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EXPLORING THE IMPACT OF SOWING DATES AND CLIMATIC CONDITIONS ON MAIZE YIELD AND QUALITY

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Abstract

In order to evaluate the influence of different sowing dates and climatic conditions, on maize yield and quality parameters (protein, fat, starch and moisture), a field polifactorial experiment was carried out in three different years at Research and Development Station for Agriculture (RDSA) Turda. Twelve maize hybrids of different maturity classes were studied using a randomized block design, with three replications, plots of 7 m^2, on medium high soil with loam clay texture, pH 6.7. Three factors were analysed in the experiment: the experimental year with three graduation, sowing date with four graduation and maize genotype with 12 graduations. The experiment provided results from four different sowing time, when measured soil temperature was: 4°C, 6°C, 8°C and 10°C, respectively. Each maize hybrid was sowed on 2 rows of 5 m length and 70 cm distance between rows. The results revealed a high influence of sowing date and climatic factors on maize yield and quality. When very early (4°C) and early (6°C) sowing dates were experimented an important decrease in maize yield was obtained compared to optimum or late sowing time.

Key words*: maize, sowing date, quality, yield.*

INTRODUCTION

Agriculture, as the main source of food, is significantly affected by climate change and extreme weather events such as temperature fluctuations, irregular rainfall and water scarcity (Markou et al., 2020). Water plays an essential role in agricultural production and is one of the most valuable resources, with water stress having a negative impact on plants, including growth retardation, reduced photosynthesis, and inhibition of essential biochemical processes (Seleiman et al., 2021). Climate change has affected global food production through varying rainfall intensity and frequency, extreme weather conditions, and increased greenhouse gases (Srivastava et al., 2021).

Maize (*Zea mays* L.) is a species of crop plant in the Poaceae family and originated in what is now Central or South America, over 55-70 million years ago (Scott & Emery, 2016). It is one of the most widespread crop plants and is cultivated from the equator up to 3000 m above sea level (Morris, 2002). Maize is an essential crop because it provides a cheap nutritious food, which provides the basic nutrition of the population and is an important crop in industrial and livestock production (Iken et al., 2002; Olaniyan & Lucas, 2004). It has the advantage of being a fully mechanizable crop with high ecological plasticity (Haş et al., 2018), being used in human nutrition in the tropical region, in animal feed in the temperate region, and recently, as raw material for biofuels (Subedi & Ma, 2009).

Currently, different hybrids are homologated in the world, their spread in production being dependent on consumer preferences and market demand (Eteng, 2017). Unlike other major cereal crops, maize is efficient at using water, nutrients and CO_2 to produce carbohydrates that are stored in leaves and stems, making it an important source of starch (Subedi & Ma, 2009). Nutritionally, maize contains 60 to 68% starch and 7 to 15% protein, opaque seed types are more nutritious and contain a high percentage of essential amino acids (https://cornindia.com).

Globally, in the last two decades there has been an increase in the areas harvested with maize, reaching 203 million ha in 2022. The growing interest in this species of crop plant is due both

to the current population explosion and to the manufacture of biodegradable products.

Romania is one of the major maize producers in Europe and in the world, its maize performance being due to modern hybrids, which have special resistance to the conditions of our country and have the necessary quality for processing (https://en.wikipedia.org; Popescu, 2015, 2018). According to data presented by the Ministry of Agriculture and Rural Development, in 2018 and 2019, in Romania were obtained the highest maize yields of 18.6 mil. tons, respectively 17 mil. tons. In 2020, the total maize production in Romania slightly exceeded 10 mil. tons (https://www.madr.ro/culturi-de-camp/cereale/porumb.html).

Previous studies have shown that the negative effects of climate change on maize production were mainly associated with warming and increased drought frequency during growing periods, ultimately reducing production (Wang et al., 2016). For yield optimization, planting at the right time is very critical, as delaying the planting date can lead to a decrease in grain yield (Anapalli et al., 2005). The timing of planting plays a crucial role in maximizing maize yield and determining grain quality (Zakaria et al., 2020) because when the maize crop experiences moisture stress, yield decreases inversely proportional to protein content, which increases significantly.

Environmental conditions have a direct and significant impact on the growth and development of maize throughout its growing season and consequently influence grain yield and quality (Rahimi et al., 2021). In recent years, there is more and more emphasis on implementing technological systems to reduce the effect of climate change on agricultural crops, therefore, there has been a need to conduct an experiment to determine the optimal moment of sowing maize hybrids and their performance in the pedo-climatic conditions of the Transylvanian Plateau.

