YIELD OF ENERGY AND PROTEIN FROM GRAIN MAIZE HYBRIDS USING AGROTECHNICAL SYSTEM, OPTIMAL FOR THE CONDITIONS IN THE PLOVDIV REGION

ДОБИВ НА ЕНЕРГИЯ И ПРОТЕИН ОТ ХИБРИДИ ЦАРЕВИЦА ЗА ЗЪРНО ПРИ ОПТИМАЛНА АГРОТЕХНИЧЕСКА СИСТЕМА ЗА УСЛОВИЯТА НА ПЛОВДИВСКИ РАЙОН

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ABSTRACT

The yields of metabolizable energy for ducks and protein, so as the multiplication effect by different varieties of maize have been investigated. For the conditions in the Plovdiv region the hybrid PR35P12 had the highest yield of crude protein - 1368 kg/ha, and metabolizable energy – AME- 171,5 GJ/ha and TME – 181,3 GJ/ha. The highest multiplication effect (protein yield/crude protein applied by seed material) – showed hybrid PR35P12 - +403.3.

Keywords: yields, metabolizable energy, protein, multiplication effect, maize

РЕЗЮМЕ

Изследвани са добивите на обменна енергия за патици и протеин, както и мултипликационния ефект при различни хибриди царевица. За условията на Пловдивски регион хибрида PR35P12 е имал най – висок добив на суров протеин – 1368 kg/ha и обменна енергия - ВОЕ- 171,5 GJ/ha и ИОЕ – 181,3 GJ/ha. Най – висок мултипликационен ефект (добив на протеин/вложен суров протеин със семената) отново е показал хибрид PR35P12 - +403.3.

Ключови думи: добиви, обменна енергия, протеин, мултипликационен ефект, царевица

РАЗШИРЕНО РЕЗЮМЕ

Целта на настоящото проучване е да се направи сравнителна характеристика на добива на обменна енергия за птици и суров протеин на 4 хибрида царевица за зърно при оптимална агротехническа система на отглеждане за екологичните условия на Пловдивски регион.

Опитът е залаган по блоков метод в четири повторения с големина на реколтната парцела 25 m^2 с хибридите Кларика, PR37D25, PR35P12 и PR35Y540.

Отчетени са показателите добив на зърно, съдържание на сухо вещество, суров протеин, безазотни екстрактни вещества (БЕВ), сурови мазнини, сурови влакнини, бруто енергия в % към абсолютно сухо вещество в зърното; добив на сухо вещество, суров протеин, видима и истинска обменна енергия за мускусни патици.

Показателят „мултипликационен ефект" е изчислен като частно на добитите протеин и обменна енергия от реалните добиви на зърно и вложените такива със семената за посев.

Съдържанията на сухо вещество и суров протеин са установени по Веенде – метод, на брутоенергия – чрез микропроцесорен калопиметър KL-11 Mikado. Съдържанията на видима и истинска обменна енергия – чрез балансови опити с Мускусни патици.

За условията на Пловдив с най-високо съдържание на суров протеин се отличава хибрид PR35P12, а с най-високо съдържание на мазнини - хибрид PR37D25. Хибрид Кларика съдържа най-много влакнини.

Изпитваните хибриди не показват различия при сравняването на добива на зърно, добив на суров протеин и добива на обменна енергия. Най-високи стойности на тези показатели са отчетени при хибрид PR35P12- съответно: суров протеин 1368 kg/ha ВОЕ-171,5 GJ/da и ИОЕ – 181,3 GJ/da. Най-ниски добиви показва хибрид Кларика.

Максимален мултипликационен ефект при описаните екологични и агротехнически условия, по отношение на суров протеин показва хибрид PR35P12- 403.3, следван от PR35Y540 и PR37D25.

За максимален добив на енергия и протеин за условията на Пловдивски регион е препоръчано отглеждането на хибрид PR35P12.

INTRODUCTION

Finding solution to the food problem, fodder quality and economic efficiency related to crop growing require new approaches to determine the yields in plant production.

Grain yields do not meet the requirements regarding quality and safety of neither consumer nor the producer any more. The study of biological capabilities of given agrotechnical production system now shall be based on the maximum extraction of nutrients and not on their carriers – plants, animals, etc.

