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THE REACTION OF TWO TYPES OF MAIZE CULTIVARS (*Zea mays* L.) TO DIFFERENT SOWING DENSITY

Summary

The aim of the study was to determine the effect of sowing density on grain yield of two types of maize cultivars. The field experiment was carried out in 2012-2014 at the Department of Agronomy at the Poznań University of Life Sciences. The first order factor was: the cultivars SY Cooky and Drim "stay-green", while the second order factor was: sowing density of 6, 7, 8, 9 and 10 plants per 1 m^{-2}. The thermal and humidity conditions in the growing seasons of maize significantly influenced grain yield, ear grain number, grain moisture and the number of production ears per area unit. The "stay-green" cultivar was characterized by significantly higher grain yield compared to the traditional cultivar. The increase in sowing density decreased 1000 seed weight and ear grain number, while it increased the number of production ears per area unit and maize grain moisture during harvest. No significant interaction of the studied types of maize cultivars with sowing density in shaping grain yield components, moisture and grain yield was demonstrated.
Keywords*: maize cultivars, sowing density, yield components, grain yield*

REAKCJA DWÓCH TYPÓW ODMIAN KUKURYDZY (*Zea mays* L.) NA ZRÓŻNICOWANĄ GĘSTOŚĆ SIEWU

Streszczenie

Celem pracy było określenie wpływu gęstości siewu na wielkość plonu ziarna dwóch typów odmian kukurydzy. Doświadczenie polowe prowadzono w latach 2012-2014 w Katedrze Agronomii Uniwersytetu Przyrodniczego w Poznaniu. Czynnikiem I rzędu była odmiana: SY Cooky i Drim „stay-green", natomiast czynnikiem II rzędu gęstość siewu: 6, 7, 8, 9, 10 roślin na 1 m^{-2}. Warunki termiczne i wilgotnościowe w sezonach wegetacyjnych kukurydzy w istotny sposób kształtowały plon ziarna, liczbę ziaren w kolbie, wilgotność ziarna oraz liczbę kolb produkcyjnych na jednostce powierzchni. Mieszaniec w typie „stay-green" charakteryzował się istotnie wyższym plonem ziarna w porównaniu do odmiany tradycyjnej. Wzrost gęstości siewu spowodował spadek masy 1000 nasion i liczby ziaren w kolbie, natomiast zwiększyła się liczba kolb produkcyjnych na jednostce powierzchni oraz wilgotność ziarna kukurydzy podczas zbioru. Nie wykazano istotnego współdziałania badanych typów odmian kukurydzy z gęstością siewu w kształtowaniu komponentów plonu ziarna, wilgotności i plonu ziarna.
Słowa kluczowe: *odmiany kukurydzy, gęstość siewu, komponenty plonowania, plon ziarna*

1. Introduction

The use of the yield-generating potential of new maize cultivars (types) is possible only after adjusting agriculture practices to their requirements [1, 2]. Among many agronomic factors, one of the most important is sowing density, which largely shapes grain yield [3, 4]. It determines the supply of plants with water, nutrients and access of light to individual plants, which is important for the course of photosynthesis [5]. The optimal plant density guarantees the maximum number of correctly grained ears [6], which translates into higher grain yields or an improvement in the energy value of the silage [7]. On the one hand, a well-selected quantity on a unit area is the number of plants recommended by breeders and on the other their even distribution in the row [8]. Even plant density also ensures high productivity of each individual plant. According to Duvick [9], an increase in grain yield of modern maize cultivars is the result of improved tolerance to biotic and abiotic stresses. A farmer, meeting the requirements of precise maize sowing, contributes to the proper use of the hybrid's yielding potential, and thus improves the economic effect of field cultivation of this plant [4].

The aim of the conducted field trial was to determine the effect of different sowing densities of two types of maize cultivars on: (i) formation of grain yield components, (ii) grain yield and (iii) water content in maize grain at harvest.

