Acta Sci. Pol., Agricultura 8(4) 2009, 63-73

# INFFLUENCE OF SELECTED AGRONOMIC MEASURES ON THE CONTENT OF SOME MINERAL ELEMENTS IN GRAIN OF NAKED OAT (*Avena sativa* L.)

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**Abstract**. Field experiments were conducted in two localities: Prusy (50°07' N; 20°04' E – one experiment) and Wierzbica (50°29' N; 19°45' E – two experiments) in 2003. The objective of this study was to analyse the influence of agronomic factors on the grain yield and on the content of macroelements in grain of different forms of naked oat. In Wierzbica the grain yield was determined statistically by the genotype, the phosphorus and potassium fertilization and the application of the plants growth regulator Moddus. In Prusy grain yield was determined only by the genotype (cultivars, strains). A concentration of macroelements in forms of oat was statistically different. In both localities the phosphorus and potassium fertilization and foliar application of urea, in general, had not the statistical influence on the content of the macroelements. An exception is the influence of the foliar application of urea on the content of potassium. Plant growth regulator Moddus caused changes in the content of macroelements. These changes were not always statistically significant, but always increased the concentration of macroelements. The second plant growth regulator Promalin did not cause changes in the concentration of macroelements.

**Key words**: foliar application of fertilizers, mineral elements, naked oat, plant growth regulator

## INTRODUCTION

Oat grain, due to its chemical composition and resulting therapeutic, preventive, dietary and nutritional properties, arouses a growing interest as functional food [Gibiński et al. 1999, Rzedziecki 1999]. It can also be applied to animal feeding and naked forms are particularly useful as fodder for swine and poultry [Fabijańska et al. 2003]. Oat is a rich source of macro- and microelements, which increase the biological value of this plant [Bartnikowska et al. 2000, Givens et al. 2004]. Basic agronomical measures, such as mineral fertilization, application of growth regulators, as well as the

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genotype, have an effect on the content of macroelements in agricultural crops [Biel et al. 2006; Korzeniowska and Stanisławska-Glubiak 2006]. Analyses of mineral element content in the grain of naked forms better illustrate the influence of research factors on their concentration due to the lack of modifying effect of the husk.

The aim of this study was to estimate the influence of genotype, mineral fertilization and growth regulators on yield and the content of magnesium, calcium, sodium, potassium and phosphorus in the grain of naked oat.

## MATERIAL AND METHODS

Field experiments with oat were carried out in two localities: Prusy near Kraków (50°07’ N; 20°04’ E – one experiment) and Wierzbica (50°29’ N; 19°45’ E – two experiments) in 2003. Agronomical measures did not differ from the generally accepted and applied rules. In both localities the level of fertilization rates resulted from the assumed yield of naked oat yield at a height of 4 $t \cdot ha^{-1}$ and from the abundance of habitat. Foliar application of nitrogen (17 $kg \cdot ha^{-1}$ in Wierzbica and 9 $kg \cdot ha^{-1}$ in Prusy) constituted ¼ of nitrogen fertilization applied to soil. In Prusy, a second rate of nitrogen, also in an amount of 9 $kg \cdot ha^{-1}$, was applied additionally in the combination with a high level of fertilization.

In Wierzbica, the field experiments were established according to the fractional plan $2^{n-1}$ in two replications, where the number of factors n = 5, and each factor was conducted on two levels (k = 2). The size of a plot was 6 $m^2$, but the grain yield and yield components were evaluated on the basis of a trial area of 1 $m^2$. Sowing density amounted to 500 germinating grains per 1 $m^2$. Experimental factors along with their levels were presented in Table 1. The experiment was located on a typical brown soil, classified in quality IV with pH 5.4.

