PhD THESIS

The influence of climatic conditions on the growth and development stages of maize according to sowing date

(SUMMARY OF Ph.D. THESIS)

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Introduction

The climate of Europe and our country has undergone significant changes in the last 30 years, but especially in the last 4–5 years. The average monthly temperature is increasing and the spatial and temporal distribution of precipitation is becoming more unfavorable at the European level (TAMÁS et al., 2023).

Climate change is a change in the statistical distribution of weather conditions when this change lasts for an extended period of time (decades to millions of years). Climate change can refer to a change in average weather conditions or variation in weather in the context of long-term average conditions.

Climate change is caused by factors such as biotic processes, variations in solar radiation received by the Earth, plate tectonics, and volcanic eruptions. Certain human activities have been identified as the main causes of ongoing climate change, often referred to as global warming (NATIONAL RESEARCH COUNCIL, 2010).

Because plant performance is a result of individual genetic and environmental conditions, adding complementary data such as weather, soil, genotype, and field management can enrich the characteristics that will represent varieties, generating the potential for more accurate yield predictions. in this context (DANILEVICZ et al., 2021).

Plant production varies from year to year, being significantly influenced by fluctuations in climatic conditions and especially by the occurrence of extreme weather events (www.meteoromania.ro).

Climate variability influences all sectors of the national economy, but the most affected remains vegetable production and especially agriculture (www.icpa.ro).

The most vulnerable cultivated species will be especially the annual cereal and fallow crops, the water deficit in the summer season, which coincides with the period of maximum water requirements, causing important decreases in production. In this sense, a new reorientation in the structure of agricultural crops is required, namely varieties with a high tolerance to high temperatures and the water stress generated by the lack of water.

At the same time, the adaptation of agricultural technologies to the water resource is required, the conservation of water from the soil by choosing a system of minimum works representing a new trend of reorienting the requirements regarding the quality and conservation of soil and water resources (www.meteoromania.ro).

In the field plant culture sector, the selection of cultivated varieties mainly includes the correlation of local environmental conditions with the degree of resistance of genotypes (varieties/hybrids) to limiting vegetation conditions. Physiology research has largely been oriented towards supporting the improvement activity by studying the physiological and biochemical processes involved in the reaction of plants to stress conditions, the development of selection methods and criteria with increased efficiency in the identification of genetic differences, in order to improve resistance to low temperatures, heat, drought, excess moisture, salinity and soil acidity (PETCU et al., 2007).

The most important stage in the life cycle of any plant is emergence, because only after a crop has emerged can it be said that it has a high chance of reaching maturity and generating the expected productions. Through a fast and uniform maize emergence, it is ensured that an optimal density of the crop is obtained, which is reflected in important increases in production. Studying the thermal requirements for this phase of the maize life cycle provides information on the possibilities of hybrids to efficiently capitalize on the climatic conditions encountered in the cultivation areas of this plant. For sunrise, temperature plays a very important role. In conditions of sufficient moisture in the soil, the emergence of maize is closely influenced by the thermal factor (DAVID, 2008).

Cold tolerance is a maternally inherited trait and is determined by a system of genes with additive dominant and overdominant effects.

The uniform emergence of seedlings in early culture depends on the combination of 3 key factors: environment (favorable conditions for culture), genetics (stress/cold tolerance) and seed quality, which determines the biological potential of the hybrid (www.pioneer.com). World research centers focus on the selection of cold-tolerant hybrids to obtain consistent performances when implemented in culture in temperate zones (www.pioneer.com).

Early sowing is a sowing strategy that is successfully used in several European countries. With the intensification of dry periods during the development of maize plants in the last decades, the interest in the sowing of maize in the early crop becomes more and more current in the traditional areas of cultivation of the crop (ALDRICH et al., 1986).

