Journal of Balkan Science and Technology
journal homepage: www.jbst.nku.edu.tr/

Crude Protein Content of Maize Hybrid Varieties and Inbred Lines

Emil VASILEV *1

[1] *Maize Research Institute, 5835, Kneja, Bulgaria*

Research Article

Keywords:
Breeding
Grain
Maize
Crude protein

Received: 03.07.2022
Accepted: 31.08.2022
Published:14.09.2022

DOI: 10.55848/jbst.2022.15

ABSTRACT

Maize cropping technology during the last decades was improved and breeders created many high-yielding maize hybrid varieties. There has not been the same level of success with improving maize grain quality, especially crude protein content. This work aimed to study promising hybrid varieties and inbred lines of maize with high grain crude protein content for involvement in the breeding process. Four commercial hybrid varieties, FAO 300 to FAO 600, four new experimental hybrids and six inbred lines of maize were tested for crude protein content in grain, crude protein yield and grain yield. Kneja 435 from the commercial hybrid varieties was found to have a relatively high grain yield and the highest crude protein yield. It is very suitable for the production of animal feed. №12 (CM 5625 x XM 88/113 o_2) from the experimental hybrids is considered promising due to the high protein content and adequate grain yield. It is recommended to be used for high crude protein selection. B 311 and CM 5625 maize inbred lines had high grain crude protein content and, along with the established line HM 532 BC, can be used in the selection for the creation of high-protein maize hybrids. These findings are a contribution to the breeding process of maize.

1. Introduction

During the last decades, maize grain production has had significant achievements in Bulgaria. That success was due to cropping technology improvements, as well as to purposeful selection based on the heterosis effects that are manifested after crossing inbred lines [1, 2]. The average yields of maize varied around 424.0 - 554.0 kg/da, respectively, in 2002 and 2004, and they significantly increased to 768.2 kg/da in 2014 due to meteorological conditions and improved cropping technology. In addition to high productivity, the nutritional composition of the grain is also important. Crude protein content of the most common hybrid varieties varied from 8 to 11% and very rarely over 12%. The issue of increasing the crude protein content of maize grain through breeding has long been studied [3].

The creation of new maize hybrid varieties with high grain protein content is a goal for many breeders [4-8]. Using exotic germplasm, breeders have developed lines with high variability in crude protein content [9], but a negative correlation was found between grain yield and crude protein content in maize [10]. Creating a new maize hybrid with both adequately high grain yield and high crude protein content is a great challenge [11].

This work aimed to study promising hybrid varieties and inbred lines of maize with high grain crude protein content, thus involving them in the breeding process for new hybrids with high grain protein content and acceptable grain yield.

2. Materials and Methods

Field trials were carried out in the experimental field of Maize Research Institute – Kneja, Bulgaria (2021). The block design method was used; the plot size was 10 m^2, 3 times replicated. The soil type was typical chernozem with water-soluble nitrogen of 35.6 mg/1000 g in the soil solution before sowing. Common technology for maize growing was applied to a wide row crop of 70 cm and a seed density of 5800 plants/da. Nitrogen fertilizer at a rate of 4 kg/da active substance was applied with sowing. It was applied to stimulate the initial development of the plants but did not affect the crude protein content. Plants were harvested simultaneously at 15-16% grain moisture, and then the yields were calculated at standard storage moisture (14%). Representative grain samples were taken from each replication to determine crude protein content of the hybrids and inbred lines tested. Three groups of maize were used – commercial hybrids (Kneja 310, 435, 561 and 683A), experimental hybrids [№10 (XM 532 BC - CM 5625), №12 (CM 5625 x XM 88/113 o_2), № 17(S 144 o_2 - CSH 732 o_2) and №29 (CM 5625 - B 311) and 6 inbred lines (XM 532 BC, CM 5625, B 311, XM 88/113 o_2, S 144 o_2 and СШ 732 o_2) The content of crude protein was determined according to Kjeldahl method (CP=N x 6.25) [12]. Crude protein yield (kg/da) was determined by multiplying the grain yield (kg/da) and protein content (%). Experimental data were processed using ANOVA for MS Excel (2010) for Windows XP and the

* Corresponding author: *Maize Research Institute, 5835, Kneja, Bulgaria*
E-mail address: *vasilev_642@abv.bg*

computer software STATGRAPHICS Plus for Windows Version 2.1.