MATERIALS AND METHODS

In order to evaluate the influence of different sowing dates and climatic conditions, on maize yield and quality parameters (protein, fat, starch and moisture), a field polifactorial experiment was carried out in three different years at Research and Development Station for Agriculture (RDSA) Turda. Twelve maize hybrids of different maturity groups were studied using a randomized block design, with three replications, plots of 7 m^2, on medium high soil with loam clay texture, pH 6.7. Maize crop was included in a three year crop rotation as following: soybean, spring barley and maize. Three factors were analysed in the experiment: the experimental year with three graduation (2021, 2022, 2023), sowing date with four graduation and maize genotype with 12 graduations. The experiment provided results from four different sowing time, when measured soil temperature was: 4°C, 6°C, 8°C and 10°C, respectively. Soil temperature was measured at a depth of 10 cm, at eight o'clock in the morning. Each maize hybrid was sowed on 2 rows of 5 m length and 70 cm distance between rows. The biological material consists in maize hybrids from different maturity groups, created at RDSA Turda: Turda 248, Turda 165, Turda 201, Turda Star, Turda 332, Turda 344, Turda 335, Turda 2020, Turda 380, HST 148, HST 149, SUR 18/399.

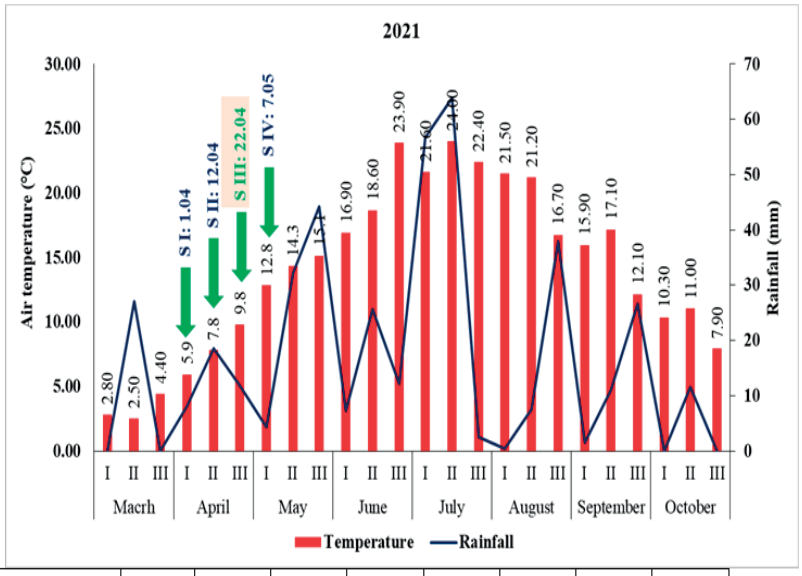
RESULTS AND DISCUSSIONS

Between March and October 2021, there is a cooling trend of air temperature in the first two months of spring, when deviations of 1.4 and 2.1°C, respectively were recorded, compared to the multiannual average (Figure 1).

In terms of precipitation, they varied from month to month, with lack or insignificant precipitation in some decades. We notice March, May and June which were characterized as slightly rainy, excessively rainy (July), while April and June were characterized as slightly dry, respectively very dry.

Based on the above, the sowing of the maize crop was carried out on the four separate dates as follows:

- First sowing date (S I): April 1, 2021, when the soil temperature was 4°C;
- Second sowing date (S II): April 12, 2021, when the soil temperature was (6°C);
- Third sowing date (S III): April 22, 2021, when the soil temperature was 8°C;
- Fourth sowing date (S IV): 7 May 2021, when the soil temperature was 10°C.



Multiannual air temrepature average (°C)	4.7	9.9	15	17.9	19.7	19.3	15.1	9.5
Multiannual average for sum of rainfall (mm)	23.6	45.9	68.7	84.8	77.1	56.5	42.5	35.6

Figure 1. Temperature and rainfall registered at RDSA Turda in 2021 (March-October)

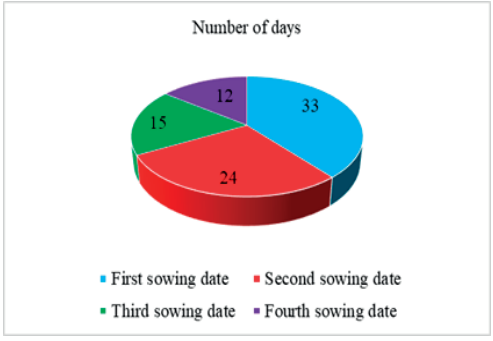


Figure 2. Number of days from sowing to emergence depending on sowing date (RDSA Turda, 2021)

