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ENERGY AND PROTEIN FEEDING OF BIOMASS FROM TWO MAIZE HYBRIDS IN RUMINANTS

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Abstract

The research was conducted in the period 2022-2023 in the experimental field of the Department of Plant Breeding, Faculty of Agriculture of Trakia University, Stara Zagora, Bulgaria. In this study, the nutritional value of three maize hybrids was investigated. The productivity of hybrids grown in non-irrigated and irrigated conditions was determined. The influence of feeding with liquid foliar fertilizers on the productivity of corn hybrids has been studied. The chemical composition has been investigated and the nutritional value of the biomass has been determined. A regression analysis was performed between some parameters and trends were detected. The analysis of the results shows a tendency towards an increase in the crude protein content of the variants treated with nutritional products. An average increase of 36.4% for LG 31.390 and 14.8% for Knezha-461 was reported over the study period. When giving the hybrid, no significant differences were found in terms of the content of PFA. The data shows that the values of FUM and FUG move within narrow limits for the variants. A negative RDP was found, which is an indicator of nitrogen deficiency for microbial protein synthesis in the rumen. Linear regression models show a strong relationship between crude protein content and biomass yield. The coefficients of determination were established for the two hybrids, LG 31.390, R2 = 0.9255 and Knezha-461, R2 = 0.7205, respectively.

Key words*: maize, biomass, fertilization, nutritional value.*

INTRODUCTION

Maize is the most commonly used raw material for the production of silage. Maize consists of fiber, which can be digested by ruminants, and starch. Silage corn is the most used energy source in dairy cattle diets worldwide (Leonhart & Beneitez, 2019). The main advantage of corn is that it has the highest energy value of all cereals, but it is also the poorest in protein (ie, it has a lower rate of protein and starch degradation in the rumen). Over the last 25 years, whole-plant maize silage has become an important and popular feedstock for dairy production, commented Ferraretto et al. (2018). Starch in the ration can be absorbed up to 100%, while the amount of utilized fibers varies depending not only on the variety (hybrid) of corn, but also on the balance of the ration. It is particularly important to evaluate the effect of the hybrid, maturity at harvest dry matter (DM) content and duration of storage on the composition and nutritional value of maize silage found Der Bedrosian et al. (2012). The development of indices combined with silage quality parameters can provide clear guidelines for evaluating the overall quality of the produced maize silage, reported Tharangani et al. (2021).

The correct selection of hybrids suitable for the area is made after researching the productivity and quality of the silage (Keskin et al., 2017). Identification of the appropriate sources is based on the existing genetic diversity (Rivas et al., 2018; Zaragoza et al., 2019). According to Ferreira et al. (2014) higher silage yields can be obtained by increasing maize planting density without affecting its nutrient composition. In a study Chayanont et al. (2021) also confirmed that density increased forage yields without negatively affecting the nutritional value of corn silage.

The influence of nitrogen sources on the biomass and quality of silage corn is the basis of a number of studies (Safdarian et al., 2014). Seadh et al. (2015) confirmed the positive effect of foliar feeding on the components and quality of the yield. A tendency towards an increase in leaf area, plant height and grain yield was also found by Brankov et al. (2020) after studying the effect of some foliar fertilizers on five lines of maize.

Silage corn (*Zea mays* L.) is the most widely used worldwide in dairy cattle diets because of its higher biomass yields, palatable, homogeneous quality at harvest, and ease of silage due to its higher soluble sugar (García-Chávez et al., 2022). Serva et al. (2023) reported relationships between fresh maize characteristics and silage characteristics. After conducting an analysis with 1500 samples, for the period from 2016 to 2022, the authors established relationships between the estimated aerobic stability of the silage, the fermentation profile and the temperature measured 14 days after the silos were opened. The inferred dependencies can provide information for precision agriculture and more specifically for maize silage preparation and storage. After analyzing 6 clusters, the authors found tendencies to increase the dry matter content while decreasing the digestible fiber.

