SUMMARY

of the doctoral thesis entitled:

RESEARCH ON THE BEHAVIOR OF SOME MAIZE HYBRIDS UNDER THE ACTION OF SOME STRESS FACTORS IN THE PEDOCLIMATIC CONDITIONS IN ROMANIA

PhD-student: **POPESCU Gh. Mihai**

Scientific coordinator**:** ***Professor, PhD*** **CRISTEA Stelica**

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Maize, in addition to its special nutritional importance for humans, represents an important fodder base in the livestock sector and a valuable raw material in industry.

The production potential of maize, a complex quantitative character, presents a series of direct and indirect constraints. The direct factors include morphological components of production such as the density practiced per unit area, the average number of grains per cob, MMB, etc., and the indirect factors consist of the genotypes' properties to adapt to the thermal, hydric regime, resistance to diseases, etc. Thus, continuous research is required to identify new crops so that the technological factors used have a superior economic effectiveness.

The doctoral thesis comprises two sections totaling 6 chapters. The first section includes the bibliographic study, and the second section represents his own research.

Chapter I entitled ***"THE CURRENT STATE OF KNOWLEDGE REGARDING MAIZE CULTURE AND THE MAIN STRESS FACTORS"***, which is also ***Section I*** of the thesis, includes the state of knowledge on the research topic. In the 27 pages of this chapter, the importance, origin, history and actuality of the maize crop are presented, as well as its chemical composition. Up-to-date information on the requirements of maize for pedoclimatic factors is in addition. Also in this chapter, reference is made to important aspects regarding maize breeding with a focus on improving resistance to biotic and abiotic stressors. The chapter ends with a subchapter on the pathogens responsible for the rotting of maize cobs and grains, with their symptomatology, epidemiology and ecology. The information presented is accompanied by suggestive images. Through the variety of results obtained in relation to the specificity of the research and especially to the particularities of the areas where it is carried out, the appropriateness of the chosen theme is noted and argued, the results being detailed in ***Section II***.

The second part of the thesis, personal research, details in 5 chapters and 98 pages the purpose and objectives of research, the natural environment and climatic

conditions specific to the research period (***CHAPTER II***), the materials and working methods (***CHAPTER III***), the results obtained under the influence of the researched factors and the analysis of the quality of production (***CHAPTER IV***), the conclusions and recommendations (***CHAPTER V***), but also the novelty and originality regarding the researched theme (***CHAPTER VI).***

Purpose and objectives of research. The purpose of the doctoral thesis was to carry out *in vivo* research on the behavior of 24 maize hybrids from FAO groups 300, 350, 400, 450 and 500 to the action of biotic and abiotic stressors. The location of the experimental fields was carried out in 10 different locations from a pedoclimatic point of view, considered representative for Romania, namely, CTS Negreşti (Negreşti, Vaslui County), CTS Mircea Vodă (Mircea Vodă, Brăila County), CTS Cogealac (Tariverde, Constanţa County), CTS Dâlga (Dor Mărunt, Călăraşi County), CTS Portăreşti (Giurgiţa, Dolj County), CTS Sibiu (Sibiu, Sibiu County), CTS Peciu Nou (Peciu Nou, Timiş County), CTS Dej (Dej, Cluj County), CTS Inand (Inand, Bihor County) and CTS Şimleu Silvaniei (Şimleu Silvaniei, Sălaj County). The institutional and administrative framework was provided by the Doctoral School for Plant and Animal Resources Engineering and Management within the University of Agronomic Sciences and Veterinary Medicine of Bucharest.

In order to achieve the proposed goal, the following objectives were pursued:

Objective 1: characterization of the agropedoclimatice conditions specific to the locations where the research was undertaken;

Objective 2: observations on the conduct of the hybrids taken in the study to the action of environmental factors and biotic stressors (diseases) through observations on resistance to the pathogen *Fusarium* spp. (notes).

Objective 3: to establish the level of production of the investigated hybrids;

Objective 4: laboratory determinations of harvest quality by determining total protein content (%) and starch content (%);

Objective 5: analysis of the influence of pedoclimatice conditions on the production level of the investigated hybrids;

Objective 6: analysis of the influence of pedoclimatice conditions on MMB and the parameters of variability for each location where research was undertaken;

Objective 7: analysis of the stability of the production of corn hybrids of FAO groups 300, 350, 400, 450 and 500 according to the methods proposed by Francis (1977), Eberhart and Russell (1966).

