in grain yield of cv. Akt as resulting from increased sowing density from 400 to 800 grains/m^2. Kozlowska-Ptaszynska et al [3] and Tobiasz-Salach and Bobrecka-Jamro [2], Leszczynska and Noworolnik [10] obtained similar results in studies on naked forms of oat. In case of husked forms, both Kozlowska-Ptaszynska et al [3] and Scigalska [11] state that traditional cultivars may produce satisfactory yields at a lower sowing density (ie 400 grains per m^2).

Table 3

Effect of years of the experiment and sowing density on grain yield its components

Years	Sowing density [grains per sq. meter]	Grain yield [Mg · ha^{-1}]	Number of panicles per sq. meter	Number of grains per panicle	Mass of 1000 seeds [g]
1999	450 550	3.52 3.60	347.4 364.4	37.3 35.8	26.0 26.7
LSD for sowing density		n.s.	n.s.	n.s.	n.s.
2000	450 550	3.26 3.28	352.3 370.1	33.9 33.1	31.1 31.1
LSD for sowing density		n.s.	n.s.	n.s.	n.s.
2001	450 550	2.50 2.75	256.9 264.6	36.7 37.0	29.5 29.5
LSD for sowing density		0.15**	n.s.	n.s.	n.s.
Means for years 1999–2001	450 550	3.09 3.21	318.9 333.0	36.0 35.3	28.9 29.1
LSD for sowing density		0.11	11.1	n.s.	n.s.

n.s. – non-significant.

The analyzed oat cultivars and genotypes differed significantly in their grain concentrations of K, P, Ca and Mg (Table 4). Naked oat forms had higher content of K, P and Ca but lower Mg in comparison with the husked forms; only in case of Na no statistically significant differences were found. From among the four compared cultivars and genotypes, the highest K and Ca concentrations were found in the naked cv. Akt. High concentrations of P, Mg, and Na were found in naked POB-W-481 genotypes.

The two sowing densities tested in the present experiment did not markedly affect the content of macroelements in oat grain, although in the first year of the investigations a significantly higher concentrations of P and Mg were registered at lower sowing quantity (Table 5). The content of macroelements in grain of the analyzed oat cultivars and genotypes is comparable to the results obtained by Pisulewska et al [5] in studies on chemical composition of cultivars and genotypes of common oats with yellow and brown-coloured husks and to the results presented by Witkowicz and Antonkiewicz [12] who analyzed the influence of five other agronomic factors on the content of mineral elements. The present results confirm the opinion that oat is a very good source of minerals and should be used in a far greater degree in human nutrition than has been used so far [4].

Table 4

The content of macroelements (g/kg d.m.) in different forms of oat in years 1999–2001

Years	Oat forms	Content				
		K	P	Ca	Mg	Na
1999	Dukat	2.473	3.01	0.677	0.826	0.018
	Akt	2.780	4.23	0.711	0.953	0.019
	POB-W-481	2.685	4.15	0.652	1.007	0.020
	POB-W-492	2.800	4.34	0.67.	0.974	0.017
LSD for oat forms		n.s.	0.07	0.050	0.039	n.s.
2000	Dukat	4.135	3.12	0.362	0.593	0.026
	Akt	4.125	3.85	0.331	0.682	0.024
	POB-W-481	4.103	4.04	0.279	0.703	0.024
	POB-W-492	4.100	4.03	0.288	0.681	0.026
LSD for oat forms		n.s.	0.54	n.s.	0.071	n.s.
2001	Dukat	3.618	3.36	0.759	0.871	0.026
	Akt	4.143	4.23	0.767	1.114	0.026
	POB-W-481	4.035	4.27	0.695	1.115	0.026
	POB-W-492	3.963	4.04	0.737	1.097	0.023
LSD for oat forms		0.514	0.92	0.066	0.038	n.s.
Means for years 1999–2001	Dukat	3.408	3.17	0.599	0.763	0.023
	Akt	3.683	4.11	0.603	0.916	0.023
	POB-W-481	3.608	4.15	0.542	0.941	0.023
	POB-W-492	3.621	4.15	0.565	0.917	0.022
LSD for oat forms		0.171	0.23	0.022	0.019	n.s.

n.s. – non-significant.

Table 5

Effect of years of the experiment and sowing density on content of macroelements in oat grain

Years	Sowing density [grains per sq. meter]	Content				
		K	P	Ca	Mg	Na
19993	450	2.720	4.00	0.686	0.948	0.019
	550	2.649	3.88	0.670	0.932	0.018
LSD for sowing density		n.s.	0.04	n.s.	0.012	n.s.
2000	450	4.134	3.77	0.320	0.654	0.025
	550	4.098	3.75	0.310	0.675	0.025
LSD for sowing density		n.s.	n.s.	n.s.	1.3	n.s.
2001	450	3.968	3.89	0.743	1.050	0.025
	550	3.911	4.06	0.736	1.047	0.025
LSD for sowing density		n.s.	n.s.	n.s.	n.s.	n.s.
Means for years 1999–2001	450	3.607	3.89	0.583	0.884	0.023
	550	3.553	3.90	0.572	0.885	0.023
LSD for sowing density		n.s.	n.s.	n.s.	n.s.	n.s.

n.s. – non-significant.

Conclusions

1. The studied forms of oat forms ie husked cv. Dukat, naked cv. Akt and two naked oat genotypes (POB-W-481 and POB-W-492) responded differently to the course of weather conditions in the successive years of the experiment. The husked cultivar gave the highest yields in the year with the greatest precipitations (2001), whereas the naked oat forms produced the highest yields in the season with the lowest precipitations (1999).

