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IMPROVEMENT OF THE EFFECTIVENESS OF MAIZE (*Zea mays* L.) FERTILIZATION WITH NITROGEN BY THE APPLICATION OF MAGNESIUM PART I. GRAIN YIELD AND ITS STRUCTURE

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Abstract. Field studies were carried out at the Didactic and Experimental Farm in Swadzim near Poznań in the years 2004-2007 (52°26' N; 16°45' E). The experiment was carried out in a „split-plot" design with 3 factors in 4 field replications. Two cultivars were studied: Anjou 258 and LG 2244 (stay-green type), six nitrogen doses were used: 0, 30, 60, 90, 120, 150 kg $N \cdot ha^{-1}$ and doses of magnesium: 0 kg $Mg \cdot ha^{-1}$, 15 kg $Mg \cdot ha^{-1}$ (in rows) and 15 kg $Mg \cdot ha^{-1}$ (broadcasting), in the form of kieserite. Effects of these factors on the yield of maize grown for grain were estimated. A better hybrid in growing maize for grain has shown to be the cultivar of stay-green type. The dose of nitrogen modified grain yield, harvest index and the yield elements of maize. The applied fertilization with magnesium caused grain yield increase, decreasing at the same time the level of fertilization with nitrogen. Magnesium application by broadcasting was a more effective method.

Key words: fertilizer application method, magnesium, maize cultivar types, nitrogen, stay-green

INTRODUCTION

Maize (*Zea mays* L.) takes up from the soil significant amounts of nutritive components, particularly of nitrogen, which is one of yield-creating macroelements [Jankowiak et al. 1997, Grzebisz 2002]. Furthermore, maize belongs to plants strongly reacting to the fertilization with nitrogen and it is characterized by a specific dynamics of nitrogen uptake [Grzebisz 2002]. Therefore, the determination of the optimal N fertilization level, which guarantees the full utilization of the great production potential, is very important in the plant cultivation. Maize plant malnutrition with nitrogen disturbs the processes of the formation of leaves, ears and the elements of ear structure.

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These phenomena are very early revealed, as they appear already in the phase of the 8th leaf. According to Subedi and Ma [2005], plant malnutrition with nitrogen before this phase leads to an irreversible reduction in the number of ears and of the set grains even by about 30%.

Maize, in comparison with other cultivated plants, shows rather poor indices of the utilization of nutritive components, particularly of nitrogen [Jankowiak et al. 1997]. Therefore, new methods are still looked for which could contribute to a better utilization by plant of the nitrogen from the applied fertilizer. Several authors [Seidler and Mamzer 1994, Wyszkowski 2001, Grzebisz and Gaj 2007] report that the utilization of the supplied nitrogen depends to a high degree on the balancing of its dose with the doses of phosphorus and potassium, as well as on the availability of a number of other elements including magnesium.

The hypothesis of the performed experiment assumed that magnesium, whose deficit is found in the majority of Polish soils, can exert an effect on the yield size of highly productive plants, among which maize is counted. Additionally, it may exert an effect on the utilization of nitrogen from the fertilizers. Therefore, studies were undertaken to find the magnesium application method which may decrease the size of the needed nitrogen fertilization for two types of maize hybrids grown for grain.

MATERIAL AND METHODS

Field studies were carried out at the Didactic and Experimental Farm in Swadzim 52°26' N; 16°45' E), near Poznań in the years 2004-2007. Results of studies carried out in 2006 were disqualified because of a prevailing drought in the period of maize growth and development. The experiment was carried out in a „split-plot" design with 3 factors in 4 field replications. Two cultivars were studied: Anjou 258 and LG 2244 (stay-green type), six nitrogen doses were used: 0, 30, 60, 90, 120 and 150 kg $N \cdot ha^{-1}$ and doses of magnesium: 0 kg $Mg \cdot ha^{-1}$, 15 kg $Mg \cdot ha^{-1}$ (in rows) and 15 kg $Mg \cdot ha^{-1}$ (broadcasting), in the form of kieserite. Fertilization with P and K was performed before the sowing of maize in the doses: 35.2 kg $P \cdot ha^{-1}$ in the form of Polifoska 6 and 99.6 kg $K \cdot ha^{-1}$ in the form of 60% potassium salt.