Compared to the optimal sowing date performed when the soil temperature was 8°C, when emergence was noted 14 days after sowing, on average in 2021, maize genotypes needed 33, 24 and 12 days respectively until emergence when they were first sown, the second and fourth sowing dates respectively (Figure 2). The number of days form sowing to emergence varied between: 30-32 in the first sowing date, 22-26 in the second sowing date, 13-17 in the optimum sowing date and between 11-14 days when late sowing was experimented.

Using the method proposed by Eberhart and Russell (1966), the yield of twelve maize hybrids obtained on the different environmental conditions existing in the four sowing dates was evaluated. From the graph below (Figure 3), it can be seen that, regardless of genotype, yield was greatly reduced when maize was sown earlier. When delayed sowing was experimented, the yield obtained was close to that obtained in the variant in which the optimal sowing date for maize was experienced, when the soil temperature was 8°C. The Turda 380 hybrids was noted with yields of over 11000 kg/ha when sowing at a temperature of 10°C has been practised. For the Turda 335 hybrid, the yield decreased by almost 2 t/ha and 3 t/ha respectively when the early sowing variants were experimented compared to sowing on the optimal date. Regardless of the sowing date analysed, Turda 2020 and Turda 380 genotypes proved to be the most yielding.

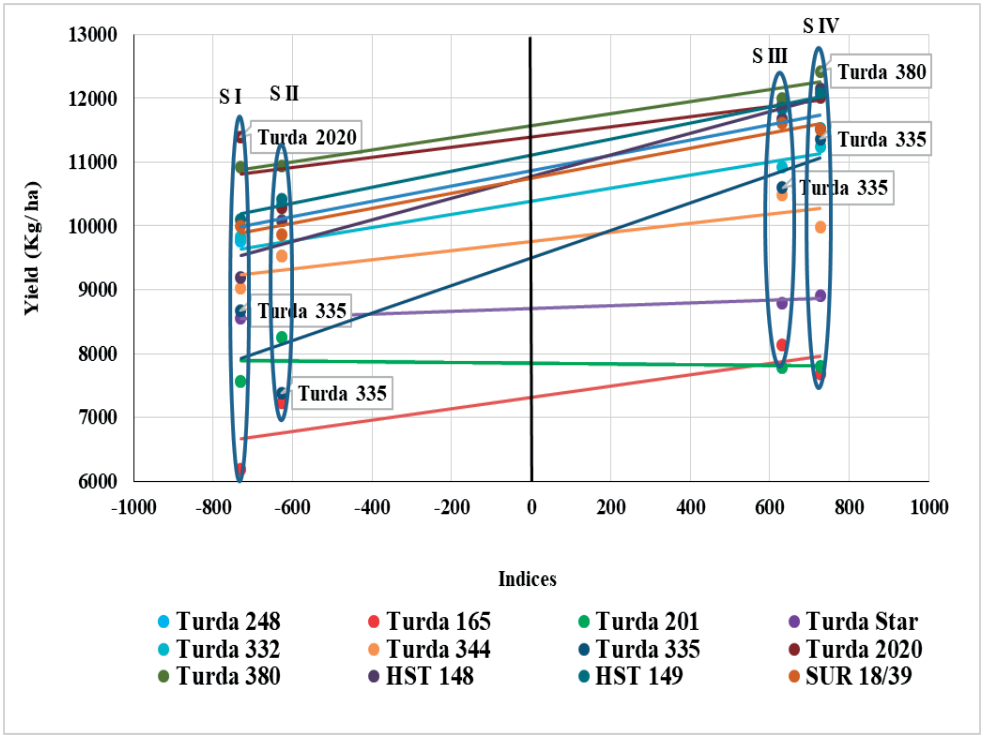


Figure 3. Yield obtained at twelve maize hybrids depending on sowing date (RDSA Turda, 2021)

