ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Agricultura 8(3) 2009, 37-42*

IMPROVEMENT OF THE EFFECTIVENESS OF MAIZE (*Zea mays* L.) FERTILIZATION WITH NITROGEN BY THE APPLICATION OF MAGNESIUM PART III. QUALITY OF EARS DESIGNED FOR SILAGE CCM

Piotr Szulc

Poznań University of Life Sciences

Abstract. A field experiment was established at the Experimental and Didactic Station in Swadzim near Poznań over 2004-2007 (52°26' N; 16°45' E). The experiment was carried out in a 'split-plot' design with 3 research factors in 4 field replications. 2 types of maize hybrids, 6 doses of nitrogen and magnesium doses (including methods of their applications) were examined. The effect of these research factors on the proportion of nutrients and raw material energy value of two types of maize hybrids grown for ear silage were assessed. The hybrid of stay-green type contained less crude fibre but more crude fat in dry matter of ears as compared with the traditional hybrid. The largest amounts of net energy concentration, net energy yield, digestible protein yield and total protein yield were obtained by applying a nitrogen dose of 120 kg $N \cdot ha^{-1}$. Fertilizing maize with N + Mg (in rows and by broadcasting), an increase in total protein yield was obtained in relation to the treatments with N fertilization only.

Keywords: CCM, maize, magnesium, nitrogen, stay-green, way of fertilizer application

INTRODUCTION

Nitrogen is without any doubt one of the basic nutritive components exerting a deciding influence on maize production [Scharf et al. 2002]. Under the effect of nitrogen fertilization and the correct supply of the remaining nutritive components, the highest yield increments can be obtained and frequently with an increased protein content [Mazur 1991]. However, one must keep in mind that too high nitrogen doses exert a negative effect on the quality of the produced plant biomass and on the soil environment [Mazur 1991]. Therefore, a search is continued for some new methods which could limit maize fertilization with nitrogen, but at the same time would permit to

Corresponding author – Adres do korespondencji: dr Piotr Szulc, Department of Soil and Plant Cultivation of Poznań University of Life Sciences, Mazowiecka 45/46, 60-623 Poznań, e-mail: pszulc@up.poznan.pl

maintain a high yielding potential. As reported by Grzebisz and Gaj [2007], and by Wyszkowski [2001], the utilization of nitrogen from the fertilizer depends in a high degree on the balancing of N dose with the dose of phosphorus and also on the availability of a number of other elements including magnesium. Furthermore, in the literature, we can find only a limited number of reports referring to the reaction of the stay-green maize hybrid type to nitrogen fertilization in combination with magnesium [Subedi et al. 2005]. Numerous Polish and foreign publications indicate that maize ears, independent of the technology of their harvest, with or without husks, are designed for fodder. The simplest and at the same time the cheapest method of ground ears conservation is their ensiling (CCM).

The hypothesis for field studies assumed that in conditions of maize grown for ear silage, the fertilization with magnesium can increase maize yield and at the same time improve the effectiveness of nitrogen fertilization.

In this connection, research was taken up in order to estimate the nutritive value of ears designed for silage (CCM) of two types of maize hybrids, depending on the level of nitrogen and magnesium fertilization.

MATERIAL AND METHODS

An exact description of the methods of studies and of thermal and humidity conditions were contained in another paper by the present author [Szulc et al. 2008a]. Ear dry matter yields were published in an earlier paper by the same author [Szulc et al. 2008b].

Estimation of nutritive components in the ears was carried out on 10 ears taken randomly from the plot. After removal of husks, the ears were ground. Analyses of organic component content in maize ears were carried out in the Department of Soil and Plant Cultivation, University of Life Sciences in Poznań, according to the following methods: total protein was determined by the examination of nitrogen content in a sample using Kjeldahl's method and the result was multiplied by coefficient 6.25; fat was studied by Soxhlet's method; crude fibre was identified by the hydrolysis of the remaining components contained in the ear; ash was determined by the dry combustion method; while nitrogen-free extracts were calculated by extraction of the remaining contents from the total 100% sum.

Evaluation of the energetic value of grain was done according to Kellner's method by calculating oat units which were converted into net energy assuming that one oat unit = 7.6 MJ of net energy for pigs [Gawęcki 1994]. This permitted to determine the net energy concentration, the energy yield and the yield of digestible protein. The yield of total protein was calculated by the multiplication of the proportional content of protein in the ears by their yield.

RESULTS AND DISCUSSION

On the average, for the period of three years of studies, a significant effect was found to be exerted by the hybrid type on the proportional contents of crude fibre and crude fat in the dry matter of ears (Table 1). A greater content of crude fibre (by 8.5 $g \cdot kg^{-1}$) was found in the Anjou 258 hybrid, in comparison with LG 2244 stay-green

type. An effect of the hybrid factor (early hybrid, semi-early hybrid and semi-late hybrid) on the content of crude fibre in ear dry matter was also found by Machul and Borowiecki [2000]. In the case of crude fat, a greater amount of this nutritive component (by 4.4 $g \cdot kg^{-1}$) was shown by the hybrid LG 2244 (stay-green type) in comparison with the traditional Anjou 258 hybrid.