For maize sowing, a single seed drill Monosem was used which was equipped with a fertilizer applicator for magnesium distribution together with seed sowing. Fertilizer coulters were set in relation to seed coulters in such a way that fertilizer was placed in the soil 5 cm to the seed side and 5 cm below the seed. Seeds were sown 5-6 cm deep. For one hectare 75500 seeds were sown (7.55 $seeds \cdot m^{-2}$).

Results of the studies were subject to one-variable analysis of variance and then, a synthesis of multiple experiments was carried out. Significance of differences was estimated at the level of $\alpha = 0.05$. For the mean years a multinomial curve of regression was determined.

The experiment was carried out on grey-brown podsolic soil of coarse sandy soil type shallowly lying on light loam and belonging to good rye complex. Abundance of nutrients in the soil and its acidity are shown in Table l. Mineral nitrogen content was determined by distillation method after previous soil extraction by a 1 $mol \cdot dm^{-3}$ NaCl solution. Estimation of Mg in soil was performed by Schachtschabel method, while K and P were determined by the method of Egner-Riehm.

Table 1. Soil conditions at Swadzim
Tabela 1. Warunki glebowe w Swadzimiu

Specification – Wyszczególnienie	Year – Rok		
	2004	2005	2007
N-NH_4, mg·kg^{-1} d.m. of soil – mg·kg^{-1} s.m. gleby	1.3	1.2	1.4
N-NO_3, mg·kg^{-1} dm of soil – mg·kg^{-1} s.m. gleby	4.5	3.1	3.2
P available – przyswajalny, mg P·kg^{-1} of soil – gleby	55.0	72.0	83.0
K available – przyswajalny, mg K·kg^{-1} of soil – gleby	120.0	171.0	170.0
Mg available – przyswajalny, mg Mg·kg^{-1} of soil – gleby	95.0	56.0	73.0
pH in – w 1 mol·dm^{-3} KCl	5.87	5.55	6.22

Thermal and moisture conditions during vegetation in the years of studies were favourable for the growth and development of maize. Total rainfall in the months of April-September amounted to 301.0 mm in 2004, 305.4 mm in 2005 and 332.9 mm in 2007. On the basis of hydrothermal coefficients, indicating in a complex way both the air temperature and atmospheric precipitations, it was stated that in the period of studies both the total rainfalls and their distribution were favourable for the growth and development of maize. Insignificant deficit of moisture was found in the soil during maize sowing (April 2004, April 2005 and April 2007) as well as in June 2005 (Table 2).

Table 2. Weather conditions at Swadzim
Tabela 2. Warunki pogodowe w Swadzimiu

Year Rok	April Kwiecień	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	October Październik	April – September Kwiecień – Wrzesień
Temperature – Temperatura, °C								
2004	9.7	12.9	16.1	18.2	20.1	14.2	10.4	14.5
2005	9.4	13.3	16.5	19.9	17.3	16.0	10.5	14.7
2007	10.8	15.2	19.3	18.9	19.2	13.7	8.5	15.1
Rainfall – Opady, mm								
2004	19.4	49.8	51.3	49.4	53.6	32.3	45.2	301.0
2005	14.5	74.3	19.1	97.4	60.7	34.4	5.0	305.4
2007	9.3	77.0	59.6	87.0	48.1	33.4	18.5	332.9
The hydrothermal coefficient of water supply according to Sielianinow[1] Współczynnik hydrotermiczny zabezpieczenia w wodę według Sielianinowa[1]								
2004	0.66	1.24	1.06	0.87	0.86	0.76	1.40	0.97
2005	0.49	1.80	0.48	1.57	1.13	0.71	0.15	0.89
2007	0.28	1.63	1.02	1.48	0.81	0.81	0.70	0.96