2. Materials and Methods
2.1. Experimental field

The field experiment was carried out at the Department of Agronomy of Poznań University of Life Sciences on the fields of the Experimental and Educational Unit in Swadzim (52^{o}26' N; 16^{o}45' E) in the years 2012-2014. It was carried out for 3 years in the same random block design (split-split-plot) with three factors in 4 field replicates. The following factors were studied: A – First order factor: type of maize hybrid, A1 - SY Cooky, A2 - Drim "stay-green" type, B – Second order factor: sowing density, B1 - 6 pcs m^{-2}, B2 - 7 pcs m^{-2}, B3 - 8 pcs m^{-2}, B4 - 9 pcs m^{-2}, B5 - 10 pcs m^{-2}. The same level of nitrogen, phosphorus and potassium fertilization was assumed for all experimental objects in the following doses: 120 kg N·ha^{-1}, 70 kg P_2O_5·ha^{-1} and 130 kg K_2O·ha^{-1}. Fertilizers were applied in early spring under a cultivator. Nitrogen was applied in the form of ammonia, phosphorus in triple granulated superphosphate, potassium in the form of potassium salt.

2.2. Weather conditions

The characteristics of the climatic conditions that prevailed during the research period were based on data from the meteorological station belonging to the Department of Agronomy of the Poznań University of Life Sciences, located on the premises of the Experimental and Didactic Institute in Swadzim (52º26' N; 16º45' E). Thermal conditions during maize cultivation in the experimental years were similar to each other and amounted on average to 15.4°C in 2012, 15.6°C in 2013 and 16.1°C in the warmest year of 2014. Significantly greater differences between years occurred in the amount of precipitation. The highest sum of rainfall was recorded in 2012 (473.6 mm), which was 76.2 mm higher than the precipitation in 2013 and 121.8 mm higher from the rainfall in 2014 (Table 1).

2.3. Soil conditions

The soil in the experimental field was classified as the 4th complex of agricultural usefulness (very good rye) and quality class IIIb. According to the international FAO classification, this soil was categorized as *Albic Luvisols*, while according to the American classification it belonged to the order *Alfisols*. In terms of horizon, it was defined as loamy sand underlined by loam according to the international classification.

2.4. Observations and measurements

Maize harvest was performed using a Wintersteiger plot harvester, and grain yield was converted to a constant moisture of 15%. Random samples were collected from the threshing mass of the grain on each plot to determine grain moisture. The measurements were made using a Super Matic electronic moisture meter. The weight of the samples collected to determine the moisture content was 250 grams. The results are given as a percentage to two decimal places.

- Number of ears [pcs m^{-2}]: all developed ears were counted in the two middle rows of each plot. Their number was divided by the size of the plot intended for harvesting.
- Number of grains in the ear [pcs.]: the number of grains in a row and the number of rows were counted on each of 10 randomly selected ears. The number of grains in the ear was obtained based on the product of these two values.
- Thousand seeds weight [g]: this value was calculated by summing up the results of two randomly collected samples containing 500 seeds each.

2.5. Statistical analysis

The statistical analyses such as analysis of variance (ANOVA), Tukey's *HSD* (honestly significant difference) test for comparisons of pairs of means were performed in the research years separately and over the years according to the model of data obtained from the experiment designed as a split-split-plot [10]. All calculations were carried out using the Statistica 13 software package (2017) and MS Excel software. Statistical significance was defined at P-value < 0.01 or P-value < 0.05 depending on the source of variation.

3. Results

The different weather conditions in the study years 2012 - 2014 were reflected in only three of the considered traits: the grain yield (t·ha^{-1}), the number of kernels per ear (pcs.) and the grain moisture (%); see Table 2. The highest mean grain yield was obtained in 2012 (11.45 t·ha^{-1}). It did not differ significantly from the mean yield in 2013 (11.15 t·ha^{-1}). A noticeable drop in yields occurred in 2014, when the mean grain yield (8.79 t·ha^{-1}) significantly differed from the mean yields in the previous years of the study (Table 3). Significant differences were observed between the mean numbers of kernels per ear over the three years of the research (Table 3). The highest value was obtained in 2013 (564.55), and the lowest in 2014 (463.94). Significant differences were also recorded between the mean values of grain moisture in the study years (Table 3). The highest mean moisture was in 2014 (27.38%) and differed significantly from the means for the previous years. The lowest mean moisture was observed in 2012 (24.87%). It was observed (Table 4) that the tested types of maize hybrid (A) reacted differently to the changing conditions in the years of the study, but only in terms of the TKW (g) and the number of ears (pcs./m^2).

