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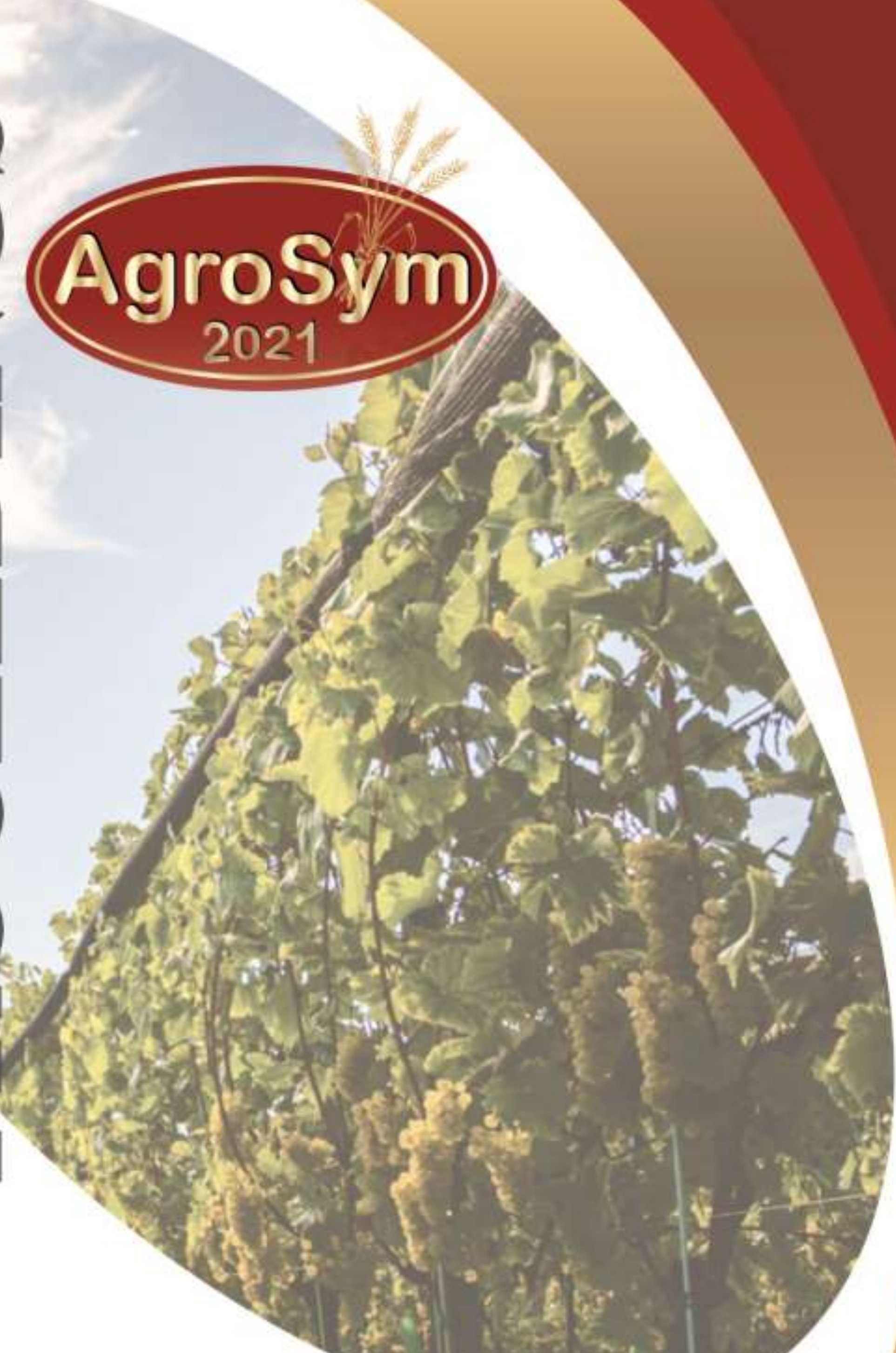

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EFFECTS OF THE SOWING DATE ON RELATIONSHIPS OF MORPHOLOGICAL PROPERTIES OF MAIZE EARS

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Abstract

The aim of this study was to observe effects of the sowing date on the relationships among morphological properties of maize ears. The trial was set up in Zemun Polje in 2019 and encompassed five sowing dates with the initial one on April 1, and then on every 10 days until May 10 (S1, S2, S3, S4, S5). Three inbred lines (L1, L2, L3) were used as a material. During sowing, seeds were classified according to their size into small (6.5-8.4 mm), large (8.5-11 mm) and the primary seed fraction (6.5-11 mm). The parameters for the following morphological ear traits were determined under laboratory conditions: ear weight, ear length, ear thickness, cob weight and the grain yield. Obtained results indicated the significant contribution of all factors in expression of observed traits, as well as the significance of the interactions. The inbred L1 was the most stable genotype for the ear weight and the cob weight. The ear length and the ear thickness varied the least in all genotypes. The initial sowing dates (S1 and S2) were the most important for the ear weight. The third sowing date was the most important for the ear length (19.81cm) and the ear thickness (5.94cm). The highest cob weight was recorded in plants sown on the fifth sowing date (S5). The LSD tests showed that the differences in the morphological traits of ears of different sowing dates were significant between S5 and the remaining four sowing dates ($p<0.05$). Various fractions used in sowing affected all traits.