[1] according to Molga [1986] – według Molgi [1986]
Interpretation of hydrotermal coefficient – Interpretacja współczynnika hydrotermicznego
0.00-0.50 – drought – susza
0.51-1.00 – halfdrought (insufficient moisture for most plants) – półsusza (wilgotność dla większości roślin niedostateczna)
1.01-2.00 – relative moisture (sufficient moisture for most plants) – względna wilgotność (wilgotność dla większości roślin dostateczna)
> 2.01 – large moisture (excessive moisture for most plants) – duże uwilgotnienie (wilgotność dla większości roślin nadmierna)

RESULTS AND DISCUSSION

Water content in the grain during harvest depended on the cultivar factor and on the size of magnesium dose, as well as on the method of Mg application (Table 3). Significantly lower water content in the grain was found in the hybrid LG 2244 (stay-green type) in relation to Anjou 258. The difference was 2.8 point %. On the average, during three years of studies, the lowest water content in the grain was obtained for a dose of 0 kg Mg·ha^{-1} (26.6%), in relation to a dose of 15 kg Mg·ha^{-1} applied by broadcasting and in rows.

Table 3. Grain yield, grain moisture and harvest index of maize
Tabela 3. Plon ziarna kukurydzy, wilgotność ziarna, wskaźnik zbioru

Specification – Wyszczególnienie		Grain moisture Wilgotność ziarna %	Grain yield Plon ziarna t·ha^{-1}	Harvest index Wskaźnik zbioru
Cultivar Odmiana	Anjou 258	28.1	10.1	0.43
	LG 2244	25.3	10.9	0.50
	$LSD_{0.05}$ – $NIR_{0,05}$	0.72	0.41	0.018
Dose of N Dawka N kg·ha^{-1}	0	26.6	9.96	0.47
	30	26.5	10.5	0.47
	60	26.8	10.6	0.47
	90	26.7	10.8	0.49
	120	26.6	10.7	0.46
	150	26.8	10.5	0.45
	$LSD_{0.05}$ – $NIR_{0,05}$	ns – ni	0.29	0.013
Dose of Mg Dawka Mg kg·ha^{-1}	0	26.6	10.5	0.48
	15 in rows – rzędowo	26.7	10.4	0.46
	15 broadcasting – rzutowo	26.9	10.5	0.46
	$LSD_{0.05}$ – $NIR_{0,05}$	0.02	ns – ni	0.006

ns – ni – non-significant differences – różnice nieistotne

No significant differences in the values of this feature were found between the application methods of magnesium (Table 3). It must be stressed that the decreased water content in the grain of the hybrid of stay-green type is an additional advantage of the cultivation of these cultivars for grain, as compared with the traditional hybrids. As calculated by Lergeou (quoted after Michalski [1997]), a drop of 1% in grain moisture was recompensed by the increase in grain yield by 0.15-0.21 t·ha^{-1}. In our own studies, on the average for the period of 3 years of studies, the hybrid LG 2244 (stay-green type) had a lower water content in grain by 2.8 point %, in comparison with the Anjou 258 cultivar, which gives an additional grain yield increase by 0.42-0.59 t·ha^{-1}.

Grain yield size significantly depended on the cultivar type and on nitrogen fertilization (Table 3). A higher grain yield by 0.80 t·ha^{-1} was obtained for the LG 2244 cultivar (stay-green type), in comparison with the Anjou 258 hybrid. Cultivars of the stay-green type in the autumn period, due to the still active vegetative parts, assimilate longer, frequently until the full maturity of grain. For this reason, one can count on an additional yield increase and on a better filling of the grain [Kowalik et al. 2006]. Furthermore, those authors reported that in case of drought occurrence, the risk of premature drying of plants in those forms is smaller in relation to other hybrids.

On the average, for the period of three years of studies, the lowest yield was found for a dose of 0 kg N·ha^{-1} (9.96 t·ha^{-1}), while the application of nitrogen doses within the range from 30 to 90 kg N·ha^{-1} caused a linear increase in the value of this feature. Further increase in the nitrogen fertilization level caused a drop in the amount of grain yield. The obtained results in our own studies confirm the studies of Kruczek [1997a]. According to that author, the maximal yield of grain, in conditions of Wielkopolska, was obtained with a dose of 90 kg N·ha^{-1}.

