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DEPENDENCE ON MAIZE EAR WEIGHT ON SOIL MOISTURE REGIME

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Studies under different conditions of the soil moisture regime were carried out to determine the dependence of the ear weight and the grain weight per ear on the amount of water that gets on the chernozem surface during the growing season of maize. The trial was set up according to the block design in four variants: rainfed variant and three variants of the maintenance of soil moisture at the level of 80-85%, 70-75% and 60-65% of the field water capacity (FWC).

Results show that the soil moisture regime very significantly affected the maize ear formation. The highest average values of the ear weight (389.2 g) and the grain weight per ear (320.3 g) were recorded in the variant 80-85% FWC. In relation to this value, values of the remaining variants were very significantly lower. A functional parabolic dependence of ear and grain weights on the water amount was established. With the total amount of water that got to the soil surface (x-510 mm) it can be expected that the ear of 370 g in weight will be formed ($y= -0.002x^2+1.999x-139.7$) and that the maximum grain weight per ear will be 303 g ($y1= -0.0016x^2+1.6241x-110.12$). Higher or lower amounts of water will affect the average decrease in the grain weight.

Key words: Maize, ear weight, grain weigh, water regime, water amount

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INTRODUCTION

The unfavourable soil moisture regime during the maize growing season is an important factor that limits maize yielding. The soil moisture deficit in the combination with high air temperatures adversely affects physiological and biochemical processes in plants, which the level and quality of yield directly reflected (STOJIĆEVIĆ, 1996; BOŠNJAK *and* MAČKIĆ, 2009; DRAGOVIĆ *et al*., 2008). The higher temperature is, the higher net assimilation rate is, which together with the water deficit in the soil leads to exhaustion of plants, because the root system has no capacity to provide plants with necessary amounts of water and mineral nutrients (IBRAHIM *and* KANDIL,2007). Literature data points out that plants, due to physiological stress, respond to the water deficit by the decrease of the majority of growth parameters (HUSSAIN *et al*., 2004; WAJID *et al*., 2004; BADR *et al*. 2005).

Many studies have been carried out with the aim to observe problems caused by soil water deficit to mitigate consequences and to find out adequate solutions for particular pedological and climatic conditions (MAKSIMOVIĆ, 1999; DRAGOVIĆ, 2006; DAGDELEN *et al*., 2006; BOŽIĆ *et al*., 2007; PAOLO *and* RINALDI, 2008). However, gained results refer to the need of further studies about this problem, because a great number of maize hybrids, developed through breeding programmes, differently respond to environmental conditions. Tolerance of genotypes to the soil moisture deficit varies. Due to production efficiency under conditions of ever more persisting drought worldwide it is very important to determine use of genetic yielding potential at the certain level of moisture. Accordingly, the effects of the chernozem moisture regime on the formation of maize yields were performed in the present study with the aim to determine the dependence of the ear weight and the grain weight on the amount of water that gets on the chernozem surface during the growing season of maize.

MATERIAL AND METHODS

Under agro-ecological conditions of Zemun Polje the experiments were carried out. The three-year (2006–2008) trail was set up according to the block design with four replicatons in four variants: three variants of the maintenance of soil moisture at the level of 80-85%, 70-75% and 60-65% of the field water capacity (FWC) and the rainfed variant (control). The elementary plot size amounted to 20 m^2 (7.14 m x 2.8 m).

A preceding crop used winter wheat. Shallow ploughing and autumn ploughing to the depth of 30 cm were done. The total rate of applied nutrients per hectare was as follows: 136 kg of nitrogen, 68 kg of phosphorus and 68 kg of potassium. The medium late maturity hybrids ZPSC 684 (FAO 600) was sown in the density of 55,000 plants ha^{-1} on optimum dates of maize sowing. Watering was performed by sprinkling irrigation, whiled dates and norms of irrigation were established on the basis of the moisture content in the rhizospheric soil layer (0 to 60 cm). The moisture content was determined thermogravimetrically, by sampling soil in the 7-10 day intervals.