Table 1. Agronomical factors and their levels in experiments conducted in Wierzbica
Tabela 1. Czynniki i ich poziomy w doświadczeniach prowadzonych w Wierzbicy

| Agronomical factors<br>Czynniki agrotechniczne | Genotype and the factor levels – Genotyp i poziomy czynnika | |
|---|---|---|
| | low – niski | high – wysoki |
| Genotype – Genotyp<br>(experiment I – eksperyment I) | strain – ród STH 4770 | cultivar – odmiana Akt |
| Genotype – Genotyp<br>(experiment II – eksperyment II) | strain – ród STH 7000 | cultivar – odmiana Akt |
| Nawożenie PK – PK fertilization | 0 $kg \cdot ha^{-1}$ PK | 226 $kg \cdot ha^{-1}$ PK |
| Foliar application of urea<br>Nawożenie dolistne mocznikiem | 0 $kg \cdot ha^{-1}$ N | 17 $kg \cdot ha^{-1}$ N |
| Plant growth regulator Moddus<br>Regulator wzrostu Moddus | 0 $dm^3 \cdot ha^{-1}$ | 0.4 $dm^3 \cdot ha^{-1}$ |
| Plant growth regulator Promalin<br>Regulator wzrostu Promalin | 0 $dm^3 \cdot ha^{-1}$ | 0.15 $dm^3 \cdot ha^{-1}$ |

The experiment conducted in Prusy was established according to the fractional plan $3^{n-1}$ in two replications, where the number of factors n = 4, and each factor was conducted on three levels (k = 3). Experimental factors along with their levels have been presented in Table 2. The size of a plot for harvesting amounted to 10 $m^2$. Sowing density was 500 germinating grains per 1 $m^2$. The soil of the experimental field was composed of degraded chernozem classified in quality class I with pH 6.8.

Table 2. Agronomical factors and their levels in experiment conducted in Prusy
Tabela 2. Czynniki i ich poziomy w doświadczeniu prowadzonym w Prusach

| Agronomical factors Czynniki agrotechniczne | The factor levels – Poziomy czynnika | | |
|---|---|---|---|
| | low – niski | average – średni | high – wysoki |
| Genotype – Genotyp | strain – ród STH 7000 | cultivar – odmiana Akt | strain – ród STH 4770 |
| PK fertilization – Nawożenie PK | 0 kg·ha$^{-1}$ PK | 72 kg·ha$^{-1}$ P | 256 kg·ha$^{-1}$ PK |
| Foliar application of urea Nawożenie dolistne mocznikiem | 0 kg·ha$^{-1}$ N | 9 kg·ha$^{-1}$ N | 18 kg·ha$^{-1}$ N |
| Plant growth regulator Moddus Regulator wzrostu Moddus | 0 dm$^3$·ha$^{-1}$ | 0.4 dm$^3$·ha$^{-1}$ | 0.6 dm$^3$·ha$^{-1}$ |

Strains selected for the study showed some specific properties such as an increased 1000 grain weight (STH 4770) and the shortened stem (STH 7000). In all the experiments the naked cultivar Akt was the control cultivar to which the new breeding strains were compared.

Oats grain from each replication was subjected to dry mineralization in a muffle oven at 550$^o$C. The content of Mg, Ca, Na, K and P in the ash obtained was determined with the ICP-AES method (inductively coupled plasma – atomic emission spectrophotometry).

The results obtained were analysed statistically using the procedure of the analysis of variance for multifactorial experiments. Only main sources of variability were considered in the analysis of variance model, excluding the interactions, due to their mainly slight effect on the variability of analysed features. In the case of the experiment conducted in Prusy, where each factor occurred on three levels, the variability of factors was resolved into linear and square components. Evaluation of the formulated null working hypotheses $H_0$: $\sum_{i=1}^{k} k_i^2 = 0$ was carried out on the basis of the F-Fisher-Snedecor test. Before carrying out the analyses of variance, the consistence of the distribution of characters with the normal distribution was tested by means of the Kołmogorow--Smirnow test; and the assumption of variance of error homogeneity by means of the chi-square Bartlett test. Using models of variance analyses, the analysis of multiple regression was also carried out. For an easier comparison of the effect of particular factors, standardized regression coefficients, whose statistical significance confirms the statistically significant effect of the suitable source of variability, were presented in the tables [Stanisz 1998].