Table 1. Proportion of nutritive components in ear biomass
Tabela 1. Udział związków pokarmowych w biomasie kolb

Specification – Wyszczególnienie		In dry matter – W suchej masie, $g \cdot kg^{-1}$				
		total protein białko ogólne	crude fibre włókno surowe	ash popiół	crude fat tłuszcz surowy	N-free extract BNW
Hybrid Odmiana	Anjou 258	88.3	66.5	14.3	41.5	789
	LG 2244	90.4	58.0	14.2	45.9	791
	$NIR_{0.05} – LSD_{0,05}$	ns – ni	5.69	ns – ni	2.96	ns – ni
N dose Dawka N $kg \cdot ha^{-1}$	0	82.7	67.3	13.5	41.5	794
	30	85.6	58.9	14.8	45.0	795
	60	87.1	65.6	15.0	41.5	790
	90	90.7	59.0	14.1	43.3	792
	120	95.5	58.0	13.0	44.5	789
	150	94.8	56.0	14.6	45.6	789
	$NIR_{0.05} – LSD_{0,05}$	6.10	ns – ni	ns – ni	ns – ni	3.5
Mg dose Dawka Mg $kg \cdot ha^{-1}$	0	88.7	64.9	14.4	43.3	789
	15 in rows – rzędowo	90.7	62.3	15.0	43.7	788
	15 broadcasting – rzutowo	88.7	60.8	13.5	44.1	793
	$NIR_{0.05} – LSD_{0,05}$	ns – ni	2.10	ns – ni	ns – ni	ns – ni

ns – ni – non significant differences – różnice nieistotne

Nitrogen fertilization dose modified the content of total protein and of the nitrogen-free extracts in ear dry matter (Table 1). At the interval of nitrogen doses from 0 kg $N \cdot ha^{-1}$ to 120 kg $N \cdot ha^{-1}$, the percent content of total protein was increasing in a linear way from 82.7 to 95.5 $g \cdot kg^{-1}$. The application of the highest nitrogen dose, i.e. 150 kg $N \cdot ha^{-1}$ caused an insignificant decrease in this nutritive component in ears. In the case of nitrogen free extracts, a significantly less content of this element was found for the nitrogen doses of 120 and 150 kg $N \cdot ha^{-1}$ (789 $g \cdot kg^{-1}$) in relation to the remaining N fertilization levels. A similar nitrogen fertilization effect of maize on the chemical composition of ears was obtained by Machul and Borowiecki [2000]. Those authors have shown that with the increase of nitrogen fertilization, there also increased the protein content in maize ears, while the content of the remaining nutritive components (i.e. fat, fibre, ash and nitrogen free extracts) did not change.

Crude fibre content in ear dry matter, in the synthetic understanding, depended also on the dose of magnesium (Table 1). The greatest amount of this nutritive component in ear dry matter was found for a magnesium dose of 0 kg $Mg \cdot ha^{-1}$ (64.9 $g \cdot kg^{-1}$), while the smallest amount of this component was found for a dose of 15 kg $Mg \cdot ha^{-1}$ (60.8 $g \cdot kg^{-1}$) applied by broadcasting. No statistically significant difference was found between the methods of magnesium dose application.

No effect of the studied experimental factors was found to be exerted on energy net concentration in ear dry matter (Table 2). The obtained result in our own studies was also confirmed by Kruczek [2004]. That author fertilized maize with nitrogen in doses

ranging from 25 to 130 kg N·ha^{-1} and he did not detect any significant differentiation of energy net concentration in ear dry matter under the influence of N fertilization. The yield of net energy, yield of digestible protein and total protein yield were significantly determined by the dose sizes of N and Mg (Table 2). The lowest values of these features were found for nitrogen doses of 0 kg N·ha^{-1} (101.2 GJ·ha^{-1}; 0.64 t·ha^{-1} and 0.84 t·ha^{-1}, respectively), while for the dose of 120 kg N·h^{-1}, the values were the highest (115.0 GJ·ha^{-1}, 0.85 t·ha^{-1} and 1.12 t·ha^{-1}, respectively). The application of the highest nitrogen fertilization level caused a decrease in the value of these factors. Analysis of magnesium dose indicated that the least significant values of energy net yield, digestible protein yield and total protein yield were obtained for a dose of 0 kg Mg·ha^{-1} (106.3 GJ·ha^{-1}; 0,73 t·ha^{-1} and 0,96 t·ha^{-1}, respectively), while the highest values were shown for a dose of 15 kg Mg·ha^{-1} applied in rows (113.0 GJ·ha^{-1}; 0,79 t·ha^{-1} and 1,04 t·ha^{-1}, respectively) – Table 2.