Objective 8: statistical analysis of the results obtained from the research undertaken.

The innovative nature of the research is given by the comparative *in vivo* study of a variety of 24 maize hybrids belonging to different FAO classes in the most representative pedoclimatic zones in Romania. A novelty element is the interpretation of the results obtained, by grouping the test centers located in close geographical areas and quite similar from a climatic point of view. The innovative character of the research is also given by the analysis of the MMB variability parameters of the investigated hybrids through repeatability in the experimental fields of the 10 locations. Another novelty element is the use of statistical models belonging to Francis (1977) and Eberhart

and Russell (1966) for the analysis of the stability of the productions of the 24 genotypes in the 10 locations, given the fact that the genotype-environment interaction induces changes, the phenotypic response not being the same for all genotypes in case of environmental changes.

CHAPTER II entitled ***"NATURAL FRAMEWORK AND CLIMATIC CONDITIONS SPECIFIC TO THE RESEARCH PERIOD"*** presents the natural framework of the 10 experimental fields located in Negreşti, Mircea Vodă, Cogealac, Dâlga, Portăreşti, Sibiu, Peciu Nou, Dej, Inand and Şimleu Silvaniei and also the climatic conditions specific to the years 2018, 2019 and 2020.

CHAPTER III entitled ***"MATERIALS AND WORKING METHODS"*** describes the biological material used, the organisation of the experimental fields and the description of the cultivation technology used, the observations and determinations made in each experimental field and in the laboratory and the methods used in the interpretation of the results.

The study was carried out over the years 2018, 2019 and 2020, in ten locations located in seven areas of the country, namely, in the North-East region (CTS Negreşti), in the North-West region (CTS Şimleu Silvaniei, CTS Inand, CTS Dej), in the Centre region (CTS Sibiu), in the South-East region (CTS Mircea Vodă, CTS Cogealac), in the South region (CTS Dâlga), in the south-west region (CTS Portăreşti) and in the west region (CTS Peciu Nou). The tests was carried out in the field, in monofactorial experiments arranged in the field according to the randomized block method, in 3 repetitions. The experimental variants were represented by the maize hybrid that had 24 graduations, namely: EVO 3517, LG 30315, P 9241, Inventive, SY Orpheus, Turda 201, Faraday, LG 30369, P9903, EVO 3617, Fundulea Olt, Sensor, LG 30389, P 9911, Zephyr, Fundulea 376, Lagoon, P 0412, LG 31377, DKC5830, P 0725, LG 30500, ES Zlatan, Tomasov. The experimental plot consisted of 4 rows of maize, 5.8 m long, at a distance between rows of 70 cm and between plants of 20 cm, which meant an area of 16.24 m^2/plot. The experiments were mounted on soils of cambic chernozem, vermic chernozem, wet and gleized phreatic chernozem, carbonate chernozem and sandy, clay-clayey and soft clay brown soils.

In the research years 2018, 2019 and 2020, observations were made on the vegetation period (date of emergence, date of flowering and silk, date of technical maturity), determinations on the degree of disease attack (resistance to the pathogen *Fusarium* spp.), determinations on productivity elements (production (kg/ha), MMB(g)), crop quality determinations (total protein, starch content). In order to assess the resistance to the disease caused by the pathogen *Fusarium* spp., the resistance class was used, depending on the degree of attack, established by grades, as follows: grade 1.0-2.9 (very sensitive); grade 3.0-4.9 (sensitive); grade 5.0-6.9 (medium resistance); grade 7.0-8.0 (resistant). The statistical analysis of the experimental data consisted in the calculation of statistical indices such as: calculation of means and establishment of minimum and maximum values, calculation of standard deviation, calculation of coefficients of variation and ANOVA analysis of variation. Using statistical models belonging to Francis (1977) and Eberhart and Russell (1966) to analyze the stability of the productions obtained.

CHAPTER IV entitled ***"RESULTS AND DISCUSSIONS"*** contains the results of the investigation on the growing season, the results of the research on the behaviour of maize hybrids in terms of resistance to the pathogen *Fusarium* spp., the results of the research on the elements of productivity, the results of the research on the mass of 1000 grains (MMB) and the parameters of variability for this attribute, the results of the research on the stability of the obtained productions and the results of the research on the qualitative behavior of the researched hybrids.

