**Piotr SZULC, Hubert WALIGÓRA, Witold SKRZYPCZAK**
University of Life Sciences in Poznań
Department of Soil and Plant Cultivation
ul. Mazowiecka 45/46, 60-623 Poznań
e-mail: pszulc@au.poznan.pl

# ESTIMATION OF THE SUITABILITY OF MAIZE HYBRID STAY-GREEN TYPE TO BE GROWN FOR GRAIN IN CONDITIONS OF ECOLOGICAL AGRICULTURE

*Summary*

*Field studies were carried out in the Didactic and Experimental Farm in Swadzim near Poznań, in 2004-2007. The study objective was the reaction of two maize hybrid types to zero mineral fertilization and in consequence to estimate their suitability to be grown for grain, in comparison with mineral fertilization (conventional technology). The hybrid LG 2244 stay-green type has shown to be a better suited cultivar for the use in ecological agriculture, as compared with the conventional Anjou 258 hybrid. The LG 2244 stay-green type showed a higher grain yield and a better indicator of energy effectiveness, in conditions of zero nitrogen fertilization, in comparison with the Anjou 258 hybrid. The sum of energy inputs for the production of the same amount of yield, in conditions of ecological agriculture, was lower of 32.1%, in relation to the conventional method.*

# OCENA PRZYDATNOŚCI MIESZAŃCA TYPU STAY-GREEN DO UPRAWY NA ZIARNO W WARUNKACH ROLNICTWA EKOLOGICZNEGO

*Streszczenie*

*Badania polowe wykonano w Zakładzie Dydaktyczno-Doświadczalnym w Swadzimiu, koło Poznania w latach 2004-2007. Ich celem było poznanie reakcji dwóch typów odmian kukurydzy uprawianej na ziarno na zerowe nawożenie mineralne (system ekologiczny) w porównaniu do nawożenia mineralnego (technologia konwencjonalna). Bardziej przydatnym mieszańcem do zastosowania w rolnictwie ekologicznym w przeprowadzonych badaniach polowych była odmiana LG 2244 typ stay-green, w stosunku do Anjou 258. Decydowało o tym uzyskanie większego plonu ziarna oraz wskaźnika efektywności energetycznej w warunkach zerowego nawożenia azotem, w stosunku do odmiany tradycyjnej. Suma nakładów energetycznych poniesionych na wyprodukowanie takiej samej ilości plonu ziarna w warunkach rolnictwa ekologicznego była niższa o 32,1% w stosunku do metody konwencjonalnej.*

## 1. Introduction

Vegetation production in the technology of ecological agriculture cannot employ any synthetic plant protection agents (pesticides) or any mineral fertilizers. The primary objective of ecological agriculture is not the maximization of yields, but the protection of natural environment [2]. Hence, in the technology of ecological agriculture, hybrids should be used which are resistant to pathogenic factors and which tolerate a deficit of mineral components in the soil [9, 10]. Such possibility is offered by maize hybrids of stay-green type. These hybrids are characterized by a higher tolerance to *Fusarium* diseases [12] and they possess a very good vigour, in the initial growth [11]. Furthermore, they have the ability to remobilize nitrogen from the vegetative biomass of plants to the generative yield represented by grain [3].

For the above reasons, the objective of the presented studies was the estimation of the reaction of two maize hybrid types to zero mineral fertilization and in consequence to estimate their suitability to be grown for grain, as compared with mineral fertilization (conventional technology). Additionally, the energy consumption by grain production in the ecological system was compared with that which is necessary in the conventional techniques.

## 2. Method

Field studies were carried out in the Didactic and Experimental Farm in Swadzim, near Poznań, in the years 2004-2007. Results obtained in the year 2006 were disqualified because of draught prevailing in that year. Experiment was established as a two-factorial one. The primary factor included two maize hybrids: Anjou 258 and LG 2244 stay-green type. The second factor included nitrogen fertilization: 0 kg $N \cdot ha^{-1}$ and 120 kg $N \cdot ha^{-1}$. Maize was grown in the second year after the application of a full dose manure. In the ecological system, no mineral fertilization with phosphorus and potassium were applied.

Maize was grown in the second year after manure application. Thermal conditions of field experiment and nutritive component contents were specified in earlier publications of the author [9, 10].