It is demonstrated that seed germination is closely related to thermal conditions (air, soil) (CRISTEA, 2004; SHAW, 1988; ALDRICH et al., 1986), with the amount of plant remains on the soil surface, day-night temperature fluctuations, etc. (ALDRICH et al., 1986). Consequently, crops can be rare, uneven, covered by weeds that grow before corn (www.corn.agronomy.wisc.edu).

On the other hand, in the culture with early sowing, the vegetative part of the plants has a better development, and the root penetrates the soil deeper (ALDRICH et al., 1986).

During the grain formation period, the plants consume more solar energy and produce grains with a higher dry matter content, and the productivity of hybrids sown early (soil temperature +6...+8°C) is 15-18% higher high because it vegetates for a longer period (NIELSEN, 2012).

Followed objectives

Climate changes (temperature and precipitation as the main factors) that have become more pronounced in recent times have had strong negative effects on the growth and development of crop plants. And among the crops that suffered a lot was and is maize.

The purpose of this doctoral study consists in the intervention in the technology of maize cultivation in order to reduce as much as possible the unfavorable factors.

The location of the experiences in the contact zone between the Transylvanian Plain and the Târnavel Plateau, more precisely in the N-NE part, has the following objectives:

- Identification of maize hybrids with different germplasm in order to highlight biotypes with increased tolerance to lower germination temperatures compared to the optimal temperature of 10 °C;
- Highlighting biotypes with good coldtest and high productivity potential;
- Tracking the evolution of some phases of plant development during the vegetation period in relation to the sowing season;
- Adaptation of maize hybrid culture technology to climate changes in order to advance certain vegetation phases (flowering, silking) before the occurrence of severe drought;
- Evaluation of the production and the main production and quality elements of the hybrids studied according to the sowing season;

Research methods

In order to achieve the proposed objectives, in the 4 years of study (2018, 2019, 2020, 2021) the experience was arranged in subdivided plots of the type 9 variants x 3 repetitions x 3 sowing dates, with the harvestable surface of 19.6 m2 (7m x 2.8m). The placement of the experiments in the field was carried out according to the method of subdivided plots, in three repetitions.

The research approach was made from the perspective of a polyfactorial experience of the A x B x C type

• Factor A – was represented by years of culture with four gradations:
- 2018
- 2019

- 2020
- 2021

• Factor B – was represented by the Sowing date – with three gradations:
 - Sowing date I – early sowing date
 - Sowing date II – optimal sowing date
 - Sowing date III – late sowing date.

Tabelul /Table 1.

Epoca de semănat
Sowing date

Epoca de semănat/ Sowing date — Anul/Year	Data semănatului Date of sowing		
	I	II – Mt.	III
2018	10.04.2018	24.04.2018	7.05.2018
2019	4.04.2019	18.04.2019	5.05.2019
2020	7.04.2020	21.04.2020	8.05.2020
2021	10.04.2021	24.04.2021	7.05.2021

• Factor C – was represented by the biological material made up of the nine maize hybrids:
H1 - KWS 2370 (FAO 290)
H2 - KWS 4484 (FAO 380)
H3 - Karpatis (FAO 340)
H4 - Kashmir (FAO 370)
H5 - Durango (FAO 450)
H6 - Smaragd (FAO 350)
H7 - Kapitolis (FAO 410)
H8 - P9900 (FAO 360)
H9 - P 9903 (FAO 360)

The soil work consisted of a discussion in August, deep plowing in the fall and leveling discussion in the spring and a work with the combiner to prepare the seed bed.

The application of the entire dose of fertilizers was done after the leveling discussion, and their incorporation into the soil was done with the combiner. The dose and type of fertilizer used was N16P16K16 500 kg/ha, and every three years 4 t amendments per ha were applied.

The calculation of the amount of seed was established for the plot of 650000 b.g./m2. After sowing, in order to combat annual monocotyledonous and dicotyledonous weeds, a pre-emergent weeding was done with Adengo at a dose of

0.350l/ha, and if necessary, the vegetation was treated with Tomigan 0.8l/ha + Amino 0.8l/ha.

