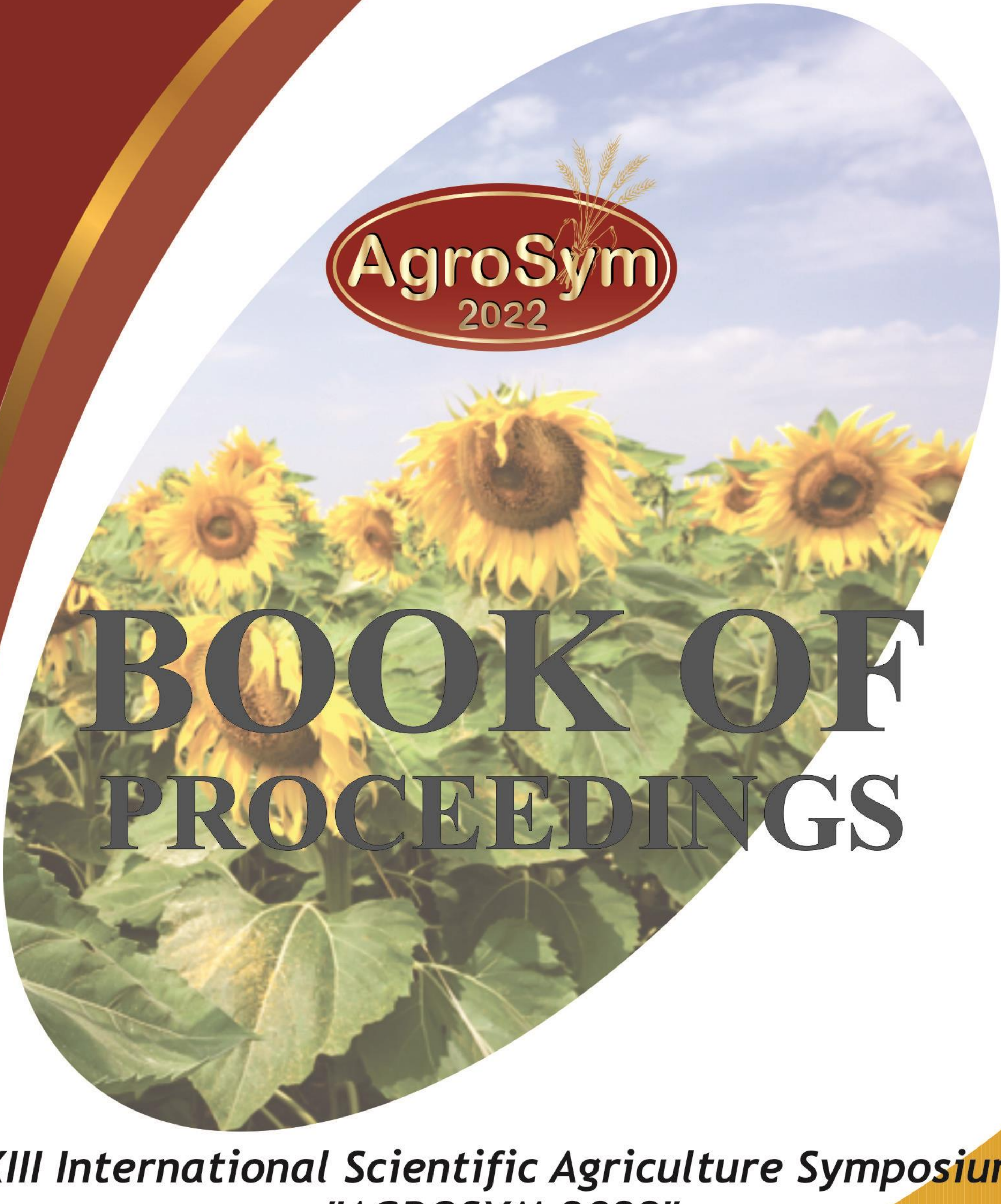

# BOOK OF PROCEEDINGS

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# CONJUNCTIVE EFFECT OF ENVIRONMENT AND GENOTYPE IN MAIZE SEED PRODUCTION