Analysis of the amount and distribution of rainfall confirmed more favourable conditions for growth and development of oat plants cultivated in Wierzbica where less rainfall deficiencies occurred in particular months of growth in relation to the requirement (Table 3). In Wierzbica, the course of rainfall lowered curve in relation to the curve of mean temperatures indicates four ten-day periods completely meeting oats water needs (1-10, 21-30 April, 11-20 May and 1-10 July), whereas in Prusy, there were only two and adjoining periods (11-20 and 21-30 May) (Figs 1, 2). Analysis of the course of the rainfall lowered curve in relation to the lowered curve of water needs according to Dzieżyc [1989] rather indicates they were satisfied (in Prusy, only up to the 10$^{th}$ of June). In Prusy, the occurrence of rainfall deficiency was noted more frequently in relation to moisture conditions from the long-time period. This unfavourable arrangement of rainfall in Prusy could be slightly reduced by the fact of lower temperatures occurring in months with water deficit in relation to the long term period, which certainly reduced evapotranspiration.

Table 3. Rainfall and air temperature in 2003
Tabela 3. Opady atmosferyczne i temperatura powietrza w 2003 roku

| Indicator – Wskaźnik | Month – Miesiąc | | | | Sum Suma |
|---|---|---|---|---|---|
| | April Kwiecień | May Maj | June Czerwiec | July Lipiec | |
| The oats water needs*, mm Potrzeby wodne owsa* | 60.0 | 78.0 | 90.0 | 72.0 | 300.0 |
| Rainfall – Opady, mm Wierzbica | 50.9 | 95.0 | 29.7 | 94.2 | 269.8 |
| Deficit/overflow, mm Niedobór/nadmiar | -9.1 | +17.0 | -60.3 | +22.2 | -30.2 |
| Rainfall – Opady, mm Prusy | 40.9 | 92.3 | 40.0 | 44.8 | 218.0 |
| Deficit/overflow, mm Niedobór/nadmiar | -19.1 | +14.3 | -50.0 | -27.2 | -82.0 |
| 1961-1990 Prusy (rainfall – opady, mm) | 48.0 | 67.0 | 88.0 | 90.0 | 293.0 |
| Temperature – Temperatura, °C Prusy | 7.0 | 14.1 | 15.4 | 17.9 | – |
| 1961-1990 Prusy (temperature – temperatura, °C) | 7.9 | 13.1 | 16.2 | 17.5 | – |

* according to Dzieżyc [1993] – według Dzieżyca [1993]

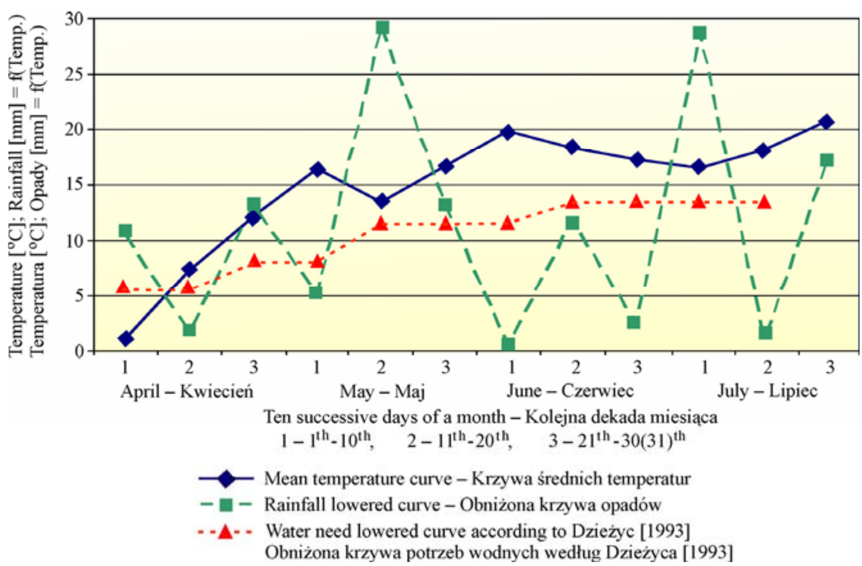


Fig. 1. Weather's diagram for the growth periods in Wierzbica
Rys. 1. Diagram pogodowy dla doświadczenia w Wierzbicy