Key words: *agroecological conditions, cob, trait variability.*

Introduction

Due to the increasingly frequent changes occurring in environmental conditions in local regions, a need to reconsider the suitability of conditions for crop production has arisen. The oscillation of soil and air temperatures and precipitation sums during the maize growing season affects the yield and the yield components. Intra-seasonal climate variability can affect crop production during all stages of the crop growing cycle: directly through the effects of temperature, water availability, radiation interception, and carbon fixation; indirectly by modulating nutrient availability and the occurrence of diseases and pests (Olesen et al., 2000, Ceglar et al., 2016). The sensitivity of the optimal crop growth and development to specific weather conditions depends on the crop and the growth stage (Cantelaube and Terres, 2005). The properties of the produced hybrid maize seed depend on many factors: genotypic combination of parental inbreds, synchronicity of flowering, duration of pollination, duration of grain filling, length of maturation, grain moisture content at harvest. During the expression of the stated factors, agroecological

conditions also change. The variability of these conditions can change the growth and development of maize (Chen et al., 2011; Asare et al., 2011; Zhou. et al.; 2016).
Although maize yield increased, there was a significant seasonal yield variation due to the variation of weather factors (Ray et al., 2015; Sun et al., 2016; Farmaha et al., 2016).
The aim of this study was to determine the significance of the sowing adapted to the conditions of local climatic regions on the formation of ear, morphological traits and grain yield of maize.

Material and Methods

Three maize inbred lines L1 (FAO 400) L2 (FAO 600) and L3 (FAO 600), developed at the Maize Research Institute, Zemun Polje (Belgrade, Serbia), were used in the study.
The one-year trial was set up according to the randomised block design in the location of Zemun Polje in 2019. Sowing was performed on five dates starting from April 1 to May 10, every 10 days (S1: April 1, S2: April 10, S3: April 20, S4: April 30, and May 10).
Seeds used in sowing were classified according to their size into three fractions by using sieves with mesh sizes of 8.5-11(mm) (F1); 6.5-8.4(mm) (F2); 6.5-11(mm) (F3). The elementary plot encompassed nine rows of one inbred, 3x3 rows of seeds of the equal size.
Ears were harvested by hand. Five ears per a row were taken for testing. Morphological traits: ear weight (EW), ear length (EL), ear thickness (ET), cob weight (CW) and grain yield (GY) were determined after harvest under the laboratory conditions using the method of arithmetic mean of measured values obtained by measuring instruments for weight, length, and width. The results were processed using descriptive statistics, mean values according to research variants. The effect of factors on trait variability was determined by the factorial analysis of parametric tests, ANOVA and LDS, using the statistical package SPSS 20.

Results and Discussion

According to results of the trial set up in 2019, S3 was the most favourable sowing date. The highest mean values of EL, ET and GY (22.803 g, 6.930 cm and 5.670 t ha^{-1}, respectively) were obtained in inbreds sown on this date. S2 was the most optimal sowing date for EW (149.797 g), while the largest cob percentage (18.750%) was in S4, which was the most unfavourable grain to cob ratio. The sowing date S5 did not favour the development of morphological traits. With regard to S5, all traits lagged in the development. The cob percentage was the only trait with the positive result (11.185%). This phenomenon can be explained by insufficiently filled grain due to unfavourable conditions during the grain filling, and therefore the seed to ear ratio was low. The sowing date, as a beginning of the production, determines the crop uniformity, first of all a stable yield, which depends on various (?) moisture, structure and temperature of the soil, method and dates of sowing and seed quality (Pommel et al., 2002). These changes limit the established cropping practices (Lobell et al., 2013; Cicchino et al., 2010; Mayer et al., 2014), due to which seeds from different sowing dates differ in quantitative and qualitative traits. The resulting differences among various sowing dates were significant between S5 and remaining dates for all traits (EW, EL, ET, GY, CW). The difference between S1 and S4, i.e. S1 and S3 was significant for the trait EW, i.e. ET, respectively (Table 1). Values of observed traits were uniform for sowing dates S1 and S2.