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## Abstract

Significant sources of normal plant development are the amount of available water, light, temperature and nutrients. This study aimed to examine to what extent the relationship between plant genetic structure and environmental conditions affects habitus and plant yield. In the two-year research, 2019 (Y1), and 2020 (Y2), with three maize lines (L1, L2, L3) produced at the Maize Research Institute, experiments were performed to assess the impact of genotype and environmental conditions on plant height to tassel (PHT), plant height to ear (PHE), ear weight (EW), cob weight (CW) and grain yield (GY). Seeds of different sizes were used in three sowings: large (S1), small (S2), and undivided (S3). The results of the PHE trial in the first year indicated a dominant genotype effect. L1 for all three sowings by seed size had the lowest cob position, S3G1 (69 cm), while L3 had the highest, (86.72 cm) for S3G1. In the second year of the study, environmental conditions and seed size significantly affected ($p \leq 0.05$) the PHE, as well as the PHT. The significance of the year effect was not confirmed by the weight of the cob. The highest yield was achieved for L1Y1S1 at 9.01 t $ha^{-1}$ and the lowest for L1Y2S3 at 2.18 t $ha^{-1}$. Significant mutual effects of factors on the variability of traits are Y × L, Y × S, and Y × L × S. Differences in environmental conditions significantly affect the variability of maize corn seed properties. These effects can be reduced by proper genotype selection and the sowing of uniform size seeds.

**Keywords:** *environmental conditions, maize, cob position*.

## Introduction

Each crop production is unique in its characteristic features. The reason for this is various factors that affect the expression of traits. The characteristics of the produced hybrid maize seed depend on many factors, such as genotypic combinations of parental lines, matching in the flowering of parental lines, duration of the fertilization time, duration of the grain-filling time, and abiotic and biotic factors. During the developmental phases of plants, agroecological conditions change, as a result of which they act differently, primarily temperature, radiation level, and humidity. Variability of traits and mode of expression is conditioned by time and space (García-Martínez et al., 2020), and changes in the growth and development of maize depend on these factors (Asare et al., 2011; Baoyuan et al.; 2016). Loss of phenotypic expression under the influence of lack of water is obvious for all cereals. Manifestations of suppression of traits in maize are expressed by reducing the number of seeds per cob, seed weight, cob length, plant height, and cob weight (Nabizadeh et al., 2012). The reduction of dry matter accumulation, which results in lower seed weight, especially in the period from silking to full maturity, is mainly caused by drought stress and insufficient radiation (Sah et al., 2020). Many phenotypic traits act as absorbers of stressful environmental conditions, so today there is maize breeding and selection of inbred lines for

specific living conditions that use these maize traits (Pandit et al., 2018). Due to climate change caused by anthropogenic factors, a relative decline in maize yield is predicted (Bolaños et al., 2019). Therefore, timely and objective predictions of the effect of factors on future crops are of great importance for production planning and providing sufficient food for a constantly growing population (Li et al., 2007).
This study aimed to identify the variability of morphological traits and yields of maize in production fields, which are the potential for proper crop management.