The amount of grain yield was also determined by the interaction between the cultivar type and the size of nitrogen fertilization (Fig. 1). These dependences have been described by quadratic equations, whereby for the hybrid LG 2244 the dependence occurred on a higher level in relation to Anjou 258 cultivar. In case of Anjou 258 cv., the maximal grain yield (9.59 t·ha^{-1}) was obtained for a nitrogen dose of 79.2 kg N·ha^{-1}, while for the LG 2244 hybrid, the maximal grain yield (11.2 t·ha^{-1}) was obtained for a nitrogen dose of 130.3 kg N·ha^{-1}.

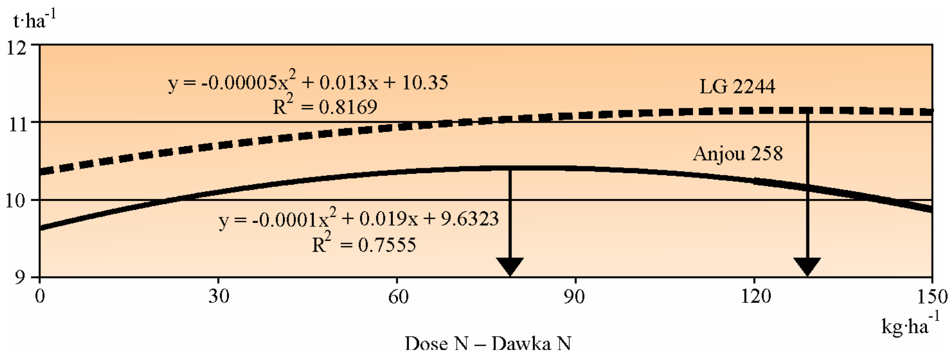

Fig. 1. Grain yield depending on the cultivar type and on the dose of nitrogen fertilization
Rys. 1. Plon ziarna w zależności od odmiany i nawożenia azotem

Grain yield depended also on the interaction between magnesium and nitrogen fertilization (Fig. 2). In case of nitrogen doses without Mg, no significant effect was found on the size of this feature. The mean grain yield for six doses of nitrogen amounted to 10.5 t·ha^{-1}. These dependences were shown for the dose of 15 kg Mg·ha^{-1} (by broadcasting) and for a dose of 15 kg Mg·ha^{-1} (sown in rows). Both curves were described by quadratic equations. In case of the magnesium dose sown in rows, the maximum grain yield (10.7 t·ha^{-1}) was obtained for the nitrogen dose of 102.6 kg N·ha^{-1}, while for the dose of magnesium applied by broadcasting, the maximal grain yield (10.8 t·ha^{-1}) was obtained for a nitrogen dose of 88.9 kg N·ha^{-1}. The use of 15 kg Mg·ha^{-1} applied by broadcasting gave an increase of grain yield by 0.14 t·ha^{-1} in relation to the magnesium applied in rows with a nitrogen dose lower by 13.7 kg N·ha^{-1}. On the other hand, the application of 15 kg Mg·ha^{-1} sown in rows and 15 kg Mg·ha^{-1} applied by broadcasting gave an increase in grain yield in relation to the nitrogen doses without magnesium by 0.15 and 0.30 t·ha^{-1}, respectively. The favourable effect of maize fertilization with magnesium, expressed by an increased grain yield, was confirmed by Fazekas et al. [1992]. Marska [1994], in turn, reported that insufficient amount of magnesium in the soil caused that the plants were not able to use properly the other elements necessary for their growth and development. On the other hand, Grzebisz and Gaj [2007] found that the increase of maize grain yield requires an optimization of the uptake of nitrogen, phsophorus, sulphur and zinc and this can be achieved by a better nutrition of plants with magnesium.