So it is very important the testing of various varieties and hybrids of cereals to be performed not only by the total yield but also by the yield of nutrients, especially if they are used for animal feeding. The efficiency of the animal production system, itself depends on the quantity of accessible nutrients in a fodder unit and the efficiency of crop growing depends on the yield of these nutrients from a unit surface area. Should this problem be solved globally, the areas used for fodder crops shall be reduced due to nutrient yield optimization.

Attempts to introduce this approach have been made in Bulgaria [2,3,6] but such studies on maize grain still do not exist and according to [8] maize grain is characterized with favourable chemical composition and very good nutritive value.

The objective of the present study is to give comparative characteristics of the yield of exchangeable energy for poultry and crude protein of 4 grain maize hybrids using agrotechnical system for growing, which is optimal for the ecological conditions in the Plovdiv region.

MATERIAL AND METHODS

The experimental work was performed in the Scientific-Experimental and Introductory Facility of the Department of Plant Growing at the AU – city of Plovdiv in the period 2005-2007.

The experiment was performed by means of a block method with four repetitions; experimental field area - 25 m^2 with hybrids Clarica, PR37D25, PR35P12 and PR35Y540.

Ploughing-in of the stubble was performed in August and deep ploughing at 28 - 30 cm was performed in October; pre-sowing cultivation with harrowing was performed twice in March and April.

Fertilization was performed in autumn before deep ploughing, with 25 kg active substance phosphorus (50 kg triple superphosphate), and before sowing with 18 kg active substance nitrogen (54 kg ammonia nitrate). The sowing was performed in the second decade of April as the seeds were pre-processed against diseases and pests (by Vitavax – 250 ml / 100 kg seeds and by Diafuran 2.5 l / 100 kg seeds respectively), at crop density of 7140 plants per da.

Herbicide Merlin duo 200 ml/ da was applied after sowing before sprouting and Equip CK - 120 ml/da was applied in the 7^{th} – 8^{th} leaf stage of maize for weed control. During

Table 1. Grain yield kg/ha
Таблица 1. Добив на зърно kg/ha

Varieties/Хибриди	Years of study/ Години на проучване			Average/ Средно
	2005	2006	2007	
Clarica	12450	9135	7921	9835
PR37D25	14000	8714	8058	10257
PR35P12	15150	12250	8964	12121
PR35Y540	14887	10481	8632	11333
LSD 5%	*257*	*1013*	*130*	

Table 2. Chemical composition and energy of grain, mean of the period 2005-2007, % in dry matter.
Таблица 2. Химичен състав и енергия на зърното, средно за периода 2005-2007 г, % към АСВ.

Indices/Показатели	Varieties /Хибриди			
	Clarica	PR37D25	PR35Y540	PR35R12
Dry matter, % Сухо вещество, %	86.90	86.97	86.34	86.06
Crude protein, % Суров протеин , %	10.45	12.14	11.47	13.15
Crude fat, % Сурови мазнини , %	6.55	6.84	4.42	4.25
Crude fibre, % Сурови влакнини ,%	5.25	4.98	5.14	5.11
NPE, %/ БЕВ, %	74.36	72.20	73.58	70.96
Gross energy, MJ/kg Бруто енергия , MJ/kg	18.56	18.76	18.51	18.67
Apparent metabolizable energy for Muscovy ducks in DM , MJ/kg/ DM /Видима обменна енергия за мускусни патици в СВ (AME n-o) MJ/kg CB	16.11	15.98	15.89	16.44
True metabolizable energy for Muscovy ducks, MJ/kg/ DM/ Истинска обменна енергия за мускусни патици в СВ (TME n-o) MJ/kg CB	17.04	17.21	17.16	17.38

crop vegetation double inter-row tillage and double intra-row tillage were performed.

The indices grain yield, dry matter content, crude protein, nitrogen free extract, crude fats, crude fibres, gross energy in % to absolute dry matter in grain, dry matter yield, crude protein, apparent and true metabolizable energy for Muscovy ducks were determined.

The index "multiplication effect" was calculated as a quotient of the obtained protein and metabolizable energy from the actual yield of grain and the ones deposited with the seeds for sowing.