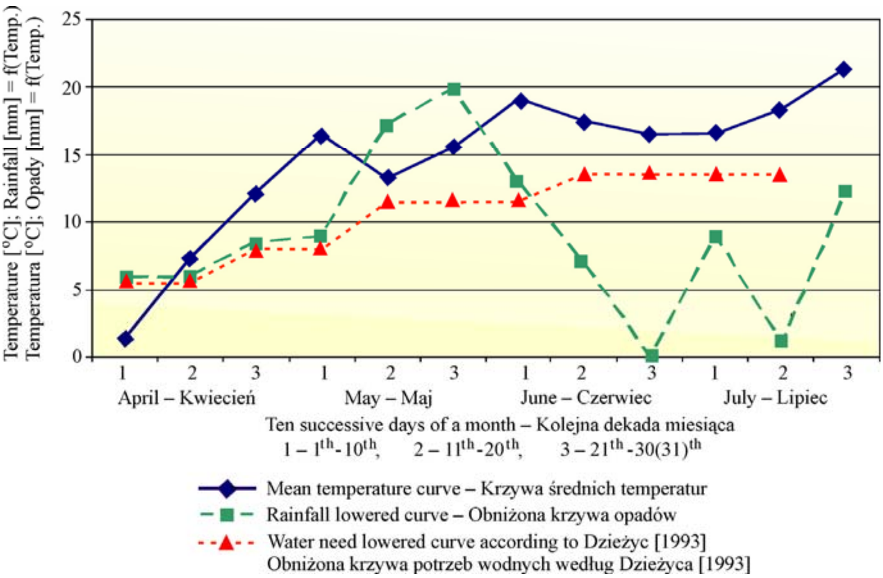


Fig. 2. Weather's diagram for the growth periods in Prusy
Rys. 2. Diagram pogodowy dla doświadczenia w Prusach

## RESULTS AND DISCUSSION

The experiments conducted indicated the effect of selected agronomical measures on oat grain yield (Tables 4, 5). In Wierzbica, the analysis of presented standardized regression coefficients allows the estimation of the statistically significant influence of only linear effects of cultivar/strain selection, phosphorus and potassium fertilization and the application of the growth regulator Moddus on oat grain yield. Both strain STH 4770 (high) and STH 7000 (dwarf) yielded lower than the cultivar Akt and in both cases the difference was statistically significant. In Prusy, the grain yield was determined mostly by the cultivar/strain selection. Dwarf strain STH 7000 gave a considerably lower yield than the cultivar Akt which, in turn, had a slightly lower yield than strain STH 4770. In the light of other studies, the yields obtained in the present experiments should be considered very high [Walens 2003, Maciorowski et al. 2006a, Szmigiel and Oleksy 2006, Tobiasz-Salach et al. 2007], although still higher yields in a micro-plot experiment were reported by Szumiło and Rachoń [2006]. The other agronomical factors tested did not cause statistically significant changes in the amount of grain yield. Under conditions of the poorer habitat in Wierzbica, a change in PK fertilization level considerably increased grain yield by 0.414 (experiment I) and by 0.474 (experiment II) standard deviation units at the lack of the effect of this factor in Prusy. Application of the regulator Moddus caused a particular reduction in oat yield in an experiment with dwarf strain STH 7000 (by 0.46 standard deviation units). In a study by Maciorowski et al. [2006b], in which dwarf forms were not present, a negative effect of the growth regulator Moddus and CCC was not found either. Despite considerable differences between habitats, the yields obtained should be considered comparable, taking into account the fact that in Wierzbica the experiments were conducted on the basis of micro-plots.