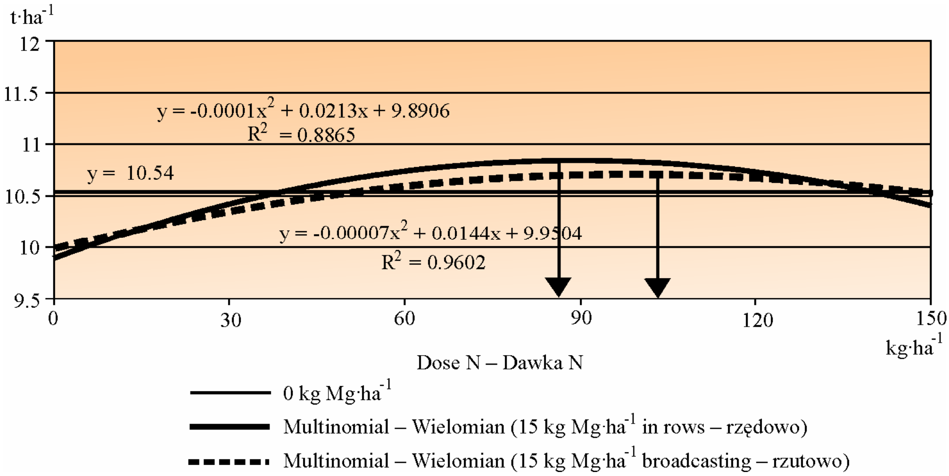

Fig. 2. Grain yield depending on the method of magnesium application and on the dose of nitrogen fertilization

Rys. 2. Plon ziarna w zależności od sposobu wysiewu nawozu magnezowego i nawożenia azotem

In the present studies, the harvest index has been calculated as the proportion of the yield of grain dry matter to the yield of dry matter of the whole plants (stalks and ears). A significantly higher value of this index was found for the LG 2244 hybrid in relation to Anjou 258 (Table 3). The higher value of this index confirms that this hybrid achieved a higher yield of grain. In case of the amount of nitrogen fertilization dose, the value of this index was increasing in the range of doses from 0 to 90 kg N·ha^{-1} (0.47--0.49), while the application of a higher fertilization level caused a significant decrease in this index value. The application in the present studies of 15 kg Mg·ha^{-1} sown by broadcasting and in rows caused a significant decrease in this index in relation to 0 kg Mg·ha^{-1}. This indicates that too large doses of nitrogen cause an increase in the yield of the vegetative organs of maize. The obtained result was also confirmed by Kruczek [1997b], who showed that the value of the index decreased also after the application of too high doses of nitrogen in the range from 120 to 270 kg N·ha^{-1}. Also Grzebisz and Gaj [2007] confirmed the dependence obtained in their own studies. According to those authors, the yield-creating reaction of maize to nitrogen doses above 150 kg N·ha^{-1} was not great. A too high dose of this macroelement leads to an excessive vegetative mass with a too large mass of leaves and weak stalks. Plants overfertilized with nitrogen reach their flowering phase later, they mature slower and in consequence it leads to a drop of grain yield.

Components of maize yielding were determined by the cultivar type and by the fertilization with nitrogen (Table 4). The number of ears per area unit and the mass of 1000 grains was significantly higher for the LG 2244 hybrid, in comparison with Anjou 258. These differences showed the following respective values: 0.23 pcs·m^{-2} and 18.8 g. In reference to the number of grains in the ear, the effects of the cultivars were in an inverted order. More grains in one ear (by 20.9 pcs) were shown by the hybrid Anjou 258 than by LG 2244.

Table 4. Structure of grain yield
Tabela 4. Elementy struktury plonu ziarna

Specification – Wyszczególnienie		Number of cobs Liczba kolb	Number of grains per ear – Liczba ziaren w kolbie	Weight of 1000 grains Masa 1000 ziaren
		$pcs \cdot m^{-2}$ – $szt. \cdot m^{-2}$	pcs – szt.	g
Cultivar Odmiana	Anjou 258	7.56	497.9	325.4
	LG 2244	7.79	477.0	344.2
	$LSD_{0.05}$ – $NIR_{0,05}$	0.121	9.69	2.50
Dose of N Dawka N $kg \cdot ha^{-1}$	0	7.68	471.6	325.2
	30	7.70	483.3	335.5
	60	7.70	488.3	333.9
	90	7.77	490.8	337.2
	120	7.67	500.2	338.1
	150	7.51	490.38	339.2
	$LSD_{0.05}$ – $NIR_{0,05}$	0.129	11.43	5.55
Dose of Mg Dawka Mg $kg \cdot ha^{-1}$	0	7.71	490.3	334.2
	15 in rows – rzędowo	7.66	485.8	335.9
	15 broadcasting – rzutowo	7.65	486.4	334.4
	$LSD_{0.05}$ – $NIR_{0,05}$	ns – ni	ns – ni	ns – ni