3. Results and Discussion

The maize vegetation period of 2021 was characterized as relatively favorable (Fig. 1), with relatively frequent rains in May and June and monthly precipitation amounts of 82.0 and 95.4 mm/m^2, respectively.

July and August were characterized by an increase in the average daily temperature and a decrease in precipitation (34.9 and 56.9 mm/m2). There was only one precipitation event on July, 20th (34.9 mm/m^2). It had a favorable effect on the realization of the biological potential of maize, to a certain extent. The grain crude protein content of commercial hybrid varieties entered in the Official Bulgarian variety list, promising experimental hybrids and inbred lines of maize are given in Table 1.

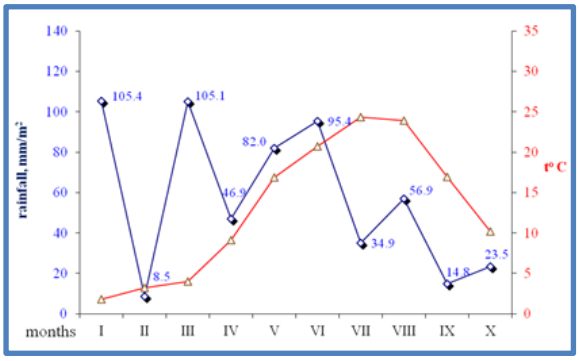

Fig. 1 Meteorological conditions during vegetation period of maize

Table 1. Crude protein content in commercial Bulgarian hybrid varieties, experimental new hybrids and inbred lines

Assessments	Crude protein, %	Standard deviation	CV%
Commercial and new experimental hybrids			
Kneja 310 (FAO 300)	10.31	± 0.78	7.57
Kneja 435 (FAO 400)	12.76	± 0.34	2.66
Kneja 561 (FAO 500)	9.17	± 0.66	7.20
Kneja 683A (FAO 600)	12.57	± 0.49	3.90
10 (XM 532 BC - CM 5625)	14.30	± 0.38	2.66
12 (CM 5625 - XM 88/113 o2)	14.34	± 0.41	2.86
17 (S 144 o2 - CSH 732 o2)	8.56	± 0.37	4.32
29 (CM 5625 - B 311)	13.34	± 1.05	7.87
Average	11.92		
LSD 5%	0.68		
Inbred lines			
XM 532 BC	17.25	± 0.27	1.57
CM 5625	16.55	± 0.38	0.23
B 311	16.92	± 0.19	1.12
XM 88/113 o2	12.25	± 0.27	2.20
S 144 o2	10.92	± 0.37	3.39
CIII 732 o2	14.15	± 0.19	1.34
Average	14.67		
LSD 5%	0.39		

Crude protein content in the two groups of plants (hybrids and inbred lines) strongly varied. For example, the hybrid varieties Kneja 310 and 561 showed low protein content - 10.31 and 9.17%, respectively. Kneja 435 and 683A had high values of this characteristic (12.76 and 12.57%, respectively). In Bulgarian practice, Kneja 435 is among the most common maize hybrids used for grain, and Kneja 683A for silage production.

From the new experimental hybrids, those with both high crude protein content and corresponding grain productivity were selected. Varieties with high protein content were №10, 12 and 29 (14.30, 14.34, and 13.34%, respectively), and with a low value was №17 (8.56%). The inbred lines are parental components of experimental hybrids. Three of them belong to the OPAQUE 2 mutant type. Their crude protein content was lower compared to other normal lines and varied from 10.92% for S 144 o_2 to 14.15% for CIII 732 o_2.

