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COMPARATIVE TESTING OF MAIZE HYBRIDS (ZEA MAYS L.), CULTIVATED FOR GRAIN, UNDER NON-IRRIGATION IN CENTRAL NORTH BULGARIA

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Abstract

The experimental work was performed in the Central North Bulgaria region – city of Pavlikeni in the period 2012 - 2014. The experiment was performed on carbonate chernozem soil type by means of a block method with four repetitions; experimental field area - 15 m2, after the predecessor winter wheat. The following hybrids were tested; P8523, P9606, P9721, P0412 and P1114. The aim of the investigation was to establish the productivity of five maize hybrids for grain, grown under the conditions of central north Bulgaria. All the stages of the established technology for maize growing under non-irrigation conditions were followed. The experimental data was processed according to the method of dispersion analysis. The analysis of the results showed, that the highest values of elements of productivity - length of the cob, number of the row per cob, number of the grains per row, mass of the cob, mass of the grains per cob and mass of 1000 grains were reported in the hybrid P0412 and the lowest in P8523 hybrid. Under the conditions of North Central Bulgaria the highest yield was obtained in P0412 hybrid – 8163 kg/ha, and the lowest one – in P8523 hybrid – 6821 kg/ha. The percentage content of protein in grain was the highest in P1114 hybrid (10.8 %) and that of fats – in P0412 (5.19 %). The highest starch content was established in P8523 hybrid (77.05 %).

Keywords: *maize, elements of productivity, yield of grain, protein, fats, starch.*

Introduction

The production potential of hybrid maize is determined by the environmental factors as well as by the technology of growing (Calvino et al., 2003; Delibaltova, 2014; Niaz et al., 2014).

The agroecological and the climatic conditions in the separate regions of Bulgaria influence the development and productivity of plants (Liu et al., 2012; Stoyanova and Mihova, 2008; Zivkov and Matev, 2005). The right choice of the maize hybrids and the proper regional distribution, as well as their growing by strictly following the agrotechnical practices, are of vital importance for the yield amounts and the quality of the produce obtained (Chen et al.,2013; Dong et al.,2016; Kandil, 2013). That necessitates the constant introduction of new hybrids that are the most suitable and efficient for the separate microregions of Bulgaria (Delibaltova, 2009; Delibaltova and Ivanova, 2009). The aim of the investigation was to establish the productivity of five maize hybrids for grain, grown under the conditions of central north Bulgaria.

Material and methods

Field trials

The experimental work was performed in the Central North Bulgaria region – city of Pavlikeni in the period 2012-2014. The experiment was performed on carbonate chernozem soil type by means of a block method with four repetitions; experimental field area - 15 m2, after the

predecessor winter wheat. The following hybrids were tested; P8523, P9606, P9721, P0412 and P1114.

Ploughing-in of the stubble was performed in August after the forecrop was gathered, and deep ploughing at 25 - 28 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 8 kg active substance phosphorus and 10 kg active substance potassium and before sowing with 18 kg active substance nitrogen. 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 65000, 63000, 63000, 59000 и 59000 plants per ha for - P8523, P9606, P9721, P0412 and P1114 respectively. Herbicide Gardian3000 ml/ ha was applied before sowing and Merlin duo – 1500 ml/ha was applied during vegetation of maize for weed control. All the stages of the established technology for maize growing under non-irrigation conditions were followed. The indices height of the plants, height of the cob, length of the cob, number of the row per cob, number of the grains per row, mass of the cob, mass of the grains per cob, mass of 1000 grains, grain yield and protein, fats, starch content in grain were determined.

Statistical analysis

For the purpose of determining the quantity dependence between the studied indicators, the experimental data were processed according to the Anova Method of dispersion analysis, and the differences between the variants were determined by means of the Dunkan's Multiple Range Test (Dunkan, 1995).

Results and discussion

The period of study (2012-2014) comprised years, which differed significantly concerning the major meteorological factors (air temperature and precipitation sum) having an effect on maize productivity. The most favourable for the growth and development of the plants was reported to be 2014, followed by 2013 and the most unfavourable was 2012. The last experimental year (2014) was characterized by temperature values close to those established for many years and by enough and evenly distributed precipitations fully meeting the requirements of the hybrids for moisture from emergence till ripening. In the first year of the experiment (2012) the rainfalls were insufficient and unevenly distributed. The dryness during the critical stages of maize development had on the production possibilities of the plants.