According to Hidalgo et al. (2018) and Mandić et al. (2018) corn for silage is characterized by high biomass yields and good palatability. The higher content of sugars makes silage preferable to other crops (Ali et al., 2019), but the loss of leaf quantity and quality from senescence reduces nutritional quality noted (Khan & Rahman, 2015). The rapid rates of formation of biomass that is resistant to some foliar diseases are the basis of the interest in this forage (Rivas et al., 2018; Sánchez et al., 2019). According to other authors (Combs, 2015), the content of crude protein (CP), neutral detergent fiber (NDF), and neutral detergent fiber digestibility (NDFD) should also be taken into consideration.

A huge number of feeds and feed additives are used in animal nutrition. To facilitate their use, different classifications are offered. Plant fodder is of the greatest importance in animal nutrition. Assessment of the nutritional value of feed is based on an assessment of the content of individual organic compounds and especially of the energy and protein value. Increasing the nutritional value of whole-plant maize silage is the goal of the updated technologies reported Ferraretto et al. (2018). In addition, the content of water and dry matter, crude protein and crude fiber, the presence of deficient mineral substances, vitamins and essential amino acids is taken into account.

The objective of the present study was to investigate the effect of foliar fertilization on the productivity and nutritional value of green maize.

MATERIALS AND METHODS

In order to achieve this goal, an experiment with two hybrids of corn was conducted in southern Bulgaria. Under field conditions, in 2022-2023, an experiment with corn hybrids of different genetic origins was planned. One of the researched hybrids is Knezha-461, from the variety list of Bulgaria and a selection of the Maize Institute - Knezha. The other hybrid LG 31.390 is from the Limagrain variety sheet, from the Hydraneo technology. The representatives of this technology are distinguished by their tolerance to soil drought and extreme temperatures. The hybrid included in the field experience is FAO 370, a medium-early hybrid.

The foliar fertilizers that were applied for nutrition during the growing season are Aminozol, Boron, Zinc 700SK, Nutriplant 36, Kinsidro Grow and H-loc. The experiment was carried out under natural moisture security and under irrigation conditions. Irrigation was carried out using a drip irrigation system. Soil moisture and watering time was determined through soil samples, with a soil moisture probe. The variants of the study include: 1. Control - without irrigation and nutrition during the vegetation; 2. Control – with irrigation, without feeding; 3. With irrigation and feeding with Aminozol, Boron, Zinc 700SK, Nutriplant 36; 4. With irrigation and nutrition with Kinsidro Grove, N-loc. Fertilization time and rates are tailored to the requirements for each product applied.

The properties of the meadow-cinnamon soil type in the field are as follows: sandy loam, organic matter for the 0-50 cm layer 3.93%, mineral nitrogen 33.2 mg/1000 g, 3.9 mg/1000 g mobile phosphorus and 44 mg/1000 g digestible potassium.

The average growing season temperature was 20.6°C in the first year and 20.6°C in the second year, while the 1990-2020 average was 19.9°C. Data show a warming trend. The amount of precipitation during the vegetation period was 254.9 mm, in the first year and

275.5 mm in the second year of the experiment. The average for the period 1990-2020 was 279.7 mm. Their uneven distribution is also essential, which does not provide the crop with enough water in the soil horizon.

The experiment was based on a fractional plot experimental design with four replications of the experimental area size of 15 m^2. Sowing was carried out at a row spacing of 70 cm and an intra-row distance of 20 cm, at a depth of 5 to 6 cm. Fertilization with N14 nitrogen was carried out, after which foliar fertilizer treatment was carried out. The application of foliar fertilizers is tailored to the development phase of the maize. In the analysis of plant material, samples were taken from 10 randomly selected plants.

The chemical analysis of the maize was carried out by the Weende method.

By the formulas of Todorov et al. (2004; 2007) the FUM, FUG, PDI and RDP content for ruminants were calculated.