ns – ni – non-significant differences – różnice nieistotne

The number of production ears per area unit was increasing in a linear way in the range of doses from 0 kg $N \cdot ha^{-1}$ (7.68 $pcs \cdot m^{-2}$) to 90 kg $N \cdot ha^{-1}$ (7.77 $pcs \cdot m^{-2}$). On the other hand, the application of higher doses of nitrogen fertilization caused a breakdown of this feature value (Table 4). In case of this feature, an interaction was also shown between the cultivar type and the nitrogen fertilization level (Fig. 3). In case of Anjou 258 hybrid, the application of 150 kg $N \cdot ha^{-1}$ caused a significant drop in this feature value (7.24 $pcs \cdot m^{-2}$), while for the cultivar of stay-green type, the level of nitrogen fertilization did not differentiate this feature.

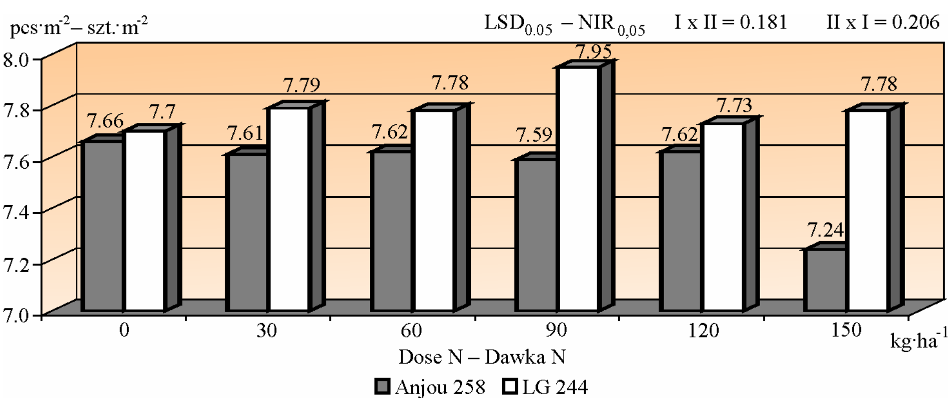

Fig. 3. Number of ears depending on the cultivar type and on the dose of nitrogen fertilization
Rys. 3. Liczba kolb w zależności od odmiany i nawożenia azotem

The least number of grains in the ear was found for a dose of 0 kg N·ha^{-1} (471.6 pcs). The value of this feature was increasing linearly in the range of doses from 30 to 120 kg N·ha^{-1}. On the other hand, the application of 150 kg N·ha^{-1} caused an insignificant decrease in this feature value (Table 4). The number of grains in one ear was also determined by the interaction between the cultivar type and the nitrogen fertilization level (Fig. 4). These dependences have been described by quadratic equations, whereby for the hybrid Anjou 258 this dependence took place on a higher level, in comparison with the cultivar LG 2244. In case of Anjou 258 cv. the maximal number of grains in one ear (506.9 pcs) was obtained for a dose of 121.5 kg N·ha^{-1}, while for the hybrid LG 2244 (stay-green type), the maximal number of grains in one ear (482.8 pcs) was obtained for a nitrogen dose of 103.5 kg N·ha^{-1}. Kruczek [1997b], in his estimation of the effect of nitrogen fertilization on the number of grains in one ear, found that there is no significant dependence but only a tendency to an increase in this feature under the influence of nitrogen fertilization. On the other hand, Lang [1978] showed that nitrogen fertilization on a level of 180 kg N·ha^{-1} has a negative effect on the number of grains in one ear.