Table 4. The yield of oats grain [g·m$^{-2}$], the content of microelements [g·kg$^{-1}$ d.m.] and regression coefficients for experiments conducted in Wierzbica
Tabela 4. Plon [g·m$^{-2}$], zawartość makroskładników [g·kg$^{-1}$ s.m.] w ziarnie owsa oraz współczynniki regresji dla doświadczeń prowadzonych w Wierzbicy

| Factor<br>Czynnik | Experiment I – Doświadczenie I | | | Experiment II – Doświadczenie II | | |
|---|---|---|---|---|---|---|
| | The factor level and standardized regression coefficient<br>Poziom czynnika oraz standaryzowany współczynnik regresji | | | | | |
| | low<br>niski | high<br>wysoki | coefficient<br>współczynnik | low<br>niski | high<br>wysoki | coefficient<br>współczynnik |
| Grain yield – Plon ziarna | | | | | | |
| Cultivar/strain – Odmiana/ród | 505.64 | 567.25 | 0.465** | 500.21 | 567.25 | 0.394** |
| PK | 509.02 | 563.87 | 0.414* | 493.35 | 574.10 | 0.474** |
| N | 544.19 | 528.69 | -0.117 | 536.52 | 530.94 | -0.033 |
| Moddus | 537.68 | 535.21 | -0.019 | 572.91 | 494.54 | -0.460** |
| Promalin | 538.61 | 534.28 | -0.033 | 536.82 | 530.64 | -0.036 |
| Magnesium – Magnez | | | | | | |
| Cultivar/strain – Odmiana/ród | 2.10 | 2.09 | -0.049 | 1.99 | 2.09 | 0.420** |
| PK | 2.12 | 2.07 | -0.270 | 2.06 | 2.02 | -0.154 |
| N | 2.07 | 2.12 | 0.291 | 2.00 | 2.08 | 0.307* |
| Moddus | 2.05 | 2.15 | 0.538** | 1.98 | 2.10 | 0.459** |
| Promalin | 2.11 | 2.09 | -0.123 | 2.04 | 2.04 | -0.012 |
| Calcium – Wapń | | | | | | |
| Cultivar/strain – Odmiana/ród | 0.82 | 0.97 | 0.780** | 1.04 | 0.97 | -0.411* |
| PK | 0.88 | 0.91 | 0.124 | 1.02 | 1.00 | -0.101 |
| N | 0.90 | 0.89 | -0.007 | 0.99 | 1.02 | 0.142 |
| Moddus | 0.89 | 0.90 | 0.048 | 1.00 | 1.02 | 0.111 |
| Promalin | 0.90 | 0.89 | -0.014 | 1.00 | 1.01 | 0.043 |
| Sodium – Sód | | | | | | |
| Cultivar/strain – Odmiana/ród | 0.024 | 0.020 | -0.148 | 0.045 | 0.020 | -0.526** |
| PK | 0.022 | 0.022 | 0.011 | 0.030 | 0.035 | 0.112 |
| N | 0.021 | 0.023 | 0.097 | 0.033 | 0.032 | -0.018 |
| Moddus | 0.016 | 0.028 | 0.401* | 0.026 | 0.039 | 0.286 |
| Promalin | 0.018 | 0.026 | 0.280 | 0.028 | 0.037 | 0.194 |
| Potassium – Potas | | | | | | |
| Cultivar/strain – Odmiana/ród | 1.32 | 1.40 | 0.283 | 1.57 | 1.40 | -0.359* |
| PK | 1.35 | 1.37 | 0.044 | 1.45 | 1.52 | 0.162 |
| N | 1.32 | 1.41 | 0.307* | 1.45 | 1.52 | 0.154 |
| Moddus | 1.29 | 1.44 | 0.511** | 1.36 | 1.61 | 0.542** |
| Promalin | 1.34 | 1.39 | 0.165 | 1.47 | 1.50 | 0.075 |
| Phosphorus – Fosfor | | | | | | |
| Cultivar/strain – Odmiana/ród | 3.71 | 3.70 | -0.029 | 3.92 | 3.70 | -0.246 |
| PK | 3.64 | 3.76 | 0.136 | 3.80 | 3.81 | 0.009 |
| N | 3.70 | 3.70 | 0.006 | 3.82 | 3.79 | -0.031 |
| Moddus | 3.57 | 3.83 | 0.305 | 3.67 | 3.94 | 0.283 |
| Promalin | 3.79 | 3.62 | -0.199 | 3.92 | 3.69 | -0.242 |

* significant at P = 0.05 – istotne na poziomie P = 0.05
** significant at P = 0.01 – istotne na poziomie P = 0.01