GE = 0.0242 CP + 0.0366 EE + 0.0209 CF + 0.017 NFE

ME = 0.0152 DP + 0.0342 DEE + 0.0128 DCF + 0.0159 DNFE

q = ME / GE

FUM = ME (0.075 + 0.039q)

FUG = ME (0.04 + 0.1q)

PDI = 1.11CP (1 - Deg) Dsi + 0.093 FOM

FOM = DOM - DEE - FP - CP (1 - Deg)

FP = 250 – 0.5 DM

RDP = CP (Deg – 0.1) – 0.145 FOM

where: CF - crude fibre, CP - crude protein, DEE - digestible ether extract, Deg - degradability of dietary protein in the rumen, DF - digestible fibre, DNFE - digestible nitrogen free extract, DOM – digestible organic matter, DP - digestible protein, Dsi - digestibility in small intestine, EE - ether extract, FOM - fermentable organic matter, FP - silage fermentable products, FUG – feed unit for growth (= 6 MJ net energy for growth), FUM – feed unit for milk (= 6 MJ net energy for lactation), GE - gross energy, ME - metabolizable energy, NFE - nitrogen free extract, PDI - protein digestible in (small) intestine, RDP - rumen degradable protein.

Statistical analysis was performed with Anova.

RESULTS AND DISCUSSIONS

The factors influencing the development and productivity of corn are mainly heat and moisture in the soil horizon. During the two years of the experiment, the crop was sown at optimal times. Main fertilization with nitrogen 14 active substance/da was performed. Fertilizers with liquid foliar fertilizers were carried out during the growing season, as stipulated in the methodology. To maintain moisture in the soil, 4 waterings were implemented in the first year and 6 waterings in the second year, with the size of the irrigation rate being 30 mm.

Figure 1 shows the crude protein content results of two maize hybrids. The analysis shows that under non-irrigated conditions and without foliar fertilization, the lowest results were obtained in both hybrids during the vegetation period. In the mid-early hybrid LG 31.390 the content was 8.90 g/kg DM, while in Knezha-461 it was 9.13 Knezha-461, on average for the study period. The quality indicators of the grain are genetically determined, but they are also influenced by the level of agricultural technology, climatic factors during the growing season and by the specific agro-ecological conditions of the area where the crop is grown. Under the influence of irrigation, the data show that the content of crude protein, in the biomass, increased with a greater growth in the second experimental year. Total aboveground biomass and biomass of crop components increased as a function of amount of water and fertilizer applied also reported by Gheysari et al. (2009).

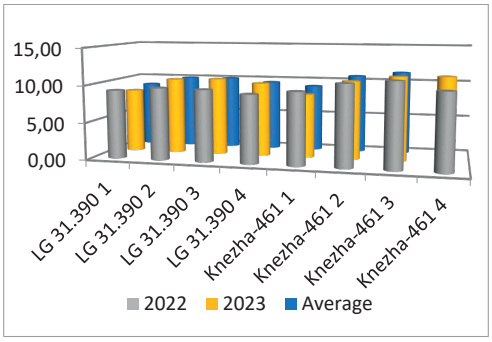

Figure 1. Content of crude protein by hybrids maize and years, g/kg DM

When optimizing soil moisture, the hybrid LG 31.390 was distinguished by a 12.11% increase in crude protein content, compared to the non-irrigated variant. An increase from 4.91% to 19.84% was recorded in the two years. In Knezha-461, the average increase for the period was 17.08%. In the first year, it was reported by 12.17%, and in 2023 it is 22.46% higher. The optimization of soil moisture has created favorable conditions for plant development. Over the years of the study, a varying number of waterings were submitted. In 2022, only 4 irrigations were carried out, and the irrigation was carried out during the phenophase - end of leaf formation. In the second year, irrigation started earlier and provided enough readily available moisture for the plants.