Gained results were processed by the analysis of variance, while the differences among certain variants were analysed by the LSD test at the significance levels of 5% and 1%. The dependence of the ear weight and the grain weight on the amount of water was established by the regression analysis.

AGRO-ECOLOGICAL CONDITIONS AND IRRIGATION

The studies were carried out on calcareous chernozem, which had a relatively favourable water and air properties alongside the profile depth (0-100 cm). Bulk density ranged from 1.17 to 1.41 g cm^{-3}, while total porosity varied from 54.65 to 46.15%. The $CaCO_3$ content to the depth of 40 cm was approximately 5%, while it amounted over 20% in deeper layers. The soil at the depth of 0-40 cm was fairly supplied with humus (approximately 3%) and was rich in total nitrogen, available phosphorus and potassium. With the increase of the depth, the content of these nutrients decreased.

Air temperatures and precipitation sums during the growing season of maize varied over years (Table 1). The lowest average air temperature (17.9°C) and the highest precipitation sum (417.1 mm) were recorded during the growing season of 2006. The warmest growing season was in 2007 (19.5°C), while the driest growing season was in 2008 (224.6 mm).

Table 1 - Average monthly air temperatures (°C) and precipitation sums (mm) in the period April-September

Year	IV	V	VI	VII	VIII	IX	Average/ Sum
Average monthly air temperature (°C)							
2006	12.2	15.8	18.8	22.8	19.6	18.5	17.9
2007	13.2	18.8	22.5	23.9	23.7	15.1	19.5
2008	13.3	18.3	22.3	22.6	22.8	16.6	19.3
2006-2008	12.9	17.6	21.2	23.1	22.0	16.7	18.9
Precipitation sum (mm)							
2006	93.1	33.3	143.6	27.3	109.0	10.8	417.1
2007	31.1	42.0	63.0	18.7	51.6	73.0	279.4
2008	27.3	39.7	36.3	46.2	19.7	55.4	224.6
2006-2008	50.5	38.3	81.0	30.7	60.1	46.4	307.0

The trial was irrigated each year, because precipitation sums were insufficient for the maintenance of soil moisture above the values prescribed for irrigation (Table 2). The total amount of water that got on the soil surface during the growing season of maize by the maintenance of soil moisture at the level of 80-85%, 70-75% and 60-65% FWC, on the average for three years, amounted to 485 mm, 430 mm and 387 mm, respectively.

Table 2. Irrigation norm and the total amount of water (precipitation+irrigation) over variants of investigation (mm)

Year	80–85% FWC		70–75% FWC		60–65% FWC		Control (precipitation)
	Irrigation norm	Total	Irrigation norm	Total	Irrigation norm	Total	
2006	100	517	70	487	0	417	417
2007	155	434	115	394	95	374	279
2008	280	504	200	424	145	369	224
Average	178	485	128	430	80	387	307

RESULTS AND DISCUSSION

Achieved results indicate that the soil moisture regime very significantly affected the formation of maize ears and contributed to obtaining very significant differences among studied variances for ear weights and grain weights per ear (Table 3).

The three-year highest average values of the ear weight (389.2 g) and the grain weight per ear (320.3 g) were recorded in the variant with pre-irrigation soil moisture of 80-85% FWC and the total amount of water got to the soil surface of 485 mm. Significantly lower values were recorded in the remaining variants. Maize plants in the variant with pre-irrigation soil moisture of 70-75% were supplied with 430 mm water and formed the average ear of 353.8 g with the grain weight per ear of 290.4 g. In the variant of 60-65% FWC, under conditions of 387 mm water, the average ear weight was 328.8 g, while the average grain weight per ear amounted to 269.3 g. The lowest values of weights (266.8g and 218.0 g) were obtained under rainfed conditions with the average precipitation sum during the growing period of 307 mm.