Table 5. The yield of oats grain [t·ha$^{-1}$], the content of macroelements [g·kg$^{-1}$ d.m.] and regression coefficients for experiment conducted in Prusy

Tabela 5. Plon [t·ha$^{-1}$], zawartość makroskładników [g·kg$^{-1}$ s.m.] w ziarnie owsa oraz współczynniki regresji dla doświadczenia prowadzonego w Prusach

| Factor<br>Czynnik | The factor level<br>Poziom czynnika | | | Standardized regression coefficients of effects<br>Standaryzowane współczynniki regresji efektów | | |
|---|---|---|---|---|---|---|
| | low<br>niski | average<br>średni | high<br>wysoki | linear<br>liniowych | quadratic<br>kwadratowych | constant<br>stała |
| Grain yield – Plon ziarna | | | | | | |
| Cultivar/strain – Odmiana/ród | 4.591 | 5.901 | 6.201 | 0.600** | -0.273* | 0.366 |
| PK | 5.928 | 5.557 | 5.724 | -0.076 | 0.050 | |
| N | 5.577 | 5.670 | 5.718 | 0.052 | -0.083 | |
| Moddus | 5.778 | 5.681 | 5.564 | -0.079 | 0.066 | |
| Magnesium – Magnez | | | | | | |
| Cultivar/strain – Odmiana/ród | 1.82 | 1.85 | 1.97 | 0.572** | 0.191* | 0.047 |
| PK | 1.86 | 1.88 | 1.88 | 0.082 | -0.051 | |
| N | 1.87 | 1.89 | 1.84 | -0.118 | -0.138 | |
| Moddus | 1.85 | 1.88 | 1.88 | 0.114 | -0.050 | |
| Calcium – Wapń | | | | | | |
| Cultivar/strain – Odmiana/ród | 1.08 | 1.11 | 0.98 | -0.293* | -0.368** | 0.531 |
| PK | 1.08 | 1.05 | 1.10 | 0.061 | 0.017 | |
| N | 1.08 | 1.08 | 1.04 | -0.127 | -0.199 | |
| Moddus | 1.07 | 1.05 | 1.11 | 0.146 | 0.009 | |
| Sodium – Sód | | | | | | |
| Cultivar/strain – Odmiana/ród | 0.019 | 0.029 | 0.009 | -0.131 | -0.126 | -0.298 |
| PK | 0.015 | 0.018 | 0.035 | 0.242 | 0.154 | |
| N | 0.024 | 0.016 | 0.032 | 0.106 | 0.229 | |
| Moddus | 0.014 | 0.022 | 0.028 | 0.174 | 0.046 | |
| Potassium – Potas | | | | | | |
| Cultivar/strain – Odmiana/ród | 1.46 | 1.52 | 1.43 | -0.100 | -0.324* | 0.425 |
| PK | 1.56 | 1.45 | 1.49 | -0.206 | 0.150 | |
| N | 1.45 | 1.49 | 1.52 | 0.204 | -0.106 | |
| Moddus | 1.45 | 1.49 | 1.50 | 0.162 | -0.152 | |
| Phosphorus – Fosfor | | | | | | |
| Cultivar/strain – Odmiana/ród | 3.98 | 4.10 | 4.29 | 0.748 | 0.168 | -0.227 |
| PK | 4.03 | 4.09 | 4.27 | 0.586 | 0.111 | |
| N | 4.15 | 4.15 | 4.02 | -0.315 | 0.353 | |
| Moddus | 4.05 | 4.16 | 4.10 | 0.117 | 0.390 | |

* significant at P = 0.05 – istotne na poziomie P = 0.05
** significant at P = 0.01 – istotne na poziomie P = 0.01