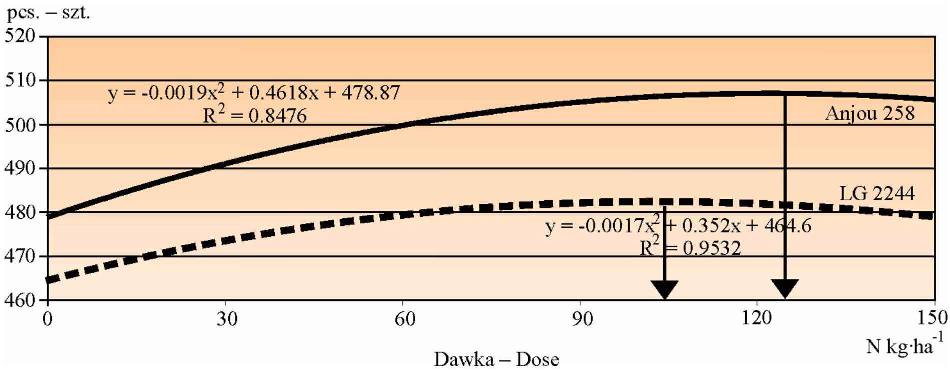

Fig. 4. Number of grains in one ear depending on the cultivar type and on the dose of nitrogen fertilization
Rys. 4. Liczba ziaren w kolbie w zależności od odmiany i nawożenia azotem

In the present studies, the lowest mass of 1000 grains was found for a dose of 0 kg N·ha^{-1} (325.2 g), while the greatest mass was shown by a dose of 150 kg N·ha^{-1} (339.2 g) (Table 4) The mass of 1000 grains depended also on the interaction between the hybrid type and the nitrogen fertilization level (Fig. 5). Both curves have been described by a linear equation, whereby for the hybrid LG 2244 the dependence took place on a higher level as compared with the hybrid Anjou 258. It was also found that there occurred an interaction between the cultivar type and the amount of magnesium dose exerting an effect on the value of the discussed feature (Fig. 6). The hybrid LG 2244 possessed a greater mass of 1000 grains in relation to the cultivar Anjou 258 and it was independent of the magnesium dose and the method of its application. In case of Anjou 258 cv. the amount of magnesium dose and the method of its application had no significant effect on the value of this feature, while for the hybrid LG 2244 (stay-green type), the greatest mass of 1000 grains was found for a dose of 15 kg Mg·ha^{-1} (sown in rows) in comparison with doses of 0 kg Mg·ha^{-1} (broadcasted). Kruczek [1997b], analogically as in case of the number of grains in one ear, also in case of the mass of 1000 grains did not find any significant dependence but only a tendency to an increase in the mass of 1000 grains under the influence of the increasing doses of nitrogen. Bennet [1993] reported that symptoms of magnesium deficit in the soil may lead to a decrease in the masses of seeds and fruits. On the other hand, Panak et al. [1990] and Sienkiewicz [1994] indicated that in light and acid soils, magnesium fertilization and balanced NPK are necessary to increase the yielding of plants and their quality.

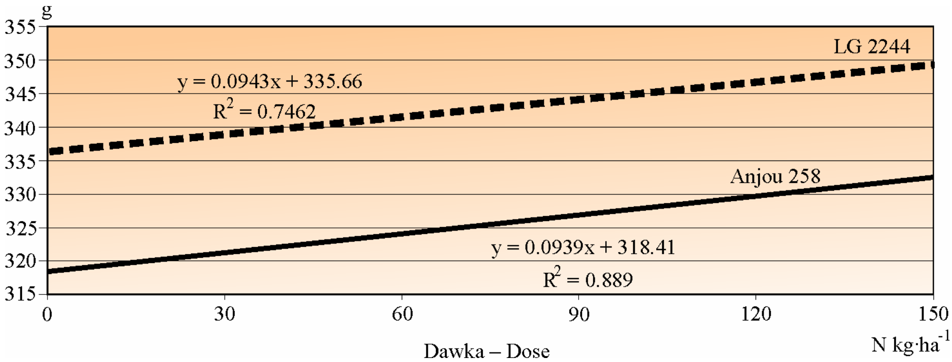

Fig. 5. Weight of 1000 grains depending on the cultivar type and on the dose of nitrogen fertilization