The content of dry matter and crude protein was determined according to Weende – method [1], the gross energy value – by the microprocessor calorimeter KL-11 Mikado. The content of apparent and true metabolizable energy was determined by means of balance experiments with Muscovy ducks according to the method of [7], modified for ducks by [5]. The correction of metabolizable energy towards zero nitrogen balance was recalculated according to the formulas of [4]:

$$AME = (EI-EO)/FI$$

$$AMEn\text{-}_0 = AME - 34.4 \times ANR/FI$$

$$TME = AME + (FEL/FI)$$

$$TMEn\text{-}_0 = TME - [(34.4x\ ANR/FI) - (34.4 \times FNL/FI)]$$

where: AME – stands for apparent exchangeable energy; EI – energy absorbed with fodder (J); EO – energy, released by the fed analogues; FI – quantity of entered fodder (g); FEL – energy, released with excrements of fed poultry – J; ANR –apparent nitrogen retention (= nitrogen absorbed with fodder – nitrogen excretion by

fed poultry - g); FNL – nitrogen excretion by non-fed analogues– g; $n-_0$ – made equal to zero nitrogen balance

The obtained data were processed mathematically by means of the Duncan's test.

The basic climatic factors, determining maize growth, development and productivity were temperatures and precipitation, their combination and distribution during vegetative period.

The analysis of these factors showed that the values of the average monthly temperatures during the years of study did not differ significantly from those of the many-year period and satisfied completely the requirements of the maize towards heat from the period of sowing to the period of ripening. Significant differences were observed in the quantity of precipitation during the individual agricultural years. The first experimental year (2005) was the moistest one, followed by 2006 and least precipitation was reported in the third year of the experiment (2007), which influenced the growth processes and productive capabilities of the maize plants.

RESULTS AND DISCUSSION

The data on grain yield of the tested hybrids in the experimental period are presented in Table 1. The obtained results showed that the grain yield changed through the years of study depending on the meteorological conditions.

The more favourable combination and distribution of meteorological factors (moisture and temperature) in 2005 were a prerequisite for higher yields, compared to 2006 and 2007.

In this year (2005) the highest grain yield obtained the hybrid PR35P12 (15150 kg/ha), followed by PR35Y540 (14887 kg/ha), and the lowest yield - Clarica (12450 kg/ha). In the second year of the experiment (2006) with the tested hybrids lower grain yields from 19.1 to 37.7 % were reported, compared to the previous year. The reason for that were the less precipitation quantity and the lower air humidity in the crucial stages of the maize plant development.

In the last year of study (2007) the grain yield was the lowest and varied from 7921 kg/ha with Clarica to 8964 kg/ha with PR35P12.

During the three years of the experiment, as well as at an average, for the period of study, the highest grain yield was statistically proven to be obtained from the hybrid PR35P12 – 12121 kg/ha and the lowest yield - from the hybrid Clarica (9835 kg/ha).

The results of chemical analysis showed that the content of crude protein with the tested hybrids varied from 10.45

Table 3/Таблица 3

Varieties/ Хибриди	Yield of dry matter, kg/ha/ Добив на сухо вещество, kg/ha			Yield of apparent metabolizable energy for Muscovy ducks GJ/ha Добив на видима обменна енергия за мускусни патици GJ/ha			Yield of true metabolizable energy for Muscovy ducks - GJ/ha Добив на истинска обменна енергия за мускусни патици GJ/ha		
	Years of study Години на проучване			Years of study Години на проучване			Years of study Години на проучване		
	2005	2006	2007	Средно/ Average	2005	2006	2007	Средно/ Average	2005	2006	2007	Средно/ Average
Clarica	10819	7938	6883	8547	174.3	127.9	110.9	137.7	184.4	135.3	117.3	145.6
PR37D25	12176	7579	7008	8921	194.6	121.1	112.0	142.6	209.5	130.4	120.6	153.5
PR35R12	13038	10542	7714	10431	214.3	173.3	126.8	171.5	226.6	183.2	134.1	181.3
PR35Y540	12853	9050	7453	9785	204.2	143.8	118.4	155.5	220.6	146.2	127.9	164.9

Table 4/Таблица 4.