Table 1. The average monthly air temperature and the monthly sum of atmospheric precipitation in Swadzim for the growing season

Tab. 1. Średnia miesięczna temperatura powietrza i miesięczna suma opadów atmosferycznych w Swadzimiu dla sezonu wegetacyjnego

Years	Temperature [ºC]							
	IV	V	VI	VII	VIII	IX	X	Mean/Sum
2012	9.3	16.3	17.0	20.0	19.8	15.0	8.6	15.4
2013	8.9	15.6	18.4	22.0	20.2	13.2	10.8	15.6
2014	11.4	14.6	17.9	23.2	18.8	16.0	11.2	16.1
1957-2013	11.4	14.6	17.9	23.2	18.8	16.0	11.2	16.1
Years	Precipitation [mm]							
2012	17.4	84.4	118.1	136.2	52.7	28.4	36.4	473.6
2013	10.5	95.5	114.9	52.9	32.4	75.9	15.3	397.4
2014	50.3	80.7	44.6	51.5	56.5	39.2	29.0	351.8
1957-2013	31.4	54.1	59.0	76.0	57.8	43.8	37.3	359.4

Source: own work / Źródło: opracowanie własne

Table 2. Results of the three-stratum (YAB) ANOVA
Tab. 2. Wyniki trzywarstwowej (YAB) analizy wariancji

Source of variability	Degrees of freedom	Mean squares				
		Grain yield	TKW	Number of kernels in ear	Grain moisture	Number of ears
Blocks	3	18.30	3556.53	3678.98	1.01	4.05
Y	2	85.24**	2549.90	104012.86**	63.36**	7.48
Error 1	6	0.75	629.79	2126.47	0.84	2.56
A	1	18.75*	41608.37**	277317.75**	7.80*	5.72*
Y×A	2	0.73	9279.27*	3541.99	2.24	6.16*
Error 2	9	2.17	1215.91	1208.37	0.81	0.99
B	4	1.80	1605.91**	11248.67**	2.49**	13.44**
Y×B	8	1.50	176.13	1117.83	0.38	4.59**
A×B	4	0.45	191.99	2002.49	0.29	0.19
Y×A×B	8	0.62	59.14	739.64	0.51	0.25
Error 3	72	1.02	188.52	1329.47	0.61	0.94

**$P < 0.01$; *$P < 0.05$; TKW – thousand kernels weight

Source: own work / Źródło: opracowanie własne

Table 3. Mean values of the traits for the years and the agronomical factors
Tab. 3. Średnie wartości cech dla lat i czynników agronomicznych

Factors	The levels	Grain yield ($t \cdot ha^{-1}$)	TKW (g)	Number of kernels in ear (pcs.)	Grain moisture (%)	Number of ears ($pcs.m^{-2}$)
Y	2012	11.45 a	318.72	528.74 b	24.87 c	8.65 a
	2013	11.15 a	302.99	564.55 a	25.93 b	8.11 a
	2014	8.79 b	313.22	463.94 c	27.38 a	7.80 a
A	A1	10.07 b	293.02 b	567.15 a	25.81 b	7.97 b
	A2	10.86 a	330.26 a	471.01 b	26.32 a	8.41 a
B	B1	10.10 a	324.36 a	536.34 a	25.87 b	7.30 c
	B2	10.75 a	315.33 ab	537.54 a	25.71 b	7.79 bc
	B3	10.70 a	305.31 b	528.50 ab	26.08 ab	8.07 bc
	B4	10.47 a	307.51 b	504.51 bc	26.07 ab	8.52 ab
	B5	10.29 a	305.71 b	488.50 c	26.57 a	9.27 a

Values in columns marked with at least one letter the same do not differ significantly ($\alpha = 0.05$)
TKW – thousand kernels weight

Source: own work / Źródło: opracowanie własne

Table 4. Mean values for the combinations Y×A and Y×B
Tab. 4. Średnie wartości dla kombinacji Y×A i Y×B