The actual paper presents an attempt of an estimation of energy inputs necessary for grain production of two types of maize grown in the ecological and the conventional technologies. The inputs of labour and energy for the agrotechnical treatments [7] were converted into energy expressed in MJ, assuming that 1 labour hour = 40 MJ [4] and 1 kWh = 3.6 MJ [1] – tab. 1. It was assumed that the energy introduced in the form of herbicides into 1 kg of biologicaly pure substance has the value of 300 MJ (tab. 2), while in mineral fertilizers l kg N = 77 MJ, 1 kg $P_2O_5$ = 14 MJ, l kg $K_2O$ = 10 MJ [4, 6] – tab. 3. Energy value of the obtained grain yield was calculated accepting, according to [4], that 1 kg d.m. corresponds to 18.36 MJ energy. Energy effectiveness of grain production was calculated according to the formula contained in [4]:

$$Ee = \frac{Pe}{Ne}$$

where:
Ee – indicator of energy effectiveness,
Pe – energy value of yield from 1 ha in MJ,
Ne – energy inputs for 1 ha in MJ.

**3. Results and discusion**

Yield size of grain for the period of three years of studies depended on the cultivar type and on the level of nitrogen fertilization (tab. 4). Significantly higher yield of grain (by 2.37 dt·ha$^{-1}$) was found for the hybrid LG 2244 stay-green type, in comparison with the traditional hybrid Anjou 258. Maize grown in the control plot without nitrogen fertilization showed a yield lower by 6.86 dt·ha$^{-1}$, in relation to the object with mineral fertilization in the dose of 120 kg N·ha$^{-1}$ (tab. 4).

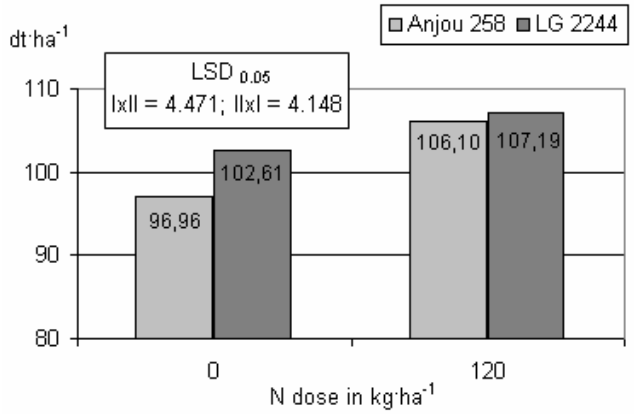


Fig. 1. Grain yield depending on hybrid type and size of nitrogen fertilization (2004-2007)

The grain yield depended also in a significant degree on the cooperation of the hybrid type with the nitrogen fertilization level (fig. 1). Significantly higher yield of grain, independent of the hybrid type, was obtained by the dose of 120 kg N·ha$^{-1}$, as compared with the control. In the object without nitrogen application (0 kg N·ha$^{-1}$), a significantly higher grain yield was shown by the hybrid LG 2244 stay-green type, in comparison with Anjou 258 hybrid. The difference was 5.65 dt·ha$^{-1}$. In case of nitrogen dose 120 kg N·ha$^{-1}$, the type of maize hybrid did not decide in any significant degree about the grain yield size (fig. 1). Our result obtained in the experiment confirmed the earlier literature reports [8, 9]. According to those earlier authors, the productivity of maize hybrids depended on the plant nutritional status with nitrogen, in other words, it indirectly depended on chlorophyll content in leaf blades. Nitrogen deficit in leaf blades decreases the intensity of photosynthesis and thereby it shortens the period of $CO_2$ assimilation which decides about the size of the created biomass.

Content of dry matter in maize grain in the field experiment depended in a significant way, exclusively on the hybrid factor (tab. 4). The value of this feature shown by the hybrid LG 2244 stay-green type was higher by 2.51 point %, in comparison with the traditional Anjou 258 hybrid. Obtaining of a greater dry matter content in the grain, in case of stay-green hybrid, decreases the inputs for the drying of such grain, increasing at the same time the economic benefit of ecological cultivation.

Effectiveness of maize growing for grain depends not only on the size of the obtained yields and the content of dry matter in the grain, but also on the inputs into the cultivation technology. This paper presents an abbreviated estimation of the energy effectiveness of maize production in its two growing variants, i.e. in the ecological and in the traditional ones. For this reason, the energy inputs have been calculated which were necessary for these technologies and the grain yield has been converted into energy value to be used in the further stage for the calculation of the indicator of the energy effectiveness of grain yield. As reported by Pudełko et al. [5], agricultural production, in spite of its nature related character, consumes a great amount of energy and, therefore, it is expensive. The knowledge of energy inputs and of the energy structure permits to look for energy saving production technologies.