The seed used in the experiments was treated with insecto-fungicides, but no other treatments were done during the vegetation period, in order to monitor the resistance of the hybrids to diseases and pests.

Sowing was carried out in three sowing seasons with a hand planter with a grain direction tube at a depth of 7 cm. The variants were harvested individually, also manually**.**

Fig. 1. Aspect din câmp: semănatul parcelelor experimentale
Fig. 1. Aspect from the field: sowing experimental plots
(sursa/source: original)

All the hybrids chosen for testing are from close maturity groups with a vegetation period that falls within the sum of the active temperatures that are achieved in our area.

The first sowing period was carried out when a temperature of 6 °C was achieved in the soil at the sowing depth. The time of sowing was advanced compared to the optimal time according to the temperature in the soil at the depth of 10 cm (about 10 days).

The evolution of average daily temperatures was monitored in order to establish the threshold of 6 °C against the optimal time of 10 °C, for the initiation of sowing for the early time.

Temperatures were recorded daily at three times (in the morning at 6:00 a.m., at 12:00 p.m. and at 6:00 p.m.) at the sowing depth of 6 cm.

The time intervals between the sowing dates was approx. 10-12 days.

Sowing started when the soil temperature reached an average of about 6-7°C with a growing tendency.

The moment of emergence, flowering, silking, the physiological maturity of the hybrids according to the sowing season was recorded.

We set the sum of the active temperatures above 10 °C and below 30 °C, for flowering, silking, physiological maturity, technical maturity.

After harvesting each experimental plot, after weighing, by bringing it to the standard humidity of 14%, the real production/ha was calculated with the help of the formulas:

Pp.c.= pp x ;, where:

pp. c. = yield/plot corrected to 14% moisture

pp= production per plot

Ur = humidity at harvest

Uc= 14% corrected humidity

Pr./ha= production per ha

s= harvestable area

To determine the yield elements, 2 rows were harvested from each experimental plot/repetition. In the end, I took 10 cobs from the other 2 rows to note the biometric data of the cobs and to determine in the laboratory the mass of one thousand grains (MMB), the hectoliter mass (M.H.).

To determine the hectoliter mass, the 0.25 l samovar scale was used, the volume of the grains in the cylinder being weighed later with the analytical balance. To obtain the value in kg/hl, the value read on the scale was multiplied by 0.4.

For quality, analyzes were made in the laboratory at SCDA Turda, regarding the protein, starch, fat and fiber content using Tango NIR analyzer.

Conclusions and recommendations

Conclusions regarding the influence of climatic conditions and sowing date on some physiological characteristics of maize

- Early sowing did not negatively affect the percentage of emerged plants, compared to the optimal sowing date, although there were situations where the temperature remained below the minimum temperature for germination several days, and the studied hybrids emerged after 22-24 days from sowing, without affecting germination.