Estimating magnesium content in the oat grain obtained in Wierzbica, a positive effect of the growth regulator Moddus and foliar application of nitrogen on the content of this element is clearly noticeable. An increase in magnesium content induced by the growth regulator Moddus probably resulted from the fact of oat stem shortening (on average by about 13 cm), which increased the concentration of this macroelement in grain. Increasing magnesium concentration resulting from the application of foliar fertilization was accompanied by a statistical differentiation of shoot height. Under conditions of a poorer habitat, a negative effect of phosphorus and magnesium fertilization and the regulator Promalin on magnesium content in the oat grain was also observed. A higher concentration of this macroelement was determined in the grain of dwarf form (STH 7000) than in the grain of the cultivar Akt. A higher content of this element in the grain of strain STH 4770 in relation to strain STH 7000 was also confirmed, irrespective of the habitat. Moreover, the genotypical factor was the only one which under conditions of a more abundant habitat in Prusy caused statistically significant changes in magnesium content in the oat grain. Linear effect of regression for this source of variability amounted to 0.572 standard deviation unit. Thus the cultivar Akt was characterized by intermediate values of magnesium content in relation to the tested strains.

In the case of calcium content in the grain, in Wierzbica, the cultivar Akt also was characterized by a moderate content of this element, whereas the grain of a dwarf form had a considerable higher concentration, and strain STH 4770 showed a noticeable effect of dilution. By contrast, in Prusy the highest concentration of this element was found in the grain of the cultivar Akt. The other tested agronomical factors did not differentiate the content of this element in oat grain.

Analysis of sodium content in the grain of naked oat obtained in Wierzbica indicates its higher content in both strains in relation to the cultivar Akt, with confirmation of a statistically significant difference only in comparison with strain STH 7000. In this case, over twofold (by more than a half of standard deviation unit) growth in the content of this macroelement was observed. In Wierzbica, also the influence of the regulator Moddus on an increase in sodium concentration was characterized by a statistically significant effect, especially in the experiment with the high strain which, as was mentioned above, may have resulted from considerable decreasing of its shoot height. A considerable, yet statistically insignificant, positive effect of the growth regulator Promalin was also recorded under these habitat conditions. This growth amounted to 0.280 standard deviation unit in experiment I and 0.194 in experiment II. Although in Prusy a statistically significant effect of the tested factors on the content of this element in oat grain was not observed, an explicit tendency for an increase in this element content in grain obtained on higher levels of particular factors is noticeable (fertilization with phosphorus and potassium, foliar application of nitrogen, using the regulator Moddus).

Potassium content in the grain obtained in Wierzbica was distinctly higher in dwarf strain STH 7000 than in the cultivar Akt. The difference was statistically significant and amounted to 0.359 standard deviation unit, and in absolute values it was 0.17g potassiumn$\cdot$kg$^{-1}$ dry matter. In both experiments in Wierzbica, a statistically significant increase in the concentration of this element in grain affected by the application of the growth regulator Moddus was observed (respectively, by 0.511 and 0.542 standard deviation unit). Also a statistically significant effect was observed after the foliar application of nitrogen in the experiment with strain STH 4770. In Prusy, only the quadratic effect caused by cultivar/strain selection appeared to be statistically significant. However, this effect cannot be analysed more thoroughly due to its qualitative character, since it results from the particular sequence of cultivar and strains in the conducted experiment and it is impossible to analyse its influence in comparable manner to that of increasing rates of nitrogen, phosphorus an potassium, or growing doses of the growth regulator Moddus, in which the sequence of levels cannot be different. The only fact resulting from this effect is lower potassium content in both strains in comparison with the cultivar Akt.

Phosphorus content in the grain of naked oats was the highest as compared with the other macroelements. Evaluation of its content in the grain by means of standardized regression coefficients did not indicate the statistically significant effect of the tested sources of variation on the amount of this element, irrespective of the edaphic conditions. Based on the results obtained, however, a number of tendencies have been shown. Strain STH 4770 was characterized by the highest content of phosphorus in oats grain from Prusy, and strain STH 7000 in grain from Wierzbica. In Wierzbica, growth regulator Moddus positively affected phosphorus content in the grain, whereas the growth regulator Promalin had a negative effect. As might be expected, phosphorus and potassium fertilization increased the content of this element, but in Prusy, because of a good habitat, fertilization only with phosphorus (average level) did not affect an increase in phosphorus content in oats grain, whereas phosphorus and potassium fertilization (high level) increased its content. Additionally, applying growth regulator Moddus in both rates resulted in an increase of the concentration of this macroelement.