Very significant differences in ear weights and grain weights per ear were recorded over years of investigation. The highest average value of the ear weight (352.9 g) was recorded in 2007, but without statistical differences in relation to the 2006 average (346.1 g). Furthermore, the highest grain weight per ear (291.6

g) was also recorded in 2007, but it was very significantly lower (280.6 g) in 2006. In 2008 in relation to both previous years, ear weights (304.9 g) and grain weights per ear (251.4 g) were very significantly lower.

Table 3. – Average values of ear weights and grain weights per ear, g

Variant	2006		2007		2008		Mean	
	Ear weight	Grain weight	Ear weight	Grain weight	Ear weight	Grain weight	Ear weight	Grain weight
80-85%	384.2	313.6	424.4	350.9	358.9	296.6	389.2	320.3
70-75%	357.6	291.4	361.5	298.1	342.2	281.6	353.8	290.4
60-65%	322.2	259.0	349.9	290.3	314.3	258.5	328.8	269.3
Control	320.4	258.3	275.8	227.0	204.2	168.7	266.8	218.0
Average	346.1	280.6	352.9	291.6	304.9	251.4	334.6	274.5

Analysis of variance - Ear weight				
Source of variation (C_v-2.76)	F value	Prob.	LSD $_{0.05}$	LSD $_{0.01}$
Year	210.2135	0.0000 **	5.729	8.231
Variant	374.7505	0.0000 **	7.728	10.440
Year x Variant	35.7417	0.0000 **	13.390	18.070
Analysis of variance - Grain weight per ear				
Source of variation (C_v-3.22)	F value	Prob.	LSD $_{0.05}$	LSD $_{0.01}$
Year	126.8107	0.0000 **	5.906	8.484
Variant	285.6786	0.0000 **	7.400	9.992
Year x Variant	25.8185	0.0000 **	12.820	17.310

The year x irrigation regime interaction was statistically very significant and differences between weights of ears and grain were obtained among variants in the same year and within the same variant over years. The highest values of weights (320.4 g and 258.3 g) under rainfed conditions were obtained in 2006 (precipitation sum - 417 mm). On the other hand, the highest values of weights (424.4 g and 350.9 g) under irrigation conditions were obtained in the variant with pre-irrigation moisture of 80-85% FWC in 2007 (precipitation+irrigation - 434 mm).

The cob percentage, depending on the soil moisture regime, varied up to 2.61% (Table 4). The average values of the cob percentage were lower in irrigated variants (17.91%) than under rainfed conditions (18.15%). The cob percentage was lower under conditions of favourable soil moisture regime, which is significant from the aspect of grain maize production. ILIĆ (2002), stated that the cob percentage was a trait of each hybrid that was insignificantly modified under effects of cropping practices or environmental factors, while studies performed by

BOĆANSKI *et al*. (2005) showed that grain yield per plant was highly correlated with the cob weight.

Table 4. Maize cob percentage (%)

Year	Variants of pre-irrigation moisture				Control
	80-85% FWC	70-75% WC	60-65% WC	Mean	
2006.	18.38	18.51	19.62	18.84	19.39
2007.	17.31	17.55	17.01	17.29	17.70
2008.	17.38	17.69	17.76	17.61	17.38
Average	17.69	17.92	18.13	17.91	18.15

Obtained three-year results show that the ear formation of maize grown on chernozem significantly varied in dependence on soil moisture. Under unfavourable, rainfed conditions the ear weight was, on average, lower by 25%. On the other hand, ear weights obtained in variants with different pre-irrigation moisture norms were higher by 46% (80-85% FWC), 33 % (70-75% FWC) and 23% (60-65% FWC). These results are in accordance with results gained by KARAM *et al*. (2003) and DI MARCO *et al*. (2007).