Table 1. Mean values of ear morphological traits over sowing dates (EL-ear length, ET- ear thickness, GY-rain yield, CW-cob weight)

Dependent Variable	(I)	Mean Difference (I-J) (J) S1	S2	S3	S4	S5		Mean values
EW	S1		-2.352	4.082	12.330*	69.715*	S1	147.445
	S2	2.352		6.433	14.681*	72.067*	S2	149.797
	S3	-4.082	-6.433		8.248*	65.633*	S3	143.363
	S4	-12.330*	-14.681*	-8.248*		57.385*	S4	135.115
	S5	-69.715*	-72.067*	-65.633*	-57.385*		S5	77.730
EL	S1		-0.526	-3.306	0.435	7.637*	S1	19.496
	S2	0.526		-2.781	0.961	8.162*	S2	20.022
	S3	3.306	2.781		3.741	10.943*	S3	22.803
	S4	-0.435	-0.961	-3.741		7.202*	S4	19.062
	S5	-7.637*	-8.162*	-10.943*	-7.202*		S5	11.860
ET	S1		-0.019	-1.548*	0.018	2.035*	S1	5.382
	S2	0.019		-1.529*	0.037	2.054*	S2	5.400
	S3	1.548*	1.529*		1.566*	3.583*	S3	6.930
	S4	-0.018	-0.037	-1.566*		2.016*	S4	5.363
	S5	-2.035*	-2.054*	-3.583*	-2.016*		S5	3.347
GY	S1		-0.144	-0.166	0.015	3.223*	S1	5.504
	S2	0.144		-0.021	0.160	3.367*	S2	5.648
	S3	0.166	0.021		0.181	3.388*	S3	5.670
	S4	-0.015	-0.160	-0.181		3.207*	S4	5.489
	S5	-3.223*	-3.367*	-3.388*	-3.207*		S5	2.282
CW	S1		0.155	0.062	-0.598	6.967*	S1	18.152
	S2	-0.155		-0.094	-0.753	6.811*	S2	17.997
	S3	-0.062	0.094		-0.659	6.905*	S3	18.090
	S4	0.598	0.753	0.659		7.564*	S4	18.750
	S5	-6.967*	-6.811*	-6.905*	-7.564*		S5	11.185

Maize is the plant that is most variable in terms of the seed shape and size. The importance of the seed size in sowing is presented in Table 2. The formation of morphological traits of seeds differed among seeds of various fractions that were used in sowing. Stress is one of the main reasons that can lead to a decrease in a germination rate and uniformity (Kranner et al., 2010), which is related to the composition of the seed material. The ears with the highest EW (131.831 g), EL (17.630 cm) and GY (4.912 tha^{-1}) were developed from seeds that had not been classified according to their size (F3) in sowing. This is a result of the highest number of seeds that were adapted to the conditions of reduced moisture, that were capable to emerge rapidly and to establish a uniform crop. The F1 fraction favoured ET (4.616 cm), but also the most unfavourable cob percentage (16.822%). The results show that the seed selection according to their size was an important aspect of the production. The differences among seeds of various sizes were significant. The ear weight (EW) significantly differed over all fractions, while grain yield (GY) significantly differed over F1 and F2. The cob weight (CW) was significantly lower in F2 seeds than in F1 and F3 seeds. The seed size did not significantly affect traits ET and EL (Table 3).

Table 2. Effect of seed fractions on the expression of seed morphological traits (EL-ear length, ET- ear thickness, GY-rain yield, CW-cob weight)

Dependent Variable		Mean Difference (I-J)			Mean values	
		(J) fraction				
	(I)	F1	F2	F3		
EW	F1		10.602*	-3.889	F1	127.942
	F2	-10.602*		-14.491*	F2	117.340
	F3	3.889	14.491*		F3	131.831
EL	F1		0.403	-2.746	F1	14.884
	F2	-0.403		-3.149	F2	14.481
	F3	2.746	3.149		F3	17.630
ET	F1		0.875	0.345	F1	4.616
	F2	-0.875		-0.530	F2	3.742
	F3	-0.345	0.530		F3	4.271
GY	F1		0.088	-0.407*	F1	4.504
	F2	-0.088		-0.495*	F2	4.416
	F3	0.407*	0.495*		F3	4.912
CW	F1		2.109*	0.087	F1	16.822
	F2	-2.109*		-2.022*	F2	14.713
	F3	-0.087	2.022*		F3	16.735

Three inbreds (L1, L2, L3) were used in the trial. The diversity in genetic potential resulted in the relationship to the application of different sowing dates (Figure 1). L1 had approximately the same values for EL and ET in all four sowing dates (S1→S4). Based on the variability of traits in relation to the sowing date, L1 was the most stable inbred, while L3 expressed the greatest variability. All three inbreds had the lowest values of EL, ET and EW in S5.