Energy inputs for grain production in ecological technology were lower by 12621.3 MJ·ha$^{-1}$, in comparison with maize growing in the conventional system (tab. 5). This difference was caused by the absence of mineral fertilization and plant protection agents (herbicides) in this production technology.

Energy value of the obtained grain yield depended on the hybrid type and on the nitrogen dose size (tab. 6). Significantly higher value of this feature was found for the LG 2244 stay-green hybrid type, in comparison with Anjou 258 hybrid. Application of 120 kg N·ha$^{-1}$ caused an increase of grain yield value by 10704.11 MJ·ha$^{-1}$, in comparison with objects where zero N fertilization was applied.

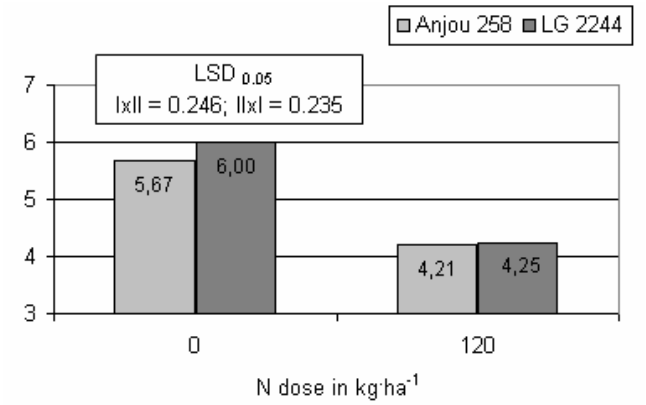


Fig. 2. Energy effectiveness indicator of grain yield (2004-2007)

Table 2. Energy inputs for herbicide application (conventional technology)

| Herbicide | Applied dose | Content of biologically active substances (b.a.s.) | | Energy inputs | |
|---|---|---|---|---|---|
| | | in herbicide | in dose | per 1 kg (b.a.s.) | per 1 ha |
| Primextra Gold 729 S.C. | l·ha$^{-1}$ | g·l$^{-1}$ | g·l$^{-1}$ | MJ | MJ |
| | 3.5 | 720 | 2520.0 | 300 | 756.0 |

Table 3. Energy contained in mineral fertilizers (conventional technology)

| Nutritive component | Dose | Energy input | |
|---|---|---|---|
| | | per component | per 1 ha |

| | | $MJ \cdot kg^{-1}$ | $MJ \cdot ha^{-1}$ |
|---|---|---|---|
| Nitrogen – N | 120 | 77 | 9240.0 |
| Phosphorus – $P_2O_2$ | 80 | 14 | 1120.0 |
| Potassium – $K_2O$ | 120 | 10 | 1200.0 |
| Total | | | 11 560.0 |

Table 4. Yield of grain and its moisture (2004-2007)

| Specification | | Grain yield $[dt \cdot ha^{-1}]$ | Content of d.m. in grain [%] |
|---|---|---|---|
| Hybrids | Anjou 258 | 101.53 | 72.03 |
| | LG 2244 | 103.90 | 74.54 |
| | $LSD_{0.05}$ | 1.971 | 0.919 |
| Dose of N in $kg \cdot ha^{-1}$ | 0 | 99.78 | 73.00 |
| | 120 | 106.64 | 73.57 |
| | $LSD_{0.05}$ | 3.647 | n.s. |

n.s. – non significant differences.

Table 5. Energy inputs for grain production

| Specification | Technology types | |
|---|---|---|
| | ecological | conventional |
| Sum of energy inputs $[MJ \cdot ha^{-1}]$ | 26 677.5 | 39 298.9 |
| Difference $[MJ \cdot ha^{-1}]$ | 12621.3 (32.1%) | |

Table 6. Energy value and indicator of grain yield energy effectiveness (2004-2007)

| Specification | | Energy value of grain yield $[MJ \cdot ha^{-1}]$ | Indicator of grain yield energy effectiveness |
|---|---|---|---|
| Hybrids | Anjou 258 | 158 451.85 | 4.94 |
| | LG 2244 | 163 711.13 | 5.12 |
| | $LSD_{0.05}$ | 2545.14 | 0.098 |
| Dose of N in $kg \cdot ha^{-1}$ | 0 | 155 729.44 | 5.83 |
| | 120 | 166 433.55 | 4.23 |
| | $LSD_{0.05}$ | 8978.65 | 0.909 |

Indicator of energy effectiveness of grain yield which is the quotient of the yield energy value in relation to the energy inputs (for the yield production), depended, in the previous field experiment, on the hybrid type, nitrogen dose and on their mutual cooperation (tab. 6, fig. 2). A higher indicator of energy effectiveness was found for the hybrid LG 2244 stay-green type, as compared with Anjou 258 hybrid. Application of 120 kg N $ha^{-1}$ decreased in a significant way the value of that indicator, in comparison with the control object without nitrogen application. That difference showed the value of 1.60.