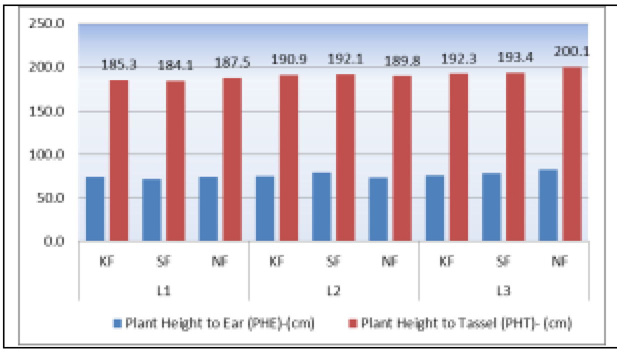
## Materials and Methods

The material used in the experiment was three maize inbred lines: L1, L2, and L3 produced at the Maize Institute, maturity group FAO 400. The experiment was set up according to a completely random design in four repetitions, at the location of Zemun Polje, for a period of two years (2019-2020). The sowing in the experiment was manual, the seeds used for sowing were divided by size into a large fraction KF (8.5-11), a small fraction SF (6.5-8.5) and an undivided fraction NF (6.5-11). The elementary plot was 5 × 5.6, with nine rows of maize (3 × 3 rows of line x seed size). During the vegetation, standard agrotechnical measures of fertilization and protection against pests and diseases were applied. In the fertilization phase, the height of the plant to the tassel (PHT) and the height of the plant to the ear (PHE) was determined. Three plants from the middle row were randomly selected to measure the height using a wooden meter. Harvesting was done after determining the grain moisture of 25 %. The cobs were harvested manually and dried to 14 %. After harvesting and drying, samples of five cobs were formed. Ears from the centre row were selected to determine ear weight (EW) and cob weight (CW). The ears were measured first and then shelled to measure the cob weight (CW). The yield was determined based on the weight of all mid-row ears.
Meteorological data for the duration of the experiment were obtained from the measuring station at the Maize Research Institute. The average monthly temperature in the vegetation period in 2019 was 20 °C, which was 1.14 °C higher than in 2020, with the average temperature in the April-October period being 18.86 °C. Compared to the official standard period of 61-90, this was 2.51 °C higher for Y1 and 1.37 °C higher for Y2. As for precipitation in 2020, the amount of precipitation was 401.70 mm in the period from April to October, and in 2019 it was 373.7 mm. Compared to the official standard period of 61-90 of 433.0 mm, this was 59.80 mm less for Y1 and 31.30 mm less for Y2. The year 2019 was characterized by large amounts of precipitation in May-June (129.6-113.7 mm), and 2020 with 125.9 mm of precipitation in June.
All data were processed with the SPSS statistical package. The analysis was performed based on the mean values of the obtained results and the analysis of variance (ANOVA) to determine the significance of the differences.

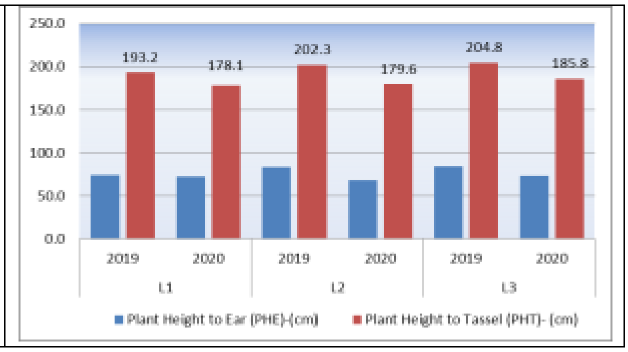
## Results and discussion

Based on the mean values of morphological traits of PHT and PHE, all three genotypes differ, as well as for cob traits CW, EW, and GY. The L3 line stood out, which has the highest results for all observed traits.
Seed sizes, in all fractions in genotype L3, had the highest results for PHT (KF-192.32, SF-193, NF-36,200.11), and for PHE, (SF-78.33 and NF-82.2) (Graph 1). The seed size factor affected variation in mean values also for EW, CW and GY. In inbred lines, L3 and L2, seeds of fraction KF had the highest GY, 8.08 t $ha^{-1}$, and 6.9 t $ha^{-1}$, respectively (Graph 3). The inbred line L1 had the highest yield of 6.6 t $ha^{-1}$ with seeds of SF. For EW and CW traits in L1 and L2 lines, LF had the best effect for exhibiting these traits, while for L3 it was NF.