- The high maintenance of the percentage of emerged plants in the first period was due to the high biological value of the seeds used for sowing and the quality of the phytosanitary products used for treatment; so we can conclude that we had available seed from hybrids with cold test and good vigor.
- We identified a positive correlation, of weak intensity, between the height of plants and grain production in maize, the correlation coefficient having a low value (r= 0.1177), and in the early period we found a reduction of the height by an average of 7 cm, of the optimal era.
- The silking date was brought forward by up to 17 days in the early era, compared to the optimal sowing time, and the biggest advance occurred in 2018, avoiding the overlap of the flowering and silking phase with the high temperatures that can lead to the loss of pollen viability and finally to poor fertilization.
- Against the backdrop of abundant rainfall and high temperatures in June 2018, the number of days from sowing to silking was reduced for most of the hybrids tested, which was recorded in the third decade of June for the first sowing season, in the first decade of July for epoch II and in the second decade of July for epoch III and we can conclude that high temperatures and abundant rainfall in June accelerate the appearance of stigmas (silk) in maize.
- In 2021, when temperatures and precipitation were closer to the normal ones for the month of June, the differences between sowind dates regarding the date of silking were not important, for most hybrids it was recorded in the range of 11.07-19.07 for sowing date I, 12.07-20.07 for sowing date II (optimal) and 17.07-25.07 for sowing date III.
- The sum of active temperatures from sowing to silking averaged 692 °C in the optimal sowing season, 673 °C in the early season and 7030°C in the late season, naturally in the SCDCB Tg area. Mures registers 689 °C .
- In the early era, the sum of active temperatures from sowing to silking averaged 667 °C over the four years of the study, ranging between 633 °C and 707 °C, in the optimal era it was between 670 °C and 718 °C, and in the late epoch it was between 668 °C and 737 °C.
- In the years 2020 and 2021, a lower amount of active temperatures was recorded from sowing to silking in Epoch I, although it took place over a longer period of time.
- On average, to reach physiological maturity, in the studied maize hybrids, 133 days were recorded in the optimal period, 141 days in the early period and 124 in the late period, and early sowing advanced physiological maturity by 3-9 days, positively influencing humidity grains.
- From the analysis of the sum of active temperatures recorded from sowing to physiological maturity, we can conclude that in the years 2018 (1287°C) and

2019 (1317°C) there were favorable conditions for sowing maize in the early season and less favorable in the years 2020 (1198°C) and 2021 (1213°C).

- The number of days in advance to reach physiological maturity in the first sowing period, compared to the second sowing period, was between 5 and 17 days in 2018, KWS Kashmir hybrid reacted the best to the early sowing period.

Conclusions regarding the influence of date on some yield elements on maize

- Maize grain yield in the early period was 1.04% higher (***, very significant) and 0.68% 000 lower in period III, compared to the optimal period.
- Depending on the year of experimentation, the maize grain yield had values between 85.56 % (201800) and 86.01 % (2020**) and an average value in the four years of 85.76 %,
- Among the maize hybrids studied, KWS Kashmir and KWS Kapitolis had a very significant and distinctly significantly higher grain yield, compared to the average of the hybrids, and KWS Kashmir and KWS Smaragd a highly significant (000) and distinctly significant (00) yield lower, while for the Pioneer hybrids the values were close and located around the average.
- In the early maize sowing period, the lowest value of the MMB was recorded, with a difference of 11.26 grams compared to the optimal period, very significantly negative.
- In the KWS 2370, KWS 4484 and P9903 hybrids we recorded higher MMB values (362, 367 and 366 grams), and in the KWS Karpatis, KWS Kapitolis and P9900 hybrids lower values (334, 317 and 320 grams), while in three of the hybrids: KWS Kashmir (351 g.), KWS Durango (344 g.) and KWS Smaragd (353 g.), the MMB values were close to those of the average (346 g.).
- The hectoliter mass had higher values in the early era.
- Hybrids: KWS Karpatis, KWS Kashmir and P9900 had values of the hectoliter mass above 82 kg/hl, while in the hybrids KWS 4484, KWS Durango and P9903 the values were below 70 kg/hl.
- Among the tested hybrids, the best humidity at harvest was obtained by KWS Karpatis, KWS Kapitolis and P9900, with 0.75 and 1.08 % lower than the average of the hybrids, and the highest humidity of the grains at harvest was determined in the hybrid KWS 4484, with a difference of 1.71 % compared to the hybrid average.
- In the early sowing season, the lowest grain moisture was recorded, at 19.47%, 2.22% less than the optimal season.