The correlation between the ear weight and the grain weight per ear was very highly positive (r^2 = 0,998**), but the positive effect of soil moisture can be expected only up to the certain level of the water amount increase (Figure 1). With the total amount of water that gets to the chernozem surface (x) it can be expected that if x=510 mm the weight of the formed ear will be y=370 g ($y = -0.002x^2 + 1.999x - 139.7$) with the maximum grain weight per ear of 303 g ($y1= -0.0016x^2 + 1.6241x - 110.12$).

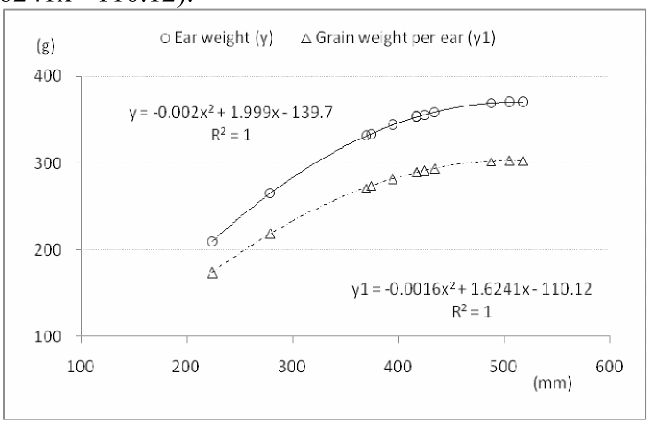

Figure1. – Ear weight (y) and grain weight per ear (y1)in dependence on water amounts(mm)

CONCLUSION

Achieved results show that soil moisture regime very significantly affected the formation of maize ears and contributed to obtaining very significant differences among studied variances for ear weights and grain weights per ear.

The highest values of average ear weight (389.2 g), grain weights per ear (320.3 g) and effects of irrigation (45.8% and 46.9%) were gained in the variant with pre-irrigation moisture of 80-85% FWC. The values obtained in remaining two variants (70-75% FWC and 60-65% FWC) were very significantly lower.

The ear weight and the grain weight per ear were very highly positively correlated (r^2 = 0,998 **). Furthermore, a functional parabolic dependence of ear and grain weights on the water amount was established. With the total amount of water that got to the soil surface (x-510 mm) it can be expected that the ear of 370 g in weight will be formed ($y = -0.002x^2 + 1.999x - 139.7$) and that the maximum grain weight per ear will be 303 g ($y1= -0.0016x^2 + 1.6241x - 110.12$). Furthermore, higher or lower amounts of water will affect the average decrease in the grain weight.

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ZAVISNOST MASE KLIPA KUKURUZA OD VODNOG REŽIMA ZEMLJIŠTA

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I z v o d

Proučavanja u uslovima različitog vodnog režima zemljišta izvedena su u cilju utvrđivanja zavisnosti mase klipa i zrna po klipu kukuruza od količine vode, koja dospeva na površinu černozema tokom vegetacionog perioda kukuruza. Ogled je bio postavljen po metodi blok sistema u prirodnom vodnom režimu i u varijantama održavanja vlažnosti zemljišta na nivou 80-85%, 70-75% and 60-65% od poljskog vodnog kapaciteta (PVK).

Rezultati pokazuju da je vodni režim zemljišta veoma značajno uticao na formiranje klipova kukuruza. Najveće prosečne vrednosti mase klipova (389,2 g) i zrna po klipu (320,3 g) dobijene su u varijanti sa predzalivnom vlažnošću 80-85% PVK. U odnosu na nju, vrednosti svih drugih varijanata bile su veoma značajno niže. Za masu klipa i zrna, u odnosu na količinu vode utvrđena je funkcionalna zavisnost paraboličnog oblika. Pri ukupno prispeloj količini vode na površinu zemljišta od 510 mm (x) može se očekivati da se formira klip mase 370 g ($y = -0.002x^2 + 1.999x - 139.7$) sa zrnom maksimalne mase, 303 g ($y1= -0.0016x^2 + 1.6241x - 110.12$) i da će veće ili manje količine vode uticati na prosečno smanjenje mase zrna.

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