Sunrise date: if in the locations of Negreşti, Mircea Vodă, Cogealac, Dâlga and Portăreşti no differences were recorded between the investigated hybrids regarding the date of sunrise, in the case of the experiments established in Sibiu, Peciu Nou, Dej, Inand and Şimleu Silvaniei there were differences regarding the date of sunrise in all years of cultivation, differences that were 1-4 days. ***Flowering date***: the lower thermal resources in the Şimleu Silvaniei and Dej locations meant that flowering took place later. ***Date of technical maturity***: it was achieved starting with August 10 (CTS Portăreşti) and ending with October 19 (CTS Mircea Vodă).

The pathogen *Fusarium* spp. has a major impact on the average grain production (kg/ha) obtained, but also on its quality. In 2018, the conditions were favorable to the attack, showing sensitivity to the EVO 3517 hybrid (FAO 300) in the Cogealac S.T.C., the Dâlga S.T.C., the Peciu Nou S.T.C., the Inand S.T.C. and the Şimleu Silvaniei S.T.C., the EVO 3617 (FAO 350) hybrid in the Peciu Nou S.T.C., the SENSOR (FAO 400) hybrid in the Cogealac S.T.C. and the ZEPHYR hybrid (FAO 400) in the Peciu Nou S.T.C., the Inand S.T.C. and the Şimleu Silvaniei S.T.C. In 2019, the hybrids INVENTIVE (FAO 300), Turda 201 (FAO 350), LG30369 (FAO 350), LG 30389 (FAO 400) and LAGOON (FAO 450) showed sensitivity in CTS Negreşti and CTS Portăreşti. In 2020, climatic conditions did not allow the pathogen to develop.

In order to better interpret the results regarding the productivity elements and considering the arrangement of the variety testing centers in different areas in terms of pedoclimatic aspect, they were grouped by geographical regions. The Inand and Peciu Nou centers, although located in close geographical areas and quite similar climatically, there were appreciable quantitative differences with a maximum of 15,290 kg/ha in 2018 and a minimum of 11,941 kg/ha in 2020 for the 24 maize hybrids investigated. The average productions of the 24 hybrids from the localities located in the Western Plain, namely Inand and Peciu Nou, have wide variation limits, from 15,387 kg/ha for the P9911 hybrid to 12,190 kg/ha, production obtained for the domestic hybrid Fundulea 376. If we refer to the number of hybrids that registered statistically assured increases compared to the control, the FAO 450 group stands out. In two hybrids in this group, P0412 and DKC 5830, the quantitative increases compared to the average were very significant, and in the LG 31317 hybrid only significant. Even if the thermal potential of the area allows and even recommends the successful cultivation of hybrids from later maturity groups, overall the highest yields were obtained in the 300 group. Among the native maize hybrids (Turda 201, Olt and Fundulea 376), Turda 201 stands out, a hybrid that in the Peciu Nou S.T. obtained a production of 15,530 kg/ha, and in the Inand S.T.S. the Olt hybrid stood out. For the growing conditions in the west of the country, the P9911 hybrid is recommended. In the Transylvanian Plateau, namely in the