The values of the morphological characteristics and the structural elements of the yield were presented in Table 1 in average for the three years. The studied hybrids differed significantly in the height of the plants. The lowest height was reported for the plants of hybrid P8523 (193.3 cm) and the highest were the plants of hybrid P1114– 241.7 cm. Referring to that characteristic P0412 hybrid fell behind P1114 by 2.6 % and P9721 surpassed P9606 by 4.3 %. The height of the first cob initiation as a characteristic determining the suitability level for mechanized maize grain harvesting varied from 63.2 cm in P8523 hybrid to 116.7 cm in P1114. Due to the lower height of the first cob initiation in P8523 and P9606, the regulation of the combine harvester is necessary for the better quality harvesting.

The analysis of the cobs showed that the late hybrid P0412 had the longest cobs – 23.7 cm and it surpassed P1114 by 7.7 %, the difference being statistically significant, while the medium lates P9721 and P9606 were surpassed by 11.8 and 20.3 %, respectively. The early hybrid P8523 formed cobs of the smallest length – 18.1 cm. The highest values of the characteristic number of rows in the cob were reported in P0412 hybrid – 16.5 rows and in the rest hybrids the number

varied from 13.1 (P8523) to 14.3 rows (P9721). It was statistically proven that P0412 hybrid surpassed by 15.9 % in average all the other studied hybrids.
Out of all the investigated hybrids the smallest number of grains in the row, in average for the three years, was established in hybrid P8523 – 38.2 and it fell behind the hybrids P9606, P9721 and P1114 by 7.3, 18.8 and 27.2 %, respectively, the biggest number of grains in the row being formed by hybrid P0412.

Table 1.Morphologic characteristics and structural elements of the yield of maize hybrids mean for the period 2012 – 2014

Hybrids	Height of the plants, cm	Height of the cob, cm	Length of the cob, cm	Number of the row per cob	Number of the grains per row	Mass of the cob, g	Mass of the grains per cob, g	Mass of 1000 grains, g
P8523	193.3 [a]	63.2 [a]	18.1 [a]	13.1 [a]	38.2 [a]	166.5 [a]	150.4 [a]	265.0 [a]
P9606	219.1 [b]	74.5 [b]	19.7 [b]	14.0 [a]	41.0 [b]	177.3 [b]	162.0 [b]	278.6 [b]
P9721	228.5 [c]	101.0 [c]	21.2 [c]	14.3 [a]	45.4 [c]	209.6 [c]	167.0 [b]	297.9 [c]
P0412	235.6 [d]	108.5 [c]	23.7 [d]	16.5 [c]	50.3 [e]	235.8 [e]	250.2 [d]	367.2 [e]
P1114	241.7 [e]	116.7 [d]	22.0 [c]	15.5 [b]	48.6 [d]	223.4 [d]	223.0 [c]	326.7 [d]
LSD 5 %	*5.38*	*8.01*	*1.52*	*1.42*	*2.77*	*10.2*	*7.80*	*11.5*

Cob weight in the late hybrids was from 223.4 to 235.8 g. P1114 hybrid fell behind P0412 by 5.5 % and the P9606 fell behind the hybrid P9724 by 18.2 %. The lowest values of that characteristic were reported in the early hybrid P8523 – 166.5 g. The differences between the hybrids were statistically significant.
The grain weight per cob in average for the period varied from 150.4 g in P8523 to 250.2 g in P0412. P1114 hybrid fell behind P0412 by 11.2 % (with statistical significance), however, both of them had higher grain weight per cob compared to P8523 – by 14.8 % and 16.6 %, respectively, as well as to P9606 and P9721 – by 13.6 % and 15.2 % in average. Grain weight per cob in P0412 was bigger compared to all the hybrids, the differences varied from 11.2 % to 16.6 % and they were statistically very significant. Like the other structural elements of the yield, 1000 grain weight characteristic also had the highest values established in hybrid P0412, i.e. 367.2 g. In the rest of the hybrids the values of that characteristic varied within the limits from 265.0 g (P8523) to 326.7 g (P1114). Data statistical processing showed that the differences between all the studied hybrids were significant.
The results obtained were presented in Table 2 and they showed that both by years and in average for the experimental period hybrid, P0412 surpassed in grain yield all the other hybrids included in the study. The higher grain yield of the hybrid was due to the higher values of its structural elements. The highest grain yields were obtained in the favourable for maize 2014 year when the temperature values and the precipitation sum fully met the plant requirements for warmth and moisture throughout the whole vegetation period. The yields obtained reached up to 11125 kg/ha in hybrid P0412. Referring to grain yield that hybrid surpassed the hybrids P1114, P9721, P9606 and P8523 by 17.4 %, 20.0 %, 21.9 % and 30.8 %, respectively, the differences being statistically significant.
In the second experimental year (2013) the grain yields obtained varied from 7240 kg/ha in the early hybrid to 8265 kg/ha in the late hybrid P0412, i.e. they were by 25.6 % lower in average in comparison with the previous year. Mathematical processing of data showed that hybrid P1114

significantly fell behind P0412 by 95 kg/ha, while hybrid P9606 fell behind P9721 by 118 kg/ha. The lowest yields were realized by hybrid P8523 – 7240 kg/ha.