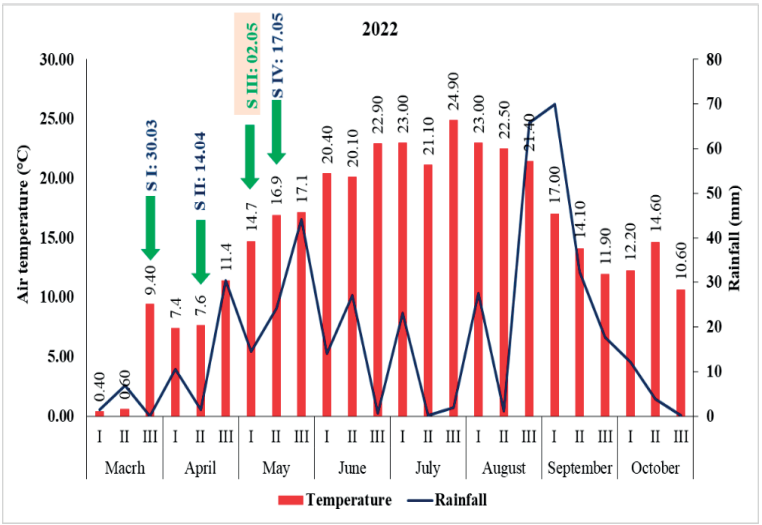
In the second experimental year (Figure 4), in the March-October time interval, after a cool April with an average temperature 1.2°C lower compared to the multiannual 65-year average, there is a warming trend in the last month of spring and summer, the months from May to August being characterized as warm.

With a deviation from the average of 3.1°C, June was one of the warmest months in 10 years. In 2022, in Turda, 5 days were recorded with hot temperatures that exceeded 32°C in the second month of summer, influencing maize plants and, of course, the yield obtained.

Also, an alarming increase in temperature was recorded in July, when the average exceeded the multiannual by more than 3°C.

Regarding the rains recorded, June 2022 had, besides the hot temperatures, a lack of rainfall, being characterized as excessively thirsty, at a time when the maize crop has high requirements for water. Climate conditions in 2022 led to a larger gap between the sowing dates experienced, as follows:

- First sowing date (S I): March 30, 2022 when the soil temperature was 4°C;
- Second sowing date (S II): April 14, 2022, when the soil temperature was 6°C;
- Third sowing date (S III): May 2, 2022, when the soil temperature was 8°C;
- Fourth sowing date (S IV): May 17 2022, when the soil temperature was 10°C.



Multiannual air temrepature average (°C)	4.4	10	15	18	19.8	19.5	15.2	9.8
Multiannual average for sum of rainfall (mm)	24.3	45.6	69.4	84.6	78	56.1	42.4	35.4

Figure 4. Temperature and rainfall registered at RDSA Turda in 2022 (March-October)

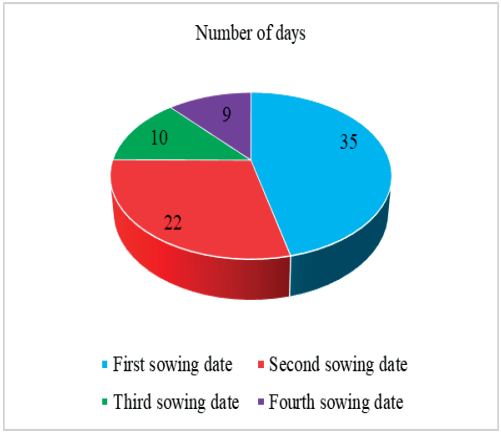


Figure 5. Number of days from sowing to emergence depending on sowing date (RDSA Turda, 2022)

Compared to the optimal sowing date performed when the soil temperature was 8°C, when emergence was noted 10 days after sowing, on average in 2022, maize genotypes needed 35, 22 and 9 days respectively until emergence when they were first sown, the second and fourth sowing dates respectively (Figure 5). The number of days form sowing to emergence varied between: 34-36 in the first sowing date, 21-23 in the second sowing date, 9-10 in the recommended sowing date and between 8-10 days when late sowing was experimented.

Given the year 2022, it would appear that the delay in sowing led to higher yields in the twelve maize hybrids studied compared to the values obtained in the variant in which sowing was practiced at 8°C in the soil (Figure 6). On average, when sown at a temperature of 8°C in the soil, maize achieved a yield of 6773 kg/ha. By practicing delayed sowing an yield increase of 872 kg/ha was obtained. The Turda 380 hybrid stands out, obtaining an yield of 8437 kg/ha when sown at a temperature of 10°C in the soil. We notice how early sowing leads to a significant decrease in maize grain yield, in the case of the Turda 335 hybrid being 3111 kg/ha, when it was sown on March 30, when the soil temperature was 4°C.