localities of Şimleu Silvaniei and Dej, the most favorable year for maize cultivation was 2019. The assortment of hybrids analyzed behaved much more favorably in CTS Dej, the differences from the average being very significantly positive. In the Şimleu Silvaniei S.T.C., the climatic conditions were less favorable, the average production being 16,466 kg/ha, but the differences compared to the control were very significantly negative. The maximum production of 22,791 kg/ha was obtained by the P0412 hybrid, and the minimum by the Turda 201 hybrid, namely 17,171 kg/ha. From the experimental data it can be deduced that even in these two centers that can be characterized as regions with a limited thermal regime, hybrids of groups 450 and 500 can be successfully cultivated. In the center of Şimleu Silvaniei, the most productive hybrid was P9911 with an average increase over the three years of 1,676 kg/ha compared to the control, and in Dej the ranking was dominated by the hybrid P0412, with an increase of 4,638 kg/ha. In order to render or to capture as faithfully as possible the general and specific adaptation capacity of the researched hybrids, a comparison was made between two rather divergent centers in terms of climatic conditions, namely, the centers of Sibiu (Sibiu County) and Negreşti (Vaslui County). The two centers differ in terms of average annual temperatures of 9.5°C in the case of the Negreşti center and 8.5°C in the case of the Sibiu center, but also in terms of rainfall, in Sibiu clearly higher. The average production obtained by the hybrids researched in Negreşti is considerably lower than that obtained in Sibiu. The only hybrids that stood out in both centers with statistically assured positive differences compared to the control are, P9241, FARADAY, P9903 and DKC 5830. The hybrids that obtained annually in the Sibiu conditions, productions of over 1,000 kg/ha compared to the control are: Sy Orpheus, FARADAY, P9903, P9911, Zephyr, P0412 and DKC 5830. These crops belong to FAO maturity groups 300, 350, 400 and 450. In Negreşti, the average productions varied between restricted limits between 9,013 and 14,829 kg/ha. Even in these harsher conditions from a water point of view, the hybrids LG30313, Inventive, P9903, LG31317, DKC5830, LG30500 and Tomasov stand out. For the south-eastern region, a parallel was made between the productions obtained by the hybrids researched in the Mircea Vodă and Cogealac centers. The most productive hybrids are those in the 500 group, followed by those in the 450 group. The only hybrid in the early and semi-early groups (300 and 350) that achieved on average in the two locations a distinctly significant production increase compared to the control is the Evo 3517. In the Mircea Voda center, the most productive hybrid proved to be P0412, with very significant differences, surprisingly followed by the early hybrid EVO 3517. The performers of the production in the Cogealac center are the late hybrids DKC 5830 and Lagoon. Therefore, it can be deduced that stability often does not coincide with the highest productive performance. The Dâlga and Portăreşti test centers are located in Călăraşi county, respectively, Dolj and they differ to some extent in the quantitative aspect of the pluviometric regime. Out of the total of 24 hybrids, six achieved statistically assured increases both at the test center in Dâlga and at the test center in Portăreşti. In Dâlga, the most productive hybrids were P 0725 with a production of 18,344 kg/ha, followed by DKC 5830 with 17,868 kg/ha and P0412 with 17,736 kg/ha. The production performers for the Portăreşti center proved to be the hybrids P9911 (21,572 kg/ha) and P0725 (21,524 kg/ha), followed by P0412 (21,019 kg/ha).

As for the behavior of MMB hybrids in the Inand and Peciu Nou centers, they were influenced by pedoclimatic conditions. At CTS Inand, the LG 30500, SY ORPHEUS and Turda 201 hybrids reached maximum values in 2020, and the best performances were recorded for the hybrids P 9911 (308 g – 2018), DKC 5830 (331 g – 2019) and P 0412 (329 g – 2020). At CTS Peciu Nou, the hybrid P 0412 was noted, which recorded the highest values of this attribute in all three experimental years and can be characterized as having good MMB stability as well.. The repeatability in time and space for MMB, highlighted the fact that among hybrids with a fairly pronounced stability can be listed Inventive and LG 30369, with small fluctuations in the two centers. The parameters of variability in the case of the 24 hybrids analyzed show that the average MMB in Inand locality in the three years has values between 269 and 290 g, and in Peciu Nou locality the variation limits are located between 321 and 338 g. In 2020, in both locations, the coefficients of variation have higher values than the other two years, which suggests a greater fluctuation of this quality under the influence of more favorable environmental conditions. In the Şimleu Silvaniei and Dej centers, hybrids reacted differently in 2018, 2019 and 2020. The high values of the MMB averages in the Şimleu Silvaniei and Dej centers denote a good behavior of the hybrids in all years of experimentation. Also in terms of this attribute, we could say that in Şimleu Silvaniei, the most favorable year was 2020, the average having a value of 339g, and in Dej the highest values were recorded in 2019. In two locations quite close in distance, the response of the hybrids in terms of weight and grain size was differentiated. Also, the varied response of hybrids is also reflected at the level of minimum and maximum values. In both centers, important values of the coefficients of variation were registered in 2020, suggesting a broader response of the 24 hybrids under study. In the specific conditions of Sibiu, the most favorable year for the formation of generative elements, including MMB, was 2020, while in the conditions of Negreşti the most favorable year was 2018. The highest amplitude of variation in the three years and the two locations is recorded in 2018 in Sibiu, which can be deduced from the differences between the minimum and maximum values as well as from the variance and the coefficient of variation. The values of the coefficients of variation reflect a moderate variation of the MMB in the center of Sibiu and a small variation in the conditions of Negreşti. The pedoclimatic conditions in the two centers differentiated the response of the 24 hybrids in achieving the weight of the grains. This statement is supported by the fact that in Mircea Vodă locality in all hybrids the MMB recorded average values in the three years of over 300g, values that in the center of Cogealac with some small exceptions did not reach this threshold. The annual averages in the center of Cogealac are lower than those in Mircea Voda, in 2020 dropping even below the threshold of 200g, with a minimum value of 153g. Compared to other centers where the biological material testing was carried out, the hybrids behaved differently in Dâlga over the three years, so that in 2020, most of the hybrids recorded lower values compared to the other two years. In Portăreşti, the lowest averages of the MMB are recorded in 2019, and in Dâlga, the minimum value was achieved in 2020. Therefore, the diversity of pedoclimatice conditions in our country acts as a buffer in fading to some extent the negative influence of atmospheric drought on grain size.