With regard to the seed size used in sowing, L1 differed from remaining two inbreds. The F2 seeds of this inbred were the most optimal for the formation of morphological traits. On the other hand, F3 seeds were the most optimal for L2 and L3 in 2019 sowing. The application of different side sizes in sowing depends on the precipitation sum and temperature conditions during sowing. The classification of seeds over fractions homogenises endosperm mass. Seeds with small endosperms are more susceptible and a dysfunction of reserve/storage substances occur (Styer and Cantliffe, 1983) adversely affecting seed vigour, but on the other hand, such seeds emerge faster due to insufficient rainfall.

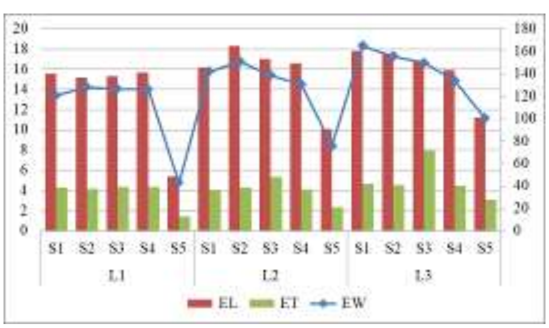

Figure 1. Effect of sowing dates on morphological traits (EW-ear weight, El-ear length, ET-ear thickness) over genotypes (L1, L2, L3)

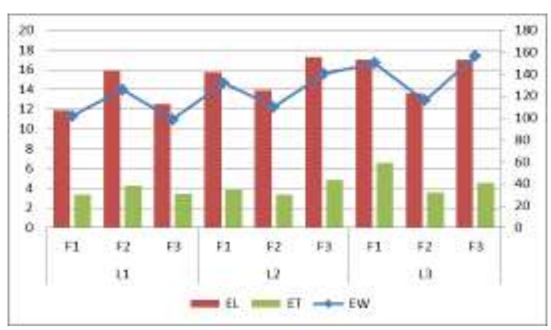

Figure 2 Effect of seed sizes on morphological traits (EW-ear weight, El-ear length, ET-ear thickness) over genotypes (L1, L2, L3)

The change of morphological traits and yield under the influence of observed factors (sowing date, genotype and seed fraction) was of the different level of significance. The ear weight (EW) and the cob weight (CW) significantly changed under the impacts of factors and their interactions. The action of both individual and combined factors was important for these traits. In contrast, ET changed the least in relation to factors. A significant change in this trait was observed with the change in sowing dates and the seed size x genotype interaction (FxG). The ear length (EL) is a trait that was also changed significantly under effects of sowing dates, genotypes and the interaction of all three factors (SxFxG). The highest effect of factors on the change of variance was on the cob weight (R = 0.818, Table 3).

Table 3. Effects of factors on the expression of seed morphological traits, ANOVA

Source	Dependent Variable (F value)				
	EW	EL	ET	GY	CW
Sowing date (S)	142.833**	7.263**	5.495**	89.915**	70.910**
Genotype (G)	68.203**	3.328*	2.228ns	30.553**	70.874**
Fraction (F)	14.754**	2.150ns	1.096ns	4.804*	16.729**
SxG	5.184**	1.205ns	0.648ns	1.846ns	4.804**
SxF	7.275**	0.957ns	0.818ns	3.294*	8.306**
GxF	33.384**	3.007*	2.492*	9.307**	23.106**
SxGxF	25.971**	2.015*	1.547ns	8.865**	21.879**

a. R Squared = 0.911 (Adjusted R Squared = 0.882)
b. R Squared = 0.429 (Adjusted R Squared = 0.243)
c. R Squared = 0.357 (Adjusted R Squared = .148)
d. R Squared = 0.828 (Adjusted R Squared = 0.772)
e. R Squared = 0.882 (Adjusted R Squared = 0.843)

EL- -ear length, ET- ear thickness, GY-rain yield, CW-cob weight

Conclusions

According to presented results it can be concluded that all three factors (genotypes, sowing dates, seed fractions) significantly contribute to the quality of seed production. Producers decide on the application of appropriate technology based on traits of the genotype. In addition to genotypes, ecological conditions are also an important decisive factor in the choice of growing practices. The choice of the proper sowing date is one of the main prerequisites for successful production. Our results show that there were significant differences in the application of different sowing dates. The best conditions for the majority of the traits were achieved by the application of S3.

The seed size, as the third analysed factor, was important for the achieved results. The F3 seed resulted in the largest ear weight, longer ears, and in the end, this resulted in the highest grain yield. The successfulness of the seed material, which was of the widest range in size, is a consequence of the fact that the largest number of seeds had enough heat and moisture for germination and emergence.

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