Maize seeds are one of the most diverse in their shape and size. The role of seed shape and size from the point of view of evolution and ecology is presented as a theory of survival and reproduction (Westoby et al., 1992). From the agronomic aspect, this phenomenon in nature still does not have a clear perspective.
According to the environmental conditions, the first year of production was more favourable for the manifestation of morphological traits. Thus, all three lines in 2019 had a higher plant up to the ear (PHE) and a higher one up to the tassel (PHT). The highest average for PHT is for the L3Y1, 204.78 cm (Graph 2).

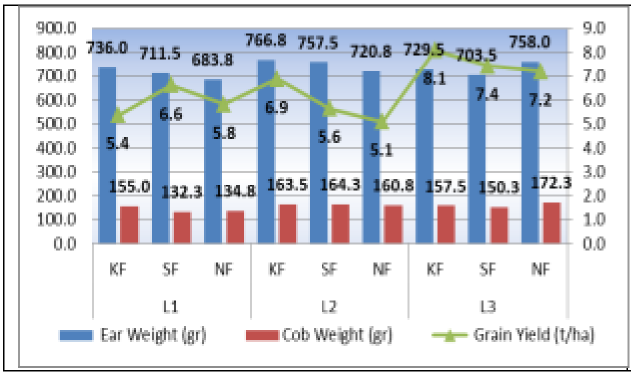


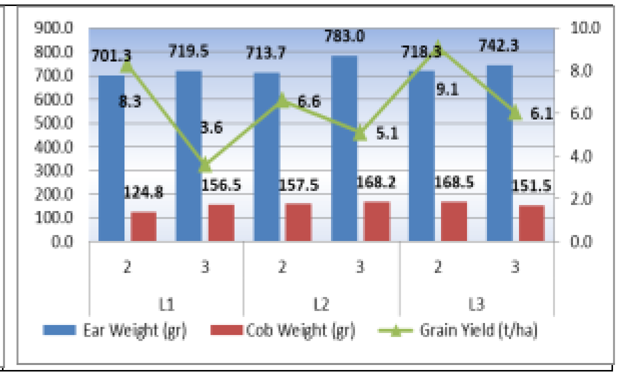

*Graph 1.* *Mean values for plant height to tassel (PHT) and plant height to ear (PHE) for inbred maize lines and seed size. L(1,2,3)-inbred lines, KF-large fraction, SF-small fraction, NF-undivided fraction.*




*Graph 2.* *Mean values for plant height to tassel (PHT) and plant height to ear (PHE) for inbred maize lines in different production years. L(1,2,3)-inbred lines.*

The year of production at GY in 2019 had a greater effect compared to 2020. All three lines had higher yields in Y1. The highest yield was 9.1 t /ha for L3Y1, and the lowest for L1Y2, 3.1 t ha$^{-1}$ (Graph 4). Maize grain yield is a product of yield components that are interconnected. During plant development, different agro-ecological conditions are defined that contribute to differences in GY (Milander et al., 2016; Madić et al., 2021).
The heaviest EW was for L2Y2 (156.6 gr), and the heaviest CW was for L3Y1 (33.7 gr). In favourable environmental conditions, the weight of the cob is positive interdependence with other characteristics of the cob, such as the length and number of rows of grains (Milander et al., 2017).




*Graph 3.* *Mean values for ear weight (EW), cob weight (CW) and grain yield (GY) for inbred maize lines and seed size. L(1,2,3)-inbred lines, KF-large fraction, SF-small fraction, NF-undivided fraction.*

*Graph 4.* *Mean values for ear weight (EW), cob weight (CW) and grain yield (GY) for inbred maize lines in different production years. L(1,2,3)-inbred lines.*

The effects of different sources of variation were assessed by analysis of variance (ANOVA). As expected, the genotype is a factor that significantly influenced the differences between the properties of inbred lines ($p \leq 0.05$). The conditions for different year production are also significant for all differences resulting from the comparison of morphological trait's mean values ($p \leq 0.05$). The factor seed size was the least important. PHE is a stable trait, which was not affected by seed size. Further, regardless of the seed size factor, there were EW variations. Interactions are a significant source of variation in the manifestation of traits. In the experiment, all interactions, double and triple, had great effects. The double G×Y interaction had the greatest effect (Table 1).