After treatment with foliar fertilizers, an increase in the crude protein in the biomass of the plants is reported. Knezha-461 (23.7%), treated with the organic fertilizer Aminozol, the inorganic one-component fertilizers Boron, Zinc 700SK and Nutriplant stands out with the largest increase compared to the non-irrigated variant. The results are an average for both years, but the analysis shows that even by year at var. 3 crude protein values are high. At var. 4 with foliar feeding with the organo-mineral fertilizer Kinsidro Grow and the nitrogen stabilizer N - Lock, the increase is 18.1% compared to the unirrigated variant. The complex action of feeding with irrigation leads to an improvement in the qualitative composition of the green mass. When compared with var. 2, where there is only optimization of the soil water supply, the crude protein content also increases. The trend was observed in Knezha-461, while in LG 31.390 the data indicated that the crude protein content, g/kg DM moved within very narrow limits. In the selection of hybrids for silage, the choice is directed to quality indicators, but also to high yield levels. On the basis of the content of crude protein in 1 kg of dry matter, the data for the yield of one acre are obtained (Table 1). The results showed a wide range of fluctuations from 67.98 kg/da to 270.08 kg/da, averaged over the period. In Knezha-461 levels of 190.06 kg/da were found, on average for all variants, and in LG 31.390 157.58 LG 31.390, which is 17.1% less. The analysis of the mean values shows a positive trend, with the same rate of increase in crude protein in lime. 3, compared to the non-irrigated variant. The data indicate that the applied fertilizers contributed to an increase in the content and the leaf mass in both hybrids.

The better moisture content in the soil has ensured a more complete absorption of the nutrients by the plants. In the second year, after 6 waterings, higher results were obtained in yield of leaf mass and crude protein content. In the first year, the yields are lower, and this is correspondingly reflected in the yields of crude protein per acre. The foliar fertilizers applied in the respective phases did not contribute to strengthening the development of the crops, because the temporary water deficit, during the phenophase of leaf formation, affected the adsorption and assimilation of nutrients. Better results were registered when applying the complex of Aminozol and the two single-component fertilizers Boron and Zinc.

Table 1. Crude protein yield from maize for silage, kg/da

Hybrids of maize	Variants	Crude protein, kg/da		
		2022	2023	Average
LG 31.390	1	46.78	89.17	67.98
	2	124.96	157.87	141.41
	3	185.68	270.27	227.97
	4	144.50	241.39	192.94
Knezha-461	1	77.56	83.82	80.69
	2	209.65	171.56	190.61
	3	254.30	285.87	270.08
	4	216.80	220.91	218.86

The increase in crude protein content was 61.2% in LG 31.390 and 41.7% in Knezha-461, compared to the irrigated variant. The medium-early hybrid LG 31.390 was found to be more responsive to feeding during the growing season. Although it is representative of Limagrain's Hydraneo technology, the hybrid is responsive to irrigation. With an increase in yield of raw protein per hectare, variant is also distinguished. 4. An average increase of 36.4% for LG 31.390 and 14.8% for Knezha-461 was reported for the period. Treatment with the complex organo-mineral fertilizer and the nitrogen stabilizer ensure better absorption of nitrogen and increase the yield.

A major advantage of corn is that it has a high energy value. In ruminants, two energy units

are used - milk feed units (FUM) for lactating animals and growth feed units (FUG) for growing animals. The use of two energy units is required due to the different utilization of the exchangeable energy of feed in lactating and growing animals. From Table 2 it can be seen that the content of FUM and FUG moves within narrow limits for both varieties - from 1.11 to 1.20 for both years, and the different treatments did not have an impact on the energy nutrition of the corn.