2. Of the two tested sowing densities, higher sowing density favorably affected the grain yields resulting from an increase in the number of panicles formed per area unit.

3. The tested naked forms of oat differed significantly in concentrations of K, P, Ca and Mg in grain in comparison with the husked form.

4. Different sowing densities had no effect on macroelement content in grain of the tested oat forms.

References

[1] Budzyński W., Wróbel E. and Dubis B.: *Reakcja owsa nagiego na czynniki agrotechniczne.* Żywność, Nauka, Technologia, Jakość 1999, **1**(18), 97–103.
[2] Tobiasz-Salach R. and Bobrecka-Jamro D.: *Wpływ gęstości siewu na plonowanie owsa oplewionego i nagoziarnistego*. Fragm. Agron. 2002, **2**(74), 71–78.
[3] Kozłowska-Ptaszyńska Z., Pawłowska J. and Woch J.: Termin i gęstość siewu nowych odmian owsa. Wyd. IUNG, Puławy 1997, 12–24.
[4] Ciołek A., Makarski B., Makarska E. and Zadura A.: *Content of some nutrients in new black oat strains*. J. Elementol. 2007, **12**(4), 251–259.
[5] Pisulewska E., Poradowski R., Antoniewicz J. and Witkowicz R.: *Wpływ zróżnicowanego nawożenia mineralnego na plon oraz skład mineralny ziarna owsa oplewionego i nagoziarnistego*. J. Elementol. 2009, **14**(4), 763–772.
[6] Filipiak K. and Wilkos S.: Obliczenia statystyczne opis systemu AWAR. Wyd. IUNG, Puławy 1995.
[7] Klima K. and Pisulewska E.: *Kształtowanie się komponentów struktury plonu ziarna owsa uprawianego w warunkach górskich w siewie czystym i mieszankach*. Roczn. AR w Poznaniu, Roln. 2000, **58(**325), 39–47.
[8] Walens M.: *Wpływ nawożenia azotowego i gęstości siewu na wysokość i jakość plonu ziarna owsa oplewionego i nagoziarnistego*. Biul. Instyt. Hodow. Aklimat. Rośl. 2003, **229**, 115–123.
[9] Dubis B. and Budzyński W.: *Reakcja owsa nagoziarnistego i oplewionego na termin i gęstość siewu*. Biul. Instyt. Hodow. Aklimat. Rośl. 2003, **229**, 139–145.
[10] Leszczyńska D. and Noworolnik K.: *Wpływ nawożenia azotem i gęstości siewu na plonowanie owsa nagoziarnistego*. Żywność 2010, **3**(70), 197–204.
[11] Ścigalska B.: *Plonowanie odmian owsa w zależności od gęstości siewu w warunkach regionu południowo-wschodniego*. Żywność, Nauka, Technologia, Jakość, PTTŻ 1999, **1**(18), 153–160.
[12] Witkowicz R. and Antonkiewicz J.: *Influence of selected agronomic measures on the content of some mineral elements in grain of naked oat (Avena sativa L.).* Acta Sci. Polon. 2009, **8**(4), 63–73.

WPŁYW GĘSTOŚCI SIEWU NA PLON I SKŁAD CHEMICZNY ZIARNA OWSA

[1] Katedra Szczegółowej Uprawy Roślin, Uniwersytet Rolniczy w Krakowie
[2] Zespół Szkół Rolniczych w Nawojowej

Abstrakt: Celem badań było określenie wpływu gęstości siewu na plon oraz skład chemiczny ziarna dwóch form owsa siewnego. Dwuczynnikowe doświadczenia polowe zakładano na madach rzecznych brunatnych w latach 1999–2001 w Polsce Południowej. Pierwszym czynnikiem badawczym były dwie formy owsa: oplewiona (odmiana Dukat) oraz nieoplewiona (2 rody POB-W-481, POB-W-492 i odmiana Akt). Czynnikiem drugim była zróżnicowana gęstość siewu: 450 ziaren na 1 m^2 i 550 ziaren na 1 m^2. Badane formy różniły się istotnie plonami ziarna. Oplewiona odmiana Dukat (średni plon z 3 lat 3,62 $Mg \cdot ha^{-1}$) we wszystkich latach prowadzenia doświadczeń plonowała wyżej o 16,7 – 30 % w porównaniu z odmianą Akt (średni plon z 3 lat 2,97 $Mg \cdot ha^{-1}$) i rodami nieoplewionymi (średni plon z 3 lat POB-W-481 3,02 $Mg \cdot ha^{-1}$, POB-W-492 2,99 $Mg \cdot ha^{-1}$). Większa gęstość siewu korzystnie wpłynęła na podniesienie liczby wiech wykształconych na jednostce powierzchni (450 ziaren na 1 m^2 – 319, 550 ziaren na 1 m^2 – 333 wiechy na 1 m^2) a tym samym na wyższe plony ziarna (450 ziaren na 1 m^2 – 3,09 $Mg \cdot h^{-1}$, 550 ziaren na 1 m^2 – 3,21 $Mg \cdot ha^{-1}$). Porównywane odmiany różniły się istotnie zawartością K, P, Ca i Mg. Formy nieoplewione miały wyższą zawartość K, P i Ca, ale niższą Mg. Badana gęstość siewu nie wpłynęła istotnie na zawartość makroskładników w ziarnie, chociaż w 1 roku badań stwierdzono istotnie większą zawartość P i Mg przy niższej ilości wysiewu.

Słowa kluczowe: owies nieoplewiony, owies oplewiony, plon ziarna, gęstość siewu, skład chemiczny