The cooperation found between the hybrid type and the level of nitrogen fertilization showed that in conditions of zero nitrogen fertilization, a higher indicator of the energy effectiveness of grain yield was shown by the hybrid LG 2244 stay-green type, in comparison with the traditional Anjou 258 hybrid (fig. 2). Application of 120 kg $N \cdot ha^{-1}$ did not cause any differentiation of this feature. Both hybrids showed almost the same value of this indicator. However, independent of the maize hybrid type, the application of 120 kg $N \cdot ha^{-1}$ caused a significant decrease in the energy effectiveness of grain yield (fig. 2).

## 4. Conclusions

1. Hybrid LG 2244 stay-green type showed higher values of grain yield, dry matter in grain, energy value of yield and energy effectiveness indicator, in comparison with the traditional hybrid Anjou 258.
2. Application of 120 kg $N \cdot ha^{-1}$ increased grain yield, energy value of yield and a decrease of the indicator of yield effectiveness, as compared with objects without nitrogen fertilization.
3. The stay-green hybrid type is a better suited one for utilization in conditions of ecological agriculture. Its advanatages include: higher yield and a higher indicator of energy effectiveness in conditions of zero nitrogen fertilization, in comparison with the traditional Anjou 258 hybrid.
4. Total sum of energy inputs necessary for the production of the same amount of grain yield in conditions of ecological agriculture is smaller by 32.1%, in relation to the conventional method.

## 5. References


[1] Chmielewski H.: Międzynarodowy układ jednostek miar. Wydawnictwa Szkolne i Pedagogiczne, Warszawa 1979.
[2] Granstedt A. Tyburski J.: Współczesne europejskie systemy rolnicze. Fragm. Agron., 2006, 90 (2), 72-95.
[3] Grzebisz W.: Nawożenie roślin uprawnych. PWRiL, Warszawa 2008.
[4] Krasowicz S.: Porównanie efektywności energetycznej różnych technologii uprawy pszenicy ozimej. Pamiętnik Puławski, 1993, z. 103: 145-159.
[5] Pudełko J. Wielicki W. Błażek M. Waszczuk K. Maciejewski T. Sobiech S.: Wpływ poziomu nawożenia mineralnego na efektywność energetyczną zmianowań. Roczniki AR Poznań, 1996, CCLXXXV, 75-84.
[6] Scholz V. Berg W. Kaulfuß P.: Energy balance of solid biofuels. J. agric. Engng Res., 1998, 71, 263-272.
[7] Sęk T.: Karta technologiczna produkcji kukurydzy. Produkcja roślinna – technologia uprawy, pod red. J. Chotkowskiego. Fundacja ,,Rozwój SGGW", Warszawa 1994.
[8] Sulewska H.: Wpływ obsady i rozmieszczenia roślin na przebieg wegetacji i kształtowanie się cech morfologicznych kukurydzy. PTPN. Wydział Nauk Rolniczych, 1990, Tom. LXIX, 129-141.
[9] Szulc P. Rybus-Zając M. Waligóra H. Skrzypczak H.: Ocena stanu odżywienia dwóch typów odmian kukurydzy na podstawie zawartości chlorofilu w warunkach braku aplikacji nawożenia azotem. Wybrane zagadnienia ekologiczne we współczesnym rolnictwie, 2008, Tom (5), 260-267.

[10] Szulc P. Skrzypczak W. Waligóra H.: Yielding of two types of maize cultivars grown on CCM in conditions of zero nitrogen fertilization. Journal of Research and Applications in Agricultural Engineering, 2008, 53(4). 104-107.
[11] Szulc P. Waligóra H. Skrzypczak W.: Reaction of two maize cultivars expressed by dry matter yields depending on nitrogen fertilization level and on magnesium application method. Acta Agrophysica, 2008, 12(1): 207-219.
[12] Szulc P. Waligóra H. Skrzypczak W.: Susceptibility of two maize cultivars to diseases and pests depending on nitrogen fertilization and on the method of magnesium application. Nauka Przyroda Technologie, 2008, Tom 2, Zeszyt 2: 1-6.