Using the average method of the coefficient of variation in assessing the stability of the productions of the investigated hybrids, it was established that they have a good capacity to adapt to pedoclimatic conditions and a good production capacity of the hybrids DKC5830, P0725, P9241, LG30500, being the most stable in most environmental conditions, the values of the coefficients of variation being below the average of hybrids, and in terms of production, individual values above average.

Regarding the areas of favorability for the hybrids of the FAO 300 group, the centers of Şimleu Silvaniei, Peciu Nou, Portăreşti, Sibiu, Mircea Vodă and Dej are particularly noteworthy. From the FAO 350 group, the hybrids P 9903 and FARADAY stand out for their high production potential and good adaptability, achieving superior yields both in favorable and less favorable conditions for maize cultivation. From the 400 group, the P9911 hybrid stood out for its good adaptive and productive capacity in all test centers except for the Negreşti and Cogealac sites, where the LG 30389 and Sensor hybrids achieved slightly higher productions. As less favorable areas for hybrids in this group, the centers of Inand, Negreşti and Cogealac remain. For all maize growing areas for which the 10 locations are representative, hybrids P0412 and DKC5830 are also recommended. Within the FAO 500 group, the P0725 and LG30500 hybrids stood out.

Regarding the protein content, the small range of variation between the minimum and maximum values, as well as the values of the coefficient of variation indicated a small variability of the protein content at the level of the hybrids analyzed. The protein content values were between 10.8 and 11.24% and the hybrids Evo 3617, Turda 201 and P 9903 stood out.

The starch content determined in the 24 maize hybrids investigated exceeded 67%, taking values in the range of 65.92-69.03%. The Evo 3517 hybrid shows a significant deviation.

CHAPTER V entitled ***"GENERAL CONCLUSIONS AND RECOMMENDATIONS"*** presents the conclusions of the research undertaken, after analysing and processing the data and the notes and observations made in the experimental field and in the laboratory, during the years of research.

Of the 24 hybrids tested, only a fairly small number showed a valuable production increase associated with a good general ability to adapt, in the sense that both in favorable and less favorable conditions they achieved the highest productions. This category includes the hybrids P9903, FARADAY (FAO 350), P9911 (FAO 400). The category of hybrids with a lower overall adaptability but good specific adaptability could include the hybrids P9241, Evo 3517, Sy Orpheus (FAO 300), Sensor, Zephyr (FAO 400), P0412, DKC5830 (FAO 450), P0725 and LG30500 (FAO 500). These crops performed through the highest yields, either only in very favorable conditions or in less favorable conditions. Based on this information, agricultural producers who have maize in their crop structure can make the best decisions regarding the choice of hybrids depending on the response they had in the test centers and the availability in purchasing the hybrid seed.

The doctoral thesis has a number of 206 pages, includes 37 tables and 94 figures (of which 35 original tables and 87 original figures) the own contribution being 77,34%.

The results obtained from the research undertaken were capitalized in 4 articles published as follows: one ISI indexing article: Impact Factor: 0.633 (2021), two ISI indexed articles and one article BDI database indexing.

The bibliography of the thesis includes 228 sources (books, articles in specialized journals, treatises, scientific papers, web sources).

The results obtained in this research contribute to the completion of the existing knowledge.