The results of this study shows a large diversification in the content of macroelements in the grain of naked oats as affected by agronomical factors, which indicates a possibility of selection of strains towards improving of grain qualitative characters [Biel et al. 2006]. Moreover, many authors point out that oats also shows a large variability of grain chemical composition depending on the genotype and agrometeorological conditions in the years of the study, which diversifies its nutritional value [Maciejewicz-Ryś and Sokół 1999]. This suggests a necessity of carrying out wide evaluation of the effect of agronomical factors on the nutritional value of new oats cultivars. From the own study and the literature [Kochanowska-Bukowska 1996, Antonkiewicz 2007, Stanisławska-Glubiak and Korzeniowska 2007] it follows that diversification in respect of the accumulation of macroelements occurs not only within particular groups of varieties of plants but even ecotypes. Contents of particular macroelements in the grain of tested genotypes, as compared with traditional forms, are in accordance with the results by other authors [Walens 2003, Szumiło and Rachoń 2006]. When comparing the contents of the tested macroelements in the grain of naked oats with their content in the grain of other cereal crops (wheat and maize) it can be concluded that oats was characterized by a higher content of calcium and magnesium, a considerably lower content of potassium, whereas the content of phosphorus in the grain was on the same level [Stanisławska-Glubiak and Korzeniowska 2007]. Presented results of the study confirm the opinion that oats is a particularly valuable source of mineral elements and should be used in human feeding to a considerably larger degree [Macierewicz-Ryś and Sokół 1999, Ciołek et al. 2007].

## CONCLUSIONS

1. Grain yield of naked oat in worse habitat conditions was determined by the genotype and phosphorus and potassium fertilization, and in the dwarf strain also by the action of the growth regulator Moddus. Under good habitat conditions grain yield was differentiated only by the genotype.
2. Tested genotypes of naked oat differed in the content of macroelements in grain. Generally, in worse habitat conditions their higher content was observed in the short-straw form – STH 7000. In better habitat conditions this form accumulated only a higher content of magnesium and phosphorus.
3. Foliar application of nitrogen favoured an increase in potassium content in naked oat grain. Phosphorus and potassium fertilization did not have an effect on the content of macroelements.

4. Application of the growth regulator Moddus resulted only in an upward tendency of the content of macroelements in grain. No effect of the regulator Prolamin on a change in mineral elements content in naked oat grain was observed.

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## WPŁYW WYBRANYCH ZABIEGÓW AGROTECHNICZNYCH NA ZAWARTOŚĆ NIEKTÓRYCH SKŁADNIKOW MINERALNYCH W ZIARNIE OWSA NAGOZIARNISTEGO (*Avena sativa* L.)

**Streszczenie**. Badano wpływ czynników agrotechnicznych na zawartość wybranych składników mineralnych w ziarnie nagoziarnistych form owsa uprawianych w dwóch miejscowościach. Doświadczenia polowe prowadzono na glebie brunatnej typowej (Wierzbica – 50°29’ N; 19°45’ E) i na czarnoziemie zdegradowanym (Prusy 50°07’ N; 20°04’ E). W Wierzbicy plon ziarna był różnicowany statystycznie przez genotyp, nawożenie fosforowo-potasowe oraz stosowanie regulatora wzrostu Moddus. W Prusach jedynym czynnikiem modyfikującym statystycznie plon ziarna był dobór odmiany/rodu. W obydwu siedliskach nawożenie fosforowo-potasowe i dolistne azotem na ogół nie miało statystycznie istotnego wpływu na zawartość makroskładników. Wyjątek stanowił wpływ nawożenia dolistnego azotem na zawartość potasu. Spośród regulatorów wzrostu tylko Moddus powodował tendencje do zwiększonej kumulacji makroskładników w ziarnie owsa nagoziarnistego.

**Słowa kluczowe**: nawożenie dolistne, owies nagoziarnisty, regulator wzrostu, składniki mineralne

Accepted for print – Zaakceptowano do druku: 20.11.2009