Conclusions on yield and quality of maize, depending on the date of sowing

- Among the tested hybrids, the highest yields in 2018 were obtained at KWS Kapitolis 15.630 kg ha-1 and at P9900, 15.670 kg ha-1,
- Production results in 2018 were higher at sowing date I (early) compared to sowing date II (optimal, conventional) in a number of five hybrids out of nine, and in two of them the production was distinctly significant (* *) and significantly (*) higher in this era **, respectively at KWS 2370 and KWS Durango.
- In 2018, decreases in yield due to late sowing (Epoca III) were recorded, compared to the optimal sowing date at six hybrids and only KWS 2370, KWS Durango and KWS Smaragd had higher yield, KWS 2370 being the only hybrid that was not affected by the date of sowing.
- The KWS Kapitolis hybrid recorded the highest productions in 2019, in the early period – 16.975 kg/ha, but we also note a good performance of the Pioneer hybrids: P9900 – 15.164 kg/ha and P9903 – 15.917 kg/ha in this period of sowing.
- In 2020, grain production in the early sowing date (SD I) was 264 kg ha-1 higher in the early era, compared to II sowing date (optimal), and at the III SD, late sowing date it was significantly higher, compared to the control.
- In 2020, the KWS Karpatis hybrid (13.358 kg/ha), which has a high stay green and is part of the Plus4Grain group, performed best in the early sowing date.
- In 2021, at the early sowing date, lower yields were obtained at the experimented maize hybrids, compared to the optimal sowing date, the difference between the two sowing dates was 424 kg/ha, significant.
- In the early sowing season, the hybrid KWS Kashmir reacted very well in 2021, recording a production of 12.790 kg ha-1, a highly significant 1.350 kg/ha higher (***) compared to the optimal season (11.440 kg ha-1).
- From the point of view of the degree of favorability for maize culture at SCDCB Tg. Mureş, we note that in 2018 and 2019 the highest productions were obtained, 14.612 and 14.553 kg ha-1, while in 2021 the lowest productions were recorded (11657 kg ha-1).
- Among the experimented hybrids, the highest yields in the four years of experimentation at SCDCB Tg. Mures were obtained at KWS Durango (12.504 11.657 kg ha-1), KWS Kashmir (12.479 kg ha-1) and KWS Kapitolis (12.320 kg ha-1).
- Maize grain production is positively correlated with the mass of 1000, the correlation coefficient having a very significant value (r=+0.455***).

- The fewest days with temperatures below the optimal maize development threshold were in 2018, when the highest productions were obtained, and the most in 2021, when the lowest productions were obtained, and between production and number unfavorable days during the vegetation period April-August for maize we calculated a very significant negative correlation, the correlation coefficient having the value r= -0.65367.
- The tested hybrids had a low protein content, which was not influenced by the time of sowing and the year of cultivation.
- It can be concluded that the advantage of sowing in the early season of maize is important for the lower moisture percentage of the grains at harvest, which saves the farmer from an expense of 130 lei/t with drying.

Originality

In the context of the increasingly pronounced climate changes of late, intervention in maize cultivation technology has become a priority. The topic covered is about sowing below the minimum grain germination threshold (below 10 °C) without having repercussions on the growth and development of the crop.

The obtained results highlighted the fact that, although some physiological processes underwent slight changes, the production results were not affected.

The early time of sowing did not influence the quality of the harvest, the content of protein, starch, fat.

The contribution of originality and of great importance for farmers is represented by the fact that, through early sowing, the silking and physiological and technical maturity phases were advanced by an important number of days, removing the maize crop from the negative influence of high temperatures during fertilization .

Also, the moisture at harvest was lower in the early era, compared to the optimal era by 2.22%, which is a great advantage for the farmer, saving him from additional expenses of bringing the production to STAS moisture.

For farmers in drier areas, earlier sowing will be a solution in maize technology until biotypes with genetic resistance to heat and water stress are developed.

In conclusion, the research of this doctoral thesis brings solutions for two problems related to maize culture:

- Early sowing avoids thermal stress caused by high temperatures during the flowering and silking phases;
- Grains have lower moisture at early harvest, which can be a benefit for farmers by reducing the costs with grain drying.

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