Table 2. Energy and protein nutrition for ruminant animals in 1 kg of DM

Hybrids of maize	Variants	2022				2023			
		FUM	FUG	PDI	RDP	FUM	FUG	PDI	RDP
LG 31.390	1	1.11	1.14	90.08	- 47.58	1.08	1.12	86.75	- 48.84
	2	1.11	1.16	90.18	- 43.20	1.06	1.08	91.14	- 38.55
	3	1.15	1.20	91.60	-36.11	1.08	1.11	91.72	- 37.85
	4	1.12	1.17	89.38	- 47.19	1.06	1.09	90.01	- 39.82
Knezha-461	1	1.10	1.13	90.60	- 43.85	1.08	1.11	86.70	- 48.56
	2	1.11	1.14	93.19	- 36.01	1.04	1.06	90.83	- 35.55
	3	1.14	1.19	95.38	- 34.80	1.03	1.05	92.61	- 30.98
	4	1.14	1.19	92.46	- 41.62	1.03	1.05	93.32	- 30.97

The PDI content for both years and both cultivars was highest in Var. 3 - 91.60 and 95.38 g PDI for 2022 and 91.72 and 92.61 g PDI for 2023, respectively, and the lowest in the group without irrigation - 90.08 and 90.60 g PDI for 2022 and 86.75 and 86.70 g PDI for 2023, respectively, where it was found and lowest level of crud protein.

Significant differences between the two varieties of maize in terms of PDI content were also not established. The RDP is negative, indicating a lack of nitrogen for microbial protein synthesis in the rumen. Due to the negative RDP, the use of green maize in ruminant rations necessitates the use of significant amounts of protein forage. Lower values of RDP in 3 variants for both years and in both varieties, guarantee a better satisfaction of microorganisms with nitrogen for microbial synthesis and on this basis are higher values of PDI.

The conducted regression analysis shows the nature of the relationship between yield of green mass and the content of crude protein in % of dry matter. In the mid-early hybrid LG 31.390, the coefficient of determination (R^2) was established, which shows what percentage of the variance of the outcome variable is explained by the action of the factor variable (Figures 2 and 3).

In this case $R^2 = 0.9255$, i.e. 92.6% of protein content depends on biomass yield.

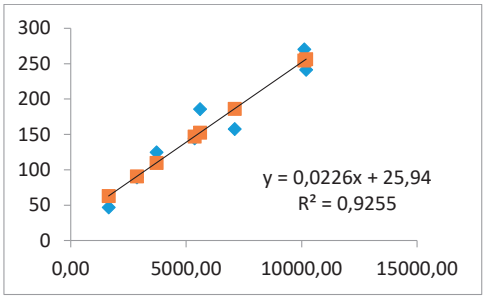

Figure 2. Linear regression model between crude protein and green matter, LG 31.390

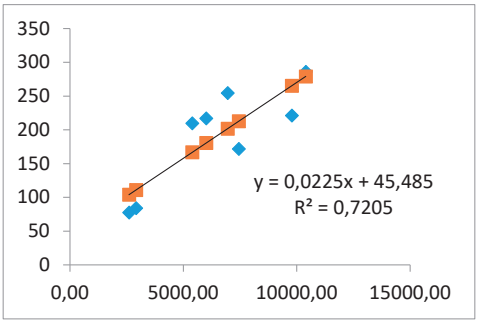

Figure 3. Linear regression model between crude protein and green matter, Knezha-461

With Knezha-461, there is a highly pronounced positive correlation dependence. The coefficient of determination has a value of 0.7205, indicating that approximately 72% of the variation in crude protein content is explained by the linear regression. The linear regression models

express the influence of the yield of green mass in relation to the content of crude protein and make it possible to theoretically establish how and in what direction the change of these indicators contributes to an increase in the quantity of crude protein.

CONCLUSIONS

The analysis of the results shows a tendency to increase the crude protein content in the variants treated with foliar fertilizers. On average over the study period, an increase of 36.4% was reported for LG 31.390 and 14.8% for Knezha-461.

In both hybrids, no significant differences were found in terms of the content of PDI. The data shows that the values of FUM and FUG move within narrow limits for the variants.

A negative RDP was found, which is an indicator of a lack of nitrogen for microbial protein synthesis in the rumen.

The linear regression models showed a strong relationship between crude protein content and biomass yield. The determination coefficients for the two hybrids were established, respectively for LG 31.390, $R^2 = 0.9255$ and Knezha-461, $R^2 = 0.7205$.

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