Rys. 5. Masa 1000 ziaren w zależności od odmiany i nawożenia azotem

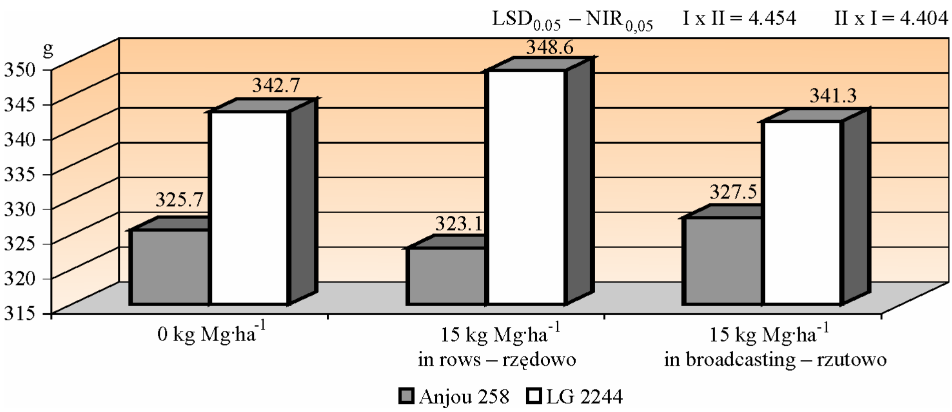

Fig. 6. Mass of 1000 grains depending on the cultivar type and on the method of magnesium application

Rys. 6. Masa 1000 ziaren w zależności od odmiany i sposobu wysiewu nawozu magnezowego

CONCLUSIONS

1. Maize cultivar LG 2244 (stay-green type) has shown to be more useful for growing for grain in comparison with Anjou 258. It gave a higher yield and at the same time it showed a smaller water content in the grain. This cultivar also obtained a higher harvest index.

2. Yield of maize grain and the harvest index increased in the range of nitrogen doses from 0 kg to 90 kg N·ha^{-1}.

3. Fertilization of maize with nitrogen and magnesium (in rows, by broadcasting) increased the yield of grain, in comparison with exclusive fertilization with nitrogen.

4. The number of production ears per area unit and the mass of 1000 grains were significantly higher for the hybrid LG 2244 in comparison with Anjou 258. In case of the number of grains in one ear, the results of the two cultivars showed an inversed order.

5. The greatest number of production ears was obtained for a dose of 90 kg N·ha^{-1}, while the greatest number of grains in one ear was shown for a dose of 120 kg N·ha^{-1}. The mass of 1000 grains was increasing in a linear way in the range of doses from 0 to 150 kg N·ha^{-1}.

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POPRAWA EFEKTYWNOŚCI NAWOŻENIA KUKURYDZY (*Zea mays* L.) AZOTEM POPRZEZ ZASTOSOWANIE MAGNEZU CZ. I. PLON ZIARNA ORAZ JEGO STRUKTURA

Streszczenie. Doświadczenie polowe przeprowadzono w Zakładzie Dydaktyczno-Doświadczalnym w Swadzimiu koło Poznania (52°26’ N; 16°45’ E) w latach 2004-2007. Doświadczenie prowadzono w układzie „split-plot” z 3 czynnikami w 4 powtórzeniach polowych. Badano wpływ stosowania 6 dawek azotu: 0, 30, 60, 90, 120, 150 kg $N \cdot ha^{-1}$ oraz dawki magnezu: 0 kg $Mg \cdot ha^{-1}$, 15 kg $Mg \cdot ha^{-1}$ (rzędowo) i 15 kg $Mg \cdot ha^{-1}$ (rzutowo) na plony ziarna dwóch odmian kukurydzy: Anjou 258 i LG 2244 (typ stay-green). Lepszym mieszańcem w uprawie na ziarno była odmiana typu stay-green LG 2244. Wielkość dawki azotu w istotny sposób wpłynęła na plon ziarna, indeks zbioru i elementy struktury plonu kukurydzy. Zastosowanie nawożenia magnezem powodowało wzrost plonu ziarna przy niższej dawce azotu. Bardziej efektywnym sposobem aplikacji magnezu był wysiew rzutowy w stosunku do rzędowego.

Słowa kluczowe: azot, kukurydza, magnez, sposób aplikacji Mg, stay-green, typy odmian

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