In the first year of the study (2012) the meteorological conditions during the hybrid vegetation were extremely unfavourable and the plants were not able to attain their biological potential. The grain yields obtained were within the limits of 4720 to 5100 kg/ha. Statistically proven, the lowest ones were those of hybrid P8523 and the highest – of P0412.

Table 2. Grain yield – kg/ha

Hybrids	Stand density Plants/ha	Years of stady			Average for the period kg/ha
		2012 kg/ha	2013 kg/ha	2014 kg/ha	
P8523	65000	4720 [a]	7240 [a]	8503 [a]	6821
P9606	63000	4887 [b]	7564 [b]	9130 [b]	7194
P9721	63000	5000 [c]	7682 [c]	9270 [c]	7317
P0412	59000	5100 [d]	8265 [e]	11125 [e]	8163
P1114	59000	4974 [c]	8170 [d]	9472 [d]	7539
LSD 5 %		*43.2*	*66.1*	*51.4*	

The results of the hybrids P1114, P9721 and P9606 had quite close values and they were statistically insignificant.

During the period of study (2012-2014) P0412 hybrid realized the yield of 8163 kg/ha in average and it surpassed the hybrids P1114, P9721 and P9606 by 2.5, 2.0 and 4.3%, respectively. The grain yield obtained from P8523 hybrid was 4720 kg/ha and it was less than the yields from all the other hybrids included in the experiment by 3.5 to 8.1 %.

The results from analyses of variance over three years for the grain yield are presented in Table 3. It was found that the effects of Hybrids and Year on the yield grain were significant. The Interaction was also statistically significant.

Table 3. Analysis of variance.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*η 2*
Hybrids	11823911,9	4	2955978,0	4834,07	0,000	34,7
Years	212822420,6	2	1064112101,0	174019,0	0,000	33,5
Interaction	6701336,2	8	837667,03	1369,88	0,000	31,8
Residual	27517,0	45	611,49			

The nutritional and forage value of maize grain is determined to a great degree by the content of proteins, fats and starch. Data of the chemical analyses (Table 4) showed that the highest protein content in grain was established in hybrid P1114 – 10.8 %. It exceeded the hybrids P0412, P9721, P9606 and P8523 by 12.5 %, 16.1 %, 36.7 % and 29.3 %, respectively.

Table 4. Chemical composition of grain, mean of the period 2012-2014

Hybrids	%		
	protein	fats	starch
P8523	8.35[a]	4.15[b]	77.05[c]
P9606	7.90[a]	4.05[b]	75.52[b]
P9721	9.30[b]	3.49[a]	74.09[b]
P0412	9.60[b]	5.19[c]	71.80[a]
P1114	10.80[c]	4.67[b]	70.50[a]
LSD 5 %	*0,89*	*0,48*	*1,51*

The fat content varied from 3.49 % in P9721 to 5.19 % in P0412.
The medium early hybrid P9606 fell behind P8523 by 23.4 %, while the medium early hybrid P9721 fell behind the two late ones (P1114 and P0412) by 33.8 and 48.7 %, respectively.
The starch percentage was lowest in P1114 – 70.5 % and highest in P8523 – 77.05 %. The early hybrid exceeded the values of that characteristic established in the hybrids P9606, P9721 and P0412 by 2.0 %, 4.0 % and 7.3 %, respectively.

Conclusions

The characteristics plant height and height of the first cob initiation had the highest values in hybrid P1114 (241.7 and 116.7 cm) and the lowest in P8523 (193.3 and 63.2 cm).
The structural elements of yield – cob length, number of rows per cob, number of grains per row, cob weight, weight of the grains per cob and 1000 grain weight varied within a broad range, the highest values being reported in hybrid P0412. There was an obvious tendency of increase of those values in the direction of early to late hybrids.
Under the conditions of North Central Bulgaria the highest yield was obtained from P0412 hybrid – 8163 kg/ha, followed by P1114 – 7539 kg/ha and the lowest one – from P8523 hybrid – 6821 kg/ha.
The percentage content of protein in grain was the highest in P1114 hybrid (10.8 %) and that of fats – in P0412 (5.19 %). The highest starch content was established in P8523 hybrid (77.05 %).

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