Y	A	Grain yield ($t \cdot ha^{-1}$)	TKW (g)	Number of kernels in ear (pcs.)	Grain moisture (%)	Number of ears ($pcs.m^{-2}$)
2012	A1	11.21 a	317.18 abc	578.58 a	24.37 a	7.98 b
	A2	11.69 a	320.27 ab	478.90 a	25.37 a	9.32 a
2013	A1	10.70 a	279.48 c	621.02 a	25.91 a	8.16 b
	A2	11.61 a	326.50 a	508.08 a	25.96 a	8.07 b
2014	A1	8.29 a	282.42 bc	501.85 a	27.14 a	7.77 b
	A2	9.28 a	344.03 a	426.04 a	27.62 a	7.83 b
Y	**B**	**Grain yield ($t \cdot ha^{-1}$)**	**TKW (g)**	**Number of kernels in ear (pcs.)**	**Grain moisture (%)**	**Number of ears ($pcs.m^{-2}$)**
2012	B1	11.60 a	331.68 a	534.69 a	24.64 a	8.77 ab
	B2	11.72 a	314.03 a	548.77 a	24.66 a	9.09 a
	B3	11.65 a	316.93 a	526.19 a	25.00 a	8.16 abcde
	B4	11.45 a	316.34 a	526.54 a	24.76 a	8.06 abcde
	B5	10.83 a	314.63 a	507.52 a	25.29 a	9.18 a
2013	B1	10.40 a	314.39 a	585.65 a	25.75 a	6.62 de
	B2	11.90 a	314.11 a	577.93 a	25.49 a	7.33 bcde
	B3	11.59 a	293.64 a	572.39 a	26.01 a	8.21 abcd
	B4	11.03 a	296.41 a	551.13 a	26.23 a	9.05 a
	B5	10.85 a	296.39 a	535.65 a	26.19 a	9.36 a
2014	B1	8.31 a	327.01 a	488.70 a	27.21 a	6.51 e
	B2	8.64 a	317.84 a	485.92 a	26.99 a	6.94 cde
	B3	8.86 a	305.36 a	486.91 a	27.24 a	7.83 abcde
	B4	8.92 a	309.78 a	435.87 a	27.23 a	8.46 abc
	B5	9.20 a	306.11 a	422.33 a	28.23 a	9.26 a

Values in columns marked with at least one letter the same do not differ significantly ($\alpha = 0.05$)
TKW – thousand kernels weight

Source: own work / Źródło: opracowanie własne

For the remaining traits, no significant interactions between years and the types of cultivars were found. The highest mean TKW was recorded for cultivar A2 (Drim type "stay-green") in 2014 (344.03 g), but it did not differ significantly from the mean TKW for that cultivar in previous years, or from the value for cultivar A1 (SY Cooky) in 2012 (Table 4). Significantly the lowest mean TKW was observed for variety A1 in 2013 (279.48 g). This mean did not differ significantly from the mean values of TKW for that variety in 2012-2013, but it differed significantly from the mean values for variety A2 in all years of the study. Examining the number of ears (pcs./m^2), the only significant difference ($P < 0.05$) occurred in 2012, when cultivar A2 obtained a significantly higher mean number of ears per m^2 (9.32) than cultivar A1, and than both cultivars in the following years (Table 4).

Regardless of the year of research and the remaining factor (B), a significant difference was noted between the means of the studied traits for both types of maize hybrid (Table 3). For all traits (except the number of kernels per ear), cultivar A2 had significantly higher mean values than cultivar A1. Only the mean number of kernels per ear for cultivar A1 (567.15) was significantly higher than the mean for A2 (471.01). Analysing the effect of sowing density (B) on the examined traits, we find that it was independent of the year of research, except in the case of one trait: the number of ears (pcs.m^{-2}). Table 4 shows that the highest mean number of ears per m^2 (9.36) was obtained in 2013 with sowing density B5 (10 pcs.m^{-2}). This mean did not differ significantly from the means obtained in the same year for densities B3 (8 pcs.m^{-2}) and B4 (9 pcs.m^{-2}), or from the mean number of ears per m^2 for all sowing densities in 2012 or for densities B3 (8 pcs.m^{-2}), B4 (9 pcs.m^{-2}) and B5 (10 pcs.m^{-2}) in 2014. Irrespective of the year of research and factor A (cultivars), sowing density was found to have a significant influence ($P < 0.01$) on all of the examined traits except grain yield (Table 2). Table 3 indicates that the highest mean TKW (324.36 g) was obtained with sowing density B1 (6 pcs.m^{-2}). This did not differ significantly from the mean TKW (315.33 g) obtained for density B2 (7 pcs.m^{-2}). From this density onwards, the mean TKW values began to decrease significantly. A similar pattern was noted for the number of kernels per ear. The highest mean number of kernels per ear obtained at density B2 (7 pcs./m^2) did not differ from the means for densities B1 (6 pcs.m^{-2}) and B3 (8 pcs.m^{-2}), but differed significantly from the mean numbers of kernels per ear for densities B4 (9 pcs.m^{-2}) and B5 (10 pcs. m^{-2}). The remaining traits – the grain moisture (%) and the number of ears (pcs.m^{-2}) – were affected differently by factor B (Table 3). The highest mean moisture (26.57%) was observed at seeding density B5 (10 pcs.m^{-2}); it did not differ significantly from the means for densities B3 (8 pcs.m^{-2}) and B4 (9 pcs.m^{-2}), but it differed significantly from the means for densities B1 (6 pcs.m^{-2}) and B2 (7 pcs.m^{-2}). Similarly, sowing density B5 (10 pcs.m^{-2}) produced the highest mean number of ears per m^{-2} (9.27). This did not differ significantly from the mean for density B4 (9 pcs.m^{-2}), but it differed significantly from the mean number of ears per m^2 for the remaining sowing densities. These other means do not differ significantly among themselves; the lowest mean value was obtained for density B1 (6 pcs.m^{-2}). In the analysis of variance (Table 2) there was no significant interaction between cultivars and sowing densities, and no simultaneous interaction of both factors with the year of research.