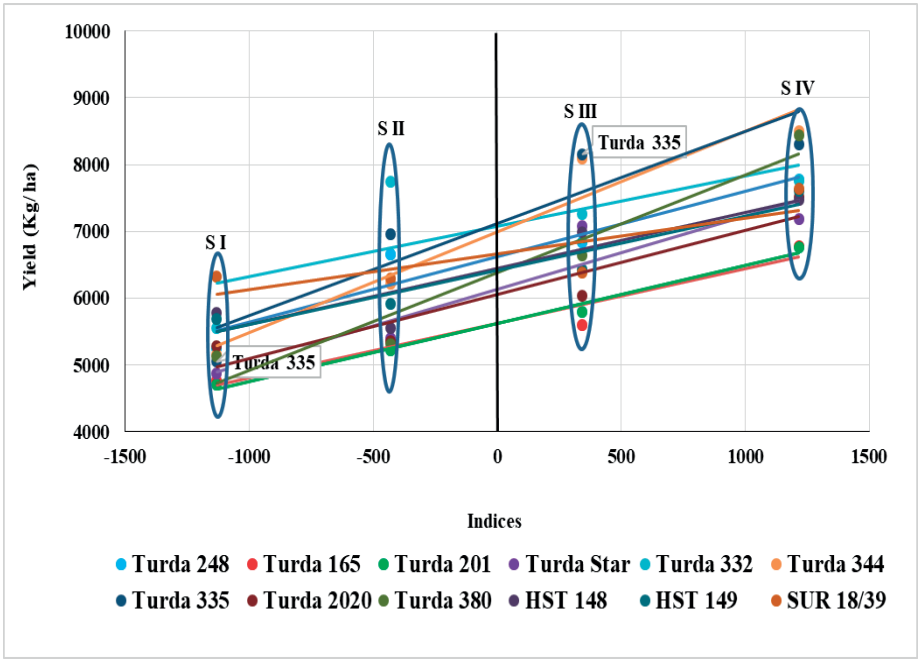
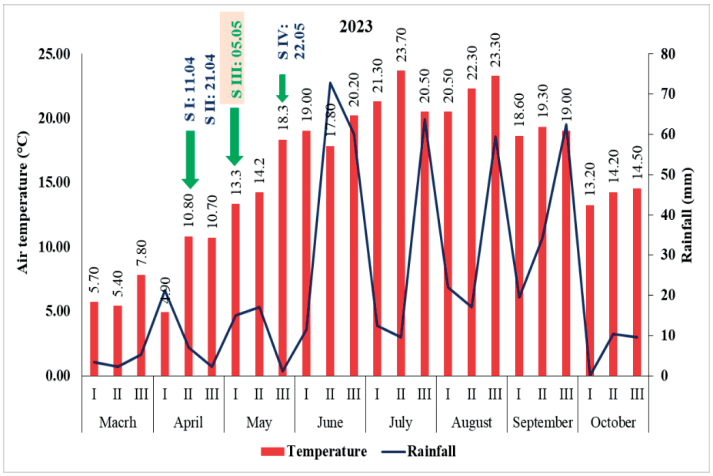


Figure 6. Yield obtained at twelve maize hybrids depending on sowing date (RDSA Turda, 2022)

In Turda, 2023 was a warm year, with an average temperature of 11.4ºC (Figure 7). The average monthly and decadal temperatures of the year show us a warming of the weather throughout the year, except for April when there was a decrease in the average temperature by 1.2ºC compared to the multiannual average. In the first decade of April there was an average temperature of 4.9ºC, much lower than the multiannual average, the month having a cool character. May had, in the first two decades, lower temperature values than the multiannual average, and from the third decade temperatures will increase, so that by the end of the year the average decadal and monthly values will be higher than the 65-year average. Although 2023 was characterized as excessively rainy, rainfall was not evenly distributed throughout the year. In the spring, when water is also important for the maize crop, rainfall was quite low. June was a rainy month, with a surplus of 59.9 mm compared to average, precipitation that also brought the ground water reserve to a higher level, this month being recorded 10 consecutive days in which it rained. In July, although the total amount of precipitation was close to normal, in the first two decades small amounts of precipitation fell, during this period being recorded the highest temperatures. The rainfall at the end of July was beneficial to the plants, which managed to provide a large reserve of water in the soil, from which the plants benefited in the first two decades of August.

In 2023, sowing was practiced as follow:

- First sowing date (S I): April 11, 2023 when the soil temperature was 4°C;
- Second sowing date (S II): April 21, 2023, when the soil temperature was 6°C;
- Third sowing date (S III): May 5, 2023, when the soil temperature was 8°C;
- Fourth sowing date (S IV): May 22. 2023, when the soil temperature was 10°C.