Table 2. Net energy concentration, net energy yield, total protein yield and digestible protein yield in ears

Tabela 2. Koncentracja energii netto, plon energii netto, plon białka ogólnego i plon białka strawnego w kolbie

Specification – Wyszczególnienie		Net energy concentration Koncentracja energii netto MJ·kg^{-1} dm – sm	Net energy yield Plon energii netto GJ·ha^{-1}	Digestible protein yield Plon białka strawnego t·ha^{-1}	Total protein yield Plon białka ogólnego t·ha^{-1}
Hybrid Odmiana	Anjou 258	9.82	109.8	0.75	0.99
	LG 2244	9.90	110.9	0.77	1.02
	$NIR_{0.05} – LSD_{0.05}$	ns – ni	ns – ni	ns – ni	ns – ni
N dose Dawka N kg·ha^{-1}	0	9.83	101.2	0.64	0.84
	30	9.88	107.1	0.72	0.95
	60	9.82	110.7	0.73	0.96
	90	9.87	113.7	0.79	1.04
	120	9.83	115.0	0.85	1.12
	150	9.89	114.6	0.84	1.10
	$NIR_{0.05} – LSD_{0.05}$	ns – ni	2.17	0.103	0.838
Mg dose Dawka Mg kg·ha^{-1}	0	9.84	106.3	0.73	0.96
	15 in rows – rzędowo	9.84	113.0	0.79	1.04
	15 broadcasting – rzutowo	9.89	111.8	0.76	1.01
	$NIR_{0.05} – LSD_{0.05}$	ns – ni	3.84	0.045	0.417

ns – ni – non significant differences – różnice nieistotne

In the case of ear total protein yield, an interaction was found between nitrogen and magnesium dose sizes (Fig. 1). By applying 15 kg Mg·ha^{-1} in rows, an increase of ear protein yield was obtained by 0.07 t·ha^{-1}, in relation to the broadcasting application, using at the same time a nitrogen dose lower by 10.6 kg N·ha^{-1}. When maize was fertilized by N + Mg (in rows and by broadcasting), total protein yield was increased respectively by: 0.21 t·ha^{-1} (applied in rows) and by 0.14 t·ha^{-1} (by broadcasting), as compared with treatments without N fertilization.

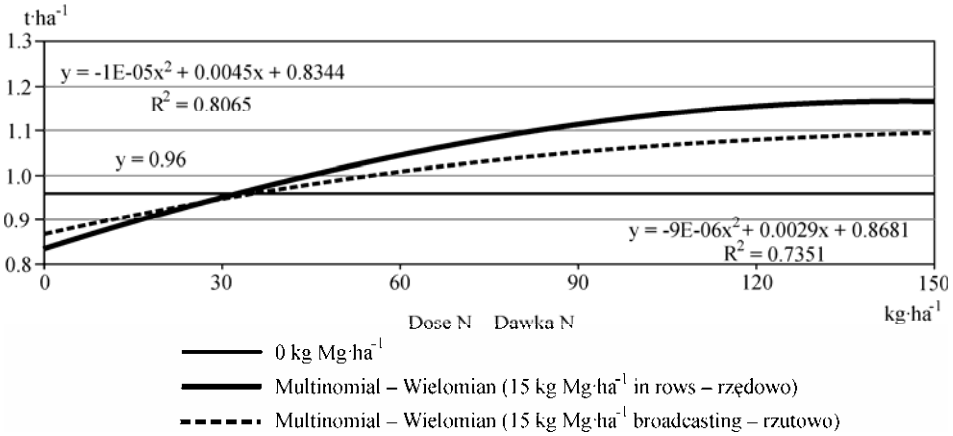

Fig. 1. Total protein yield in ears depending on nitrogen dose and on the method of magnesium application

Rys. 1. Plon białka ogólnego kolb w zależności od dawki azotu i sposobu aplikacji magnezu

CONCLUSIONS

1. Maize of stay-green type has shown to be more useful in growing for CCM because of a smaller content of crude fibre and a greater content of crude fat in ear dry matter. Furthermore, this hybrid showed a tendency to a higher concentration of net energy, net energy yield, the yield of digestible protein and total protein yield in ears, in comparison with the traditional hybrid.

2. The content of total protein in ear dry matter and net energy, the total protein yield, as well as the yield of digestible protein were in a significant way determined by the size of nitrogen dose. The highest values of these features were obtained for a dose of 120 kg N·ha^{-1}, while the smallest values were shown for a dose of 0 kg N·ha^{-1}.