Table 1. Estimation of factorial variance for phenotypes and morphological characteristics of maize lines

| | F-value | | | | |
|---|---|---|---|---|---|
| | PHE | PHT | EW | CW | GY |
| L | 5.594* | 6.889** | 1.47ns | 6.548** | 0.978ns |
| FR | 0.425ns | 0.777 * | 0.685ns | 1.142* | 0.745 * |
| Y | 43.40 ** | 79,863 ** | 4.126 * | 2.369ns | 66,987 ** |
| L * FR | 2.108 * | 0.706ns | 1,050ns | 1,628ns | 0.258ns |
| L * Y | 7.489 ** | 1,043ns | 0.835ns | 6,734 ** | 8.417 ** |
| FR * Y | 2.405ns | 1,869ns | 5.857 ** | 3.592 * | 0.882ns |
| L * FR * Y | 1.965ns | 2.102 * | 0.346ns | 0.877ns | 0.180ns |

*- Significant at the 0.05 level, **- Significant at the 0.01 level, L- inbred line, KF- large seed fraction, NF- undivided seed, SF-small fraction, PHE- plant height to ear, PHT - plant height to tassel, EW-ear weight, CB- cob weight, GY grain yield, L-inbred lines, FR-seed fractions, Y-years.

Testing the significance of differences between the level of factors and the interaction at the level of significance $p \leq 0.05$, it was found that the differences between the two sets of seeds produced in different years are relevant for almost all traits except for CW. Less significant differences were also influenced by genotype factors. There are significant differences between L1 and L3 in PHT and CW, between L1 and L3 for PHE, and for L1 and L3 there were no significant differences.

Production years affected the differences in PHT, PHE, EW and GY ($p \geq 0.05$); only CW was equal in both years. Under the influence of different seed fractions, GY changed significantly, while other traits did not show variability under the influence of seed size (Table 2).

Table 2. Mean difference of a dependent variable

| Dependent variable | | Mean difference (1-2) | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | PHE | PHT | EW | CW | GY |
| L1 | L2 | -2.5133 | -5.2796 * | -7.5833 | -4.4333 * | 0.0642 |
| L1 | L3 | -5.7858 * | -9.6262 * | -3.9833 | -3.8667 * | -1.6338 * |
| L2 | L3 | -3.2725 | -4.3467 | 3.60 | 0.57 | -1.6979 * |
| KF | NF | -1.5388 | -2.9708 | 4.65 | 0.55 | 0.7321 * |
| KF | SF | -1.1517 | -.3688 | 3.98 | 1.95 | 0.2096 |
| NF | SF | 0.3871 | 2.6021 | -0.67 | 1.40 | -0.5225 |
| Y1 | Y2 | 9.331 * | 18.952 * | -0.036 * | -0.008 | 35.053 * |

*- Significant at the 0.05 level, L- inbred lines, KF- large seed fraction, NF-undivided seed, SF-small fraction, Y1- the production year 2019, Y2- the production year 2020, PHE- plant height to ear, PHT - plant height to tassel, EW-ear weight, CB-cob weight, GY grain yield.

## Conclusion

Variations in the morphological characteristics of maize lines depended on all observed factors (genotype, location, seed size). Favourable amounts and precipitation schedule in 2019 are the result of the better expression of PHT and PHE, as well as GY. When establishing production, in addition to genotype and location, seed size also indicates the importance, first of all, of plant height characteristics and ear position on the plant, and then of the other characteristics, GY, EW, and CW. Identification of morphological traits of inbred lines that reduce stress effects is one of the indicators for proper genotype selection and production management.

## Acknowledgement

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