Other lines had a higher content of crude protein (more than 16%), the highest value belonging to XM 532 BC (17.25%). These lines were created in the Maize Research Institute – Kneja after treatment of inbred line OH–43 with chemical mutagens [13]. That chemically-modified inbred line was used for the creation of Bulgarian high protein hybrid variety for grain production Kneja 532 VP in 1982 and Kneja 633 VP for biomass production in 1986[9, 14]. Inbred lines B 311 and CM 5625 also showed high values of protein content (16.92 and 16.55%, respectively).

The CV% values showed that all assessments tested were homogenous. This characteristic identified the hybrids and inbred lines with high protein content.

Grain yield is a key indicator of the productivity of maize hybrid varieties (Table 2). Yield for the commercial varieties increased from 977.7 kg/da for Kneja 310 (FAO 300) and 1121.6 for Kneja 435 (FAO 400) to 1419.1 for Kneja 561 (FAO 500). A lower yield was obtained from Kneja 683A (FAO 600) compared to representatives of the FAO 400 and 500 groups. The differences in yields between these varieties were statistically significant, excepting Kneja 435 and Kneja 683A.

From the selected experimental hybrids, grain yield was significantly lower. The grain yield of №17 was 1195.5 kg/da, and significantly exceeded the others ranging from 24.0 to 37.9%. The same was true for Kneja 683A and Kneja 310 by 11.2 to 22.3%, respectively.

Crude protein yield is shown in Table 2. It is an indicator reflecting the quality of the grain produced. In addition, it is important when choosing a hybrid variety for the production of concentrated fodder for the needs of animal husbandry [8, 14]. It was found that there is a negative correlation between the two indicators [4]. The results of this study confirm the findings in a number of previous studies [15-17].

The highest grain yield for hybrid varieties was obtained from Kneja 561 (1419.1 kg/da), and from №17 for experimental hybrids (1195.5 kg/da); however, the crude protein content was the lowest (9.17 and 8.56%, respectively).

Crude protein yields for these hybrids were intermediate – 130.2 and 102.5 kg/da, respectively. The result of Kneja 435 was the highest - 143.1 kg/da and significantly exceeded Kneja 561 (by 10.1%).

The protein yield of experimental hybrids № 10, 12 and 29 significantly exceeded №17, due to the higher crude protein content - over 4%, although they have lower grain yields. The crude protein yield of №12 (141.0 kg/da) was close to the Kneja 435 hybrid variety and significantly exceeded the others.

4. Conclusion

Kneja 435 from the commercial hybrid varieties had relatively high grain yield and the highest crude protein yield. It is very suitable for the production of animal feed.

№12 (CM 5625 x XM 88/113 o2) from the experimental hybrids is considered a promising variety due to its high protein content and adequate grain yield. It is recommended to be used for high crude protein selection.

The B 311 and CM 5625 maize inbred lines had a high grain crude protein content and, along with the established line HM 532 BC, can be used in selection for the creation of high-protein maize hybrids.

Declaration

Author Contribution: Conceive-E.V.; Design-E.V.; Supervision-E.V.; Experimental Performance, Data Collection and/or Processing E.V.; Analysis and/or Interpretation E.V.; Literature Review-E.V.; Writer- E.V.; Critical Reviews -E.V.

Conflict of interests: The author has declared no conflicts of interest.

Orcid ID

Emil Vasilev https://orcid.org/0000-0003-4904-6950

References

[1] G. Yordanov, "“Heterosis and genetic inheritance effects of quantitative signs in medium early hybrid maize Kneja 435”, II. Length of the cob, number of rows in the cob, weight of the cob," *Plant Studies, Science & Technologies,* vol. 3, no. 6, pp. 203-207, 2013.

[2] V. Valkova, N. Petrovska, "Inheritance of quantitative signs and some biometric indexes and mutability of genetic indexes of Knezha 442 hybrid III. Length of the grain, grain weight per ear, present of in the grain in ear.," in *International conference, 135 Years agricultural Science in Sadovo and 40 years institute of plant genetic resources- Sadovo*, Plovdiv, 29 and 30 May 2017, pp. 415-423.