3. The content of nitrogen-free extracts in ear dry matter decreased significantly with the increase in nitrogen fertilization doses.

4. The application of 15 kg Mg·ha^{-1} by broadcasting and in rows caused a significant decrease in the content of crude fibre in ear dry matter, as compared with the treatment without Mg application.

5. The highest yield of net energy, digestible protein yield and the total protein yield in ears was obtained for a dose of 15 kg Mg·ha^{-1} (applied in rows), while the lowest yield was obtained for a dose of 0 kg Mg·ha^{-1}.

6. Maize fertilized with N + Mg (in rows and by broadcasting) gave an increase in total protein yield, in comparison with the treatments without N fertilization.

REFERENCES

Gawęcki K., 1994. Ćwiczenia z żywienia zwierząt i paszoznawstwo [Classes in animal feeding and fodder science]. Wyd. AR Poznań [in Polish].

Grzebisz W., Gaj R., 2007. Zintegrowany system nawożenia kukurydzy. Integrowana produkcja kukurydzy [Integrated system of maize fertilization. Integrated maize production]. IOR Poznań [in Polish].

Kruczek A., 2004. Skuteczność dwóch sposobów nawożenia kukurydzy nawozami azotowymi i nawozem wieloskładnikowym w zależności od poziomu nawożenia azotem [Effectiveness of two methods of maize fertilization with nitrogen fertilizers and multicomponent fertilizer depending on nitrogen fertilization level]. Frag. Agron. 4(84), 55-73 [in Polish].

Machul M., Borowiecki J., 2000. Wpływ nawożenia azotem na wielkość i jakość plonu kukurydzy uprawianej na kiszonkę z kolb (CCM) [Effect of nitrogen fertilization on amount and quality of yield of maize grown for ear silage (CCM)]. Pam. Puł. 121, 117-125 [in Polish].

Mazur T., 1991. Azot w glebach uprawnych [Nitrogen in arable soils]. PWN Warszawa [in Polish].

Scharf P.C., William J., Wiebold J., Lory J.A., 2002. Corn yield response to nitrogen fertilizer timing and deficiency level. Agron. J. 94, 435-441.

Subedi K.D., Ma B.L., 2005. Nitrogen uptake and partitioning in stay-green and leafy maize hybrids. Crop Sci. 45, 740-747.

Szulc P., Skrzypczak W., Waligóra H., 2008a. Improvement of the effectiveness of maize (*Zea mays* L.) fertilization with nitrogen by the application of magnesium. Part I. Grain yield and its structure. Acta Sci. Pol., Agricultura 7(4), 125-135.

Szulc P., Waligóra H., Skrzypczak W., 2008b. Reaction of two maize cultivars expressed by dry matter yields depending on nitrogen fertilization level and on magnesium application method. Acta Agrophys. 12(1), 207-219

Wyszkowski M., 2001. Wpływ magnezu na kształtowanie plonów i wzajemnych relacji między niektórymi jonami w roślinach [The effect of magnesium on changes in yield and mutual relations among certain ions in plants]. UWM Olsztyn, Rozprawy i monografie [in Polish].

POPRAWA EFEKTYWNOŚCI NAWOŻENIA KUKURYDZY (*Zea mays* L.) AZOTEM POPRZEZ ZASTOSOWANIE MAGNEZU CZ. III. JAKOŚĆ KOLB PRZEZNACZONYCH NA KISZONKĘ CCM

Streszczenie. Doświadczenie polowe przeprowadzono w Zakładzie Dydaktyczno-Doświadczalnym w Swadzimiu koło Poznania w latach 2004-2007 (52°26' N; 16°45' E). Doświadczenie prowadzono w układzie „split-plot" z 3 czynnikami badawczymi w 4 powtórzeniach polowych. Badano 2 typy odmian kukurydzy, 6 dawek azotu oraz dawki magnezu (w tym sposób ich aplikacji). Oceniano wpływ tych czynników badawczych na udział związków pokarmowych oraz wartość energetyczną surowca dwóch typów odmian kukurydzy uprawianych na kiszonkę z kolb. Mieszaniec typu stay-green zawierał mniej włókna surowego, więcej tłuszczu surowego w suchej masie kolb w porównaniu z odmianą tradycyjną. Największą ilość koncentracji energii netto, plonu energii netto, plonu białka strawnego i plonu białka ogólnego uzyskano stosując dawkę azotu na poziomie 120 kg $N \cdot ha^{-1}$. Nawożąc kukurydzę N + Mg (rzędowo i rzutowo), uzyskano zwyżkę plonu białka ogólnego w stosunku do obiektów z wyłącznym nawożeniem N.

Słowa kluczowe: CCM, kukurydza, magnez, azot, stay-green, sposób aplikacji nawozu

Accepted for print – Zaakceptowano do druku: 27.07.2009