Varieties Хибриди	Crude protein applied by seed material - kg/ha Суров протеин вложен чрез семената- kg/ha				Yield of crude protein, kg/ha Добив на суров протеин kg/ha				Multiplication effect/ Мултиплициращ ефект		
	Years of study Години на проучване				Years of study Години на проучване				Years of study Години на проучване		
	2005	2006	2007	Средно/ Average	2005	2006	2007	Средно/ Average	2005	2006	2007	Средно/ Average
Clarica	2.6	2.7	2.8	2.7	1082	849	733	888	+ 416.2	+ 314.4	+ 261.8	+ 330.8
PR37D25	3.1	3.2	3.2	3.2	1461	920	861	1081	+ 471.3	+ 287.5	+ 269.1	+ 342.6
PR35R12	3.3	3.5	3.4	3.4	1669	1418	1017	1368	+ 505.8	+ 405.1	+ 299.1	+ 403.3
PR35Y540	2.9	2.9	3.1	3.0	1427	1022	896	1115	+ 492.1	+ 352.4	+ 289.0	+ 377.8

% with Clarica to 13.15 % with PR35P12 (Table 2). The early hybrid Clarica and the middle-early PR37D25 had approximately 1.5 times higher content of crude fats compared to the middle-late (PR35P12 and PR35Y540).

The content of crude fibres varied from 4.98 % with PR37D25 to 5.25 % with Clarica.

Regarding the index "content of nitrogen free extract" in the tested hybrids the values reported were from 70.96 to 74.36 % and the gross energy was within the limits from 18.51 to 18.86 MJ.

The metabolizable energy for Muscovy ducks had the highest values with the hybrid PR35P12 – 16.44 MJ/kg and 17.38 MJ/kg, for apparent and actual respectively.

The lowest values for apparent metabolizable energy were reported with the hybrid PR35Y540 – 15.89 MJ/kg and for true metabolizable energy - with the Clarica hybrid– 17.04 MJ/kg.

Dry matter yield with the tested hybrids had its highest values in 2005 and varied from 10819 (with Clarica) to 13038 kg/ha (with PR35P12), while in 2006 it was from 10.1 to 37.7 % lower (Table 3).

The lowest dry matter yield was reported in 2007 from 6883 to 7714 kg/ha.

During the period of study this index had the highest values with the hybrid PR35P12 – 10431 kg/ha and the lowest values with the Clarica hybrid - 8547 kg/ha.

During the years of study the yield of apparent metabolizable energy (AMEo) was from 110,9 to 214,3 GJ and for true metabolizable energy (TMEo) from 117,3 to 226,6 GJ. The lowest average values for AMEo for the period of study were reported with the hybrid Clarica -137,7 and 145,6 GJ and the highest values – with the hybrid PR35P12 -171,5 and 181,3 GJ.

The crude protein yield, obtained from the tested hybrids during the experimental period varied from 733 to 1669 kg/ha. Averagely for the period of study, the crude protein yield of the hybrid PR35P12 was 54 %, 26.5 % and 22.7 % higher than the yield of the hybrids Clarica, PR37D25 and PR35Y540.

The results obtained for the crude protein multiplication effect with the tested hybrids showed that it had the highest value with the hybrid PR35P12 and the lowest - with the hybrid Clarica. This fact showed that under the combination of the described agroecological and agrotechnical conditions, the most suitable hybrid in relation to the crude protein yield was the hybrid PR35P12, followed by PR35Y540 and PR37D25.

CONCLUSIONS

For the conditions in the Plovdiv region the hybrid

PR35P12 had the highest content of crude protein and the hybrid PR37D25 had the highest content of fats. The hybrid Clarica had the highest fibre content.

The tested hybrids did not demonstrate differences in the comparison of grain yield, crude protein yield and metabolizable energy. The highest values of these indices were reported with the hybrid PR35P12 and the lowest – with the hybrid Clarica.

The maximum multiplication effect under the described agroecological and agrotechnical conditions in relation to the crude protein was demonstrated by the hybrid PR35P12, followed by PR35Y540 and PR37D25.

We recommend the growing of hybrid PR35P12 for maximum yield of energy and protein under the conditions in the Plovdiv region.

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