[3] C. G. Hopkins, "Improvement in the Chemical Composition of the Corn Kernel," *Journal of the American Chemical Society*, vol. 21, no. 11, pp. 1039-1057, 2002, doi: 10.1021/ja02061a012.

[4] N. Tomov, P. Christova, and K. Christov, "Maize with increased quantity and quality of protein in the grain " *Agriculture* no. 7 pp. 22-25, 1982.

[5] K. Hristov, P. Hristova, "Modified high protein hybrid of maize Kneja MBP 556," *Plant Science* no. 11, pp. 35-39, 1986.

[6] K. Hristov, P. Hristova, "Genetic control and inheritance of protein and zeinin intergeneric hybrids maize x teosinte and interlinear maize hybrids," presented at the Symposium Biochemical Genetics of Plants, 9-10 October, 1991.

[7] L. G. Bueno, L.J. Chaves, J.P. Oliveira, E.M. Brasil, A.J.S. Reis, A. Assunção, A.F. Pereira, and M.R. Ramos, "Controle genético do teor proteico nos grãos e de caracteres agronômicos em milho cultivado com diferentes níveis de adubação nitrogenada," *Pesquisa Agropecuária Brasileira*, no. 44, pp. 590-598, 2009.

[8] P. Hristova, "A high protein maize hybrid – Kneja BP633," pp. 166-173, 1985.

[9] N. P. Indriani, Y. Yuwariah, A. Nuraini, and D. Ruswandi, "Nutrient Content of Various Padjadjaran Hybrid Maize as Feed Forage at Arjasari Village Bandung," *Asian Journal of Crop Science*, vol. 10, no. 3, pp. 121-126, 2018, doi: 10.3923/ajcs.2018.121.126.

[10] A. J. K. Werle, F. R. A. Ferreira, R. J. B. Pinto, C. A. Mangolin, C. A. Scapim, and L. S. A. Gonçalves, "Diallel analysis of maize inbred lines for grain yield, oil and protein content," *Crop Breeding and Applied Biotechnology*, vol. 14, no. 1, pp. 23-28, 2014, doi: 10.1590/s1984-70332014000100004.

[11] M. Uribelarrea, F. E. Below, and S. P. Moose, "Grain Composition and Productivity of Maize Hybrids Derived from the Illinois Protein Strains in Response to Variable Nitrogen Supply," *Crop Science*, vol. 44, no. 5, pp. 1593-1600, 2004, doi: 10.2135/cropsci2004.1593.

[12] AOAC, *Official Methods of Analysis*, 17 ed. MD, USA: The Association of Official Analytical Chemists, 2000.

[13] L. Idikut, A. Atalay, S. N. Kara, and Ad. Kamalak, "Effect of Hybrid on Starch, Protein and Yields of Maize Grain," *Journal of Animal and Veterinary Advances*, vol. 8, no. 10, pp. 1945-1947, 2009.

[14] a. P. H. K. Hristov, "Genetic characterization of mutant inbred line XM – 532," *Genetic and selection*, no. 5, pp. 346-354, 1981.

[15] J. Zhang *et al.*, "Mapping quantitative trait loci for oil, starch, and protein concentrations in grain with high-oil maize by SSR markers," *Euphytica*, vol. 162, no. 3, pp. 335-344, 2007, doi: 10.1007/s10681-007-9500-9.

[16] M. H. Abou-Deif, B.B. Mekki, E.A.H. Mostafa, R.M. Esmail, and S.A.M. Khattab, "The Genetic Relationship Between Proteins, Oil and Grain Yield in Some Maize Hybrids," *World Journal of Agricultural Sciences*, vol. 8, no. 1, pp. 43-50, 2012.

[17] A. K. Pushpam and B. Selvi, "Screening maize genotypes for high quality protein based on assessment of protein and limiting amino acids," *Advance Research Journal of Crop Improvement*, vol. 6, no. 1, pp. 34-38, 2015, doi: 10.15740/has/arjci/6.1/34-38.