4. Discussion

The yield of maize grain is the result of a series of processes during which its individual components are formed, namely i) number of ears per unit area, ii) number of grains in the ear and iii) 1000 seed weight. The number of grains in the ear is the product of the number of grains in the row and the number of grains in the ear. The number of ears per area unit in single-ear cultivars is determined prior to maize sowing, during density planning. Formation of yield components, such as the number of grains in the ear and thousand grain weight is determined by the availability of water and nitrogen for the plant throughout the growing season, as well as by factors modifying their efficiency. Formation of the basic component of grain yield, i.e. the ear starts in maize already from the three-leaf stage (BBCH 13) and lasts to the fifth-leaf stage (BBCH 15). The number of leaves and ears with spikelet primordia is determined during this period [11]. Potentially, maize can develop up to 8 ears simultaneously. The number of ears that will develop depends on the genotype (cultivar) and the availability of water and nutrients, mainly nitrogen. Usually, only the top 1-2 ears become dominant and develop further. Nitrogen availability shapes the grain yield from the ear by affecting the number of formed grains and preventing their reduction after fertilization [12]. The size of maize grain yield is largely determined by water availability. Water shortages in the plant limit the supply of leaf assimilates, which in the form of starch are deposited already at the early stages of kernel development, leading to ovary necrosis and discarding of young kernels. Water plays an important role in the formation of starch granules during kernel development [13]. The number of grains in the ear is determined during the flowering of female flowers [14], while conditions directly before their flowering play the main role in shaping this yield component. Both water stress and shortage of nutrients in the plant extend the period between full pollination and flowering of female flowers. If the time distance is too long, pollen is released by male flowers before the female flowers can accept it [15]. The number of kernels in the ear is likely to be reduced due to the higher number of non-fertilized individual flowers [12]. The development of kernels may be stopped after fertilization if water stress is so intense that the supply of assimilates to developing kernels is drastically reduced. According to Borras et al. [16], in the grain filling period, the rate of assimilate inflow to kernels after flowering of female flowers determines their final mass. Tollenaar [17] hypothesized that if growing conditions would deteriorate shortly after the number of kernels was determined, maize would rationalized the supply of assimilates to the earliest ones, and the average kernel weight would decrease. Issues related to the formation of grain yield and its structure components were presented in the author's earlier works [18, 19]. The study [19] assessed the influence of the type of nitrogen fertilizer and magnesium dose on the formation of generative yield of the studied maize genotypes. It was found that the "stay-green" cultivar was characterized by significantly higher grain yield potential compared to the classic cultivar. The difference between the examined cultivar types was on average 11.6 dt·ha^{-1} over the years. The obtained result in our own research was consistent with the previous report [20]. The authors of the latter study showed that regardless of nitrogen and magnesium dose, the "stay-green" hybrid yielded

8.0 dt·ha^{-1} higher than the classic cultivar. In this work, a very interesting interaction of the type of nitrogen fertilizer with the type of maize hybrid was obtained. Regardless of the type of nitrogen fertilizer, the "stay-green" hybrid yielded higher. However, for slow-acting fertilizers (ammonium sulfate, urea and a mixture of ammonium nitrate with urea), the advantage of the "stay-green" type was significantly greater than in the control variant (without nitrogen fertilizer), as well as with the use of fast-acting fertilizers (ammonium nitrate and calcium ammonium nitrate). This relationship confirmed previous literature reports indicating the specificity of the "stay-green" cultivars, which implied a fertilization system based on slow-acting fertilizers. The preference for this group of fertilizers was indicated by the negative nitrogen remobilization factor in the grain filling phase [21]. In this phase, the main source of nitrogen for the plant is component soil resources. Considering the role of a maize hybrid type in shaping thousand grain weight [19], it was found that the value of this trait was significantly greater (by 37.46 g) for the cultivar ES Paroli SG compared to ES Palazzo. The obtained increase in TSW resulted from a greater nitrogen accumulation in the developing ear and the performance of maize vegetative parts in supplying nitrogen and assimilates to the growing kernels in the ear [22]. Rajcan and Tollenaar [23] reported that the period of grain filling depended on the factors responsible for the durability of leaf greenness and the rate of nitrogen remobilization from the vegetative parts of maize. The "stay-green" cultivar assimilates longer at the end of the growing season, thanks to the still active green vegetative parts, often until full grain maturity, as a result of which a higher thousand seed weight should be expected compared to the classic cultivar. In turn, the number of grains in the ear is the product of the number of rows in the ear and the number of grains in the row. It was demonstrated that the "stay-green" cultivar was characterized by significantly lower values of both discussed traits. The number of rows in the ear is a genetic trait. However, the number of rows is reduced under abiotic stress conditions, negatively affecting grain yield [24]. On the other hand, in the period from the 6th to the 12th leaf, the plant builds up potential yield components, as then the number of grain rows is established, a genetically-determined trait, which has been confirmed in the authors' previous research [19]. The number of production ears per area unit is positively correlated with the quantitative status of plants before harvest. Plant losses during maize growing season largely affect the number of formed ears. It was found [19] that at the same seed sowing rate, the "stay-green" cultivar was characterized by a significantly higher number of the formed production ears established per surface area unit compared to the traditional cultivar. Most likely the "stay-green" hybrid retained a higher number of plants before harvest compared to the traditional cultivar. This also explained higher yielding of this cultivar. On the other hand, the research hypothesis in [18] assumed that the hierarchy of individual yield components could be different depending on the type of maize hybrid. Correlation, multiple regression and the pathway analysis coefficients were used to determine the correlation between these traits. It was shown that the "stay-green" hybrid was characterized by a higher yielding potential compared to the traditional cultivar. Moreover, the grain of this hybrid was characterized by a higher dry matter content compared to the classic cultivar. The main features determining grain yield of the classic cultivar, in order of weight, were: i) number of ears per area unit, ii) 1000 seed weight and iii) number of grains in the ear. In the case of the "stay-green" hybrid, the number of production ears per area unit and number of grains in the ear equally determined grain yield. Hybrids of the "stay-green" type were characterized by a greater yielding potential under increased precipitation conditions in the period from 15 July to 15 August. However, it should be noted that the obtained relationship concerned only the town where the field research was conducted.

Higher number of plants per area unit increases maize grain yield to a certain extent, and exceeding this limit causes a decrease in yield [25]. According to this author, maize hybrids of different earliness class showed a similar relationship between sowing density and grain yield, which was also demonstrated in the current study. Thousand seed weight of maize grains changed under the influence of sowing density and was the highest when 60 and 70 thousand grains per 1 ha were sown. A further increase in seeding density caused a decrease in this trait, which was in line with the results obtained by Moaveni et al. [26]. The number of grains in the ear in the present study also decreased along with an increase in maize sowing density. Similarly, Gökmen et al. [27] found a tendency of increased number of grains in the ear at a lower sowing density.

5. Conclusions

1. Thermal and humidity conditions in the growing seasons of maize significantly influenced grain yield, ear grain number, grain moisture and the number of production ears per area unit.
2. The "stay-green" cultivar was characterized by significantly higher grain yield compared to the traditional cultivar. At the same time, this maize cultivar was characterized by a higher 1000 seed weight, number of production ears per area unit and grain water content at harvest.
3. Higher sowing density decreased 1000 seed weight, ear grain number, while it increased the number of production ears per area unit and maize grain moisture during harvest.

6. References

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