Multiannual air temrepature average (°C)	4.4	10	15	18	19.8	19.5	15.2	9.8
Multiannual average for sum of rainfall (mm)	24.3	45.6	69.4	84.6	78	56.1	42.4	35.4

Figure 7. Temperature and rainfall registered at RDSA Turda in 2023 (March-October)

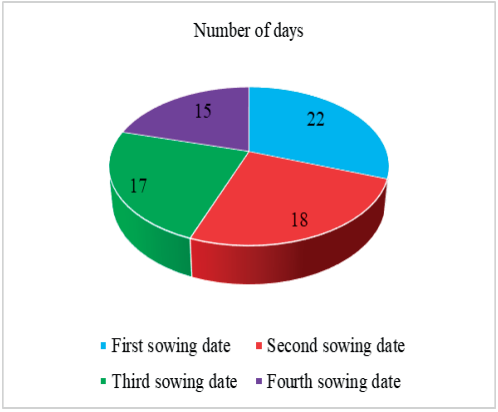


Figure 8. Number of days from sowing to emergence depending on sowing date (RDSA Turda, 2023)

Compared to the other two experimental years, under the conditions of 2023 the number of days from sowing to sunrise was quite close within the four sowing dates, between the first sowing date and the optimal one being a difference of only 5 days (Figure 8).

Compared to the optimal sowing date performed when the soil temperature was 8°C, when emergence was noted 17 days after sowing, on average in 2023, maize genotypes needed 22, 18 and 15 days respectively until emergence when they were first sown, the second and fourth sowing dates respectively. In the climatic conditions of 2023, maize genotypes reacted differently in terms of yields obtained depending on the date of sowing (Figure 9). There is a superiority of yields in genotypes sown in the second date, noting the HST 148 hybrid with a yield of 10720 kg/ha. Sown at 4°C in the climatic conditions of the third year, the Sur 18/39 hybrid achieved a yield of 10736 kg/ha. On average, the yields obtained in the four sowing dates were close, namely: 8330 kg/ha (S I), 9141 kg/ha (S II), 8910 kg/ha (SIII), 8894 kg/ha (S IV).

Based on the results obtained, the quality of maize grains varied slightly depending on the sowing date (Figure 10). Maximum values for fat content (3.51%) and fibre content (2.75%) were obtained, on average, when maize was sown late. While most protein (7.38%) was identified when maize was sown at 6°C in the soil, the maximum starch content (64.22%) was obtained when sowing maize at 4°C.

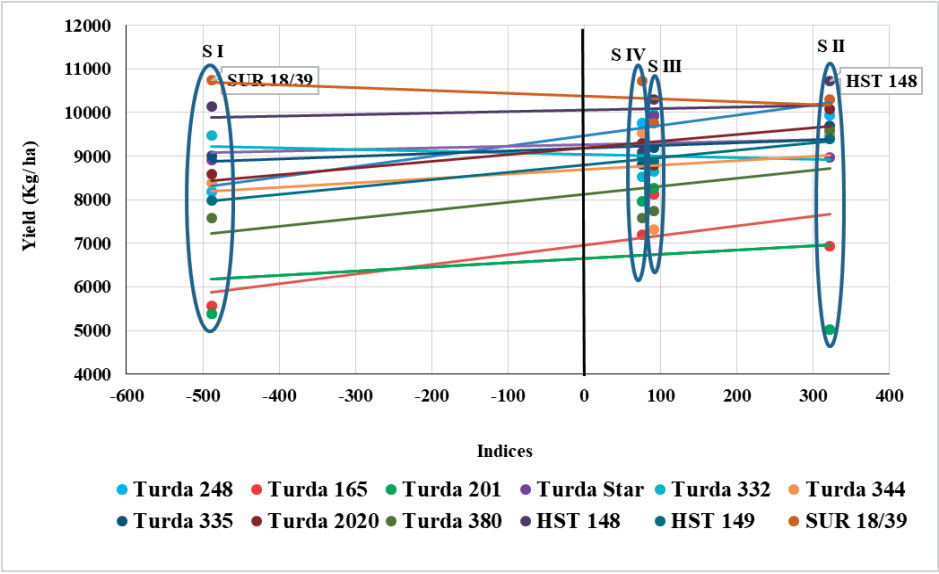


Figure 9. Yield obtained at twelve maize hybrids depending on sowing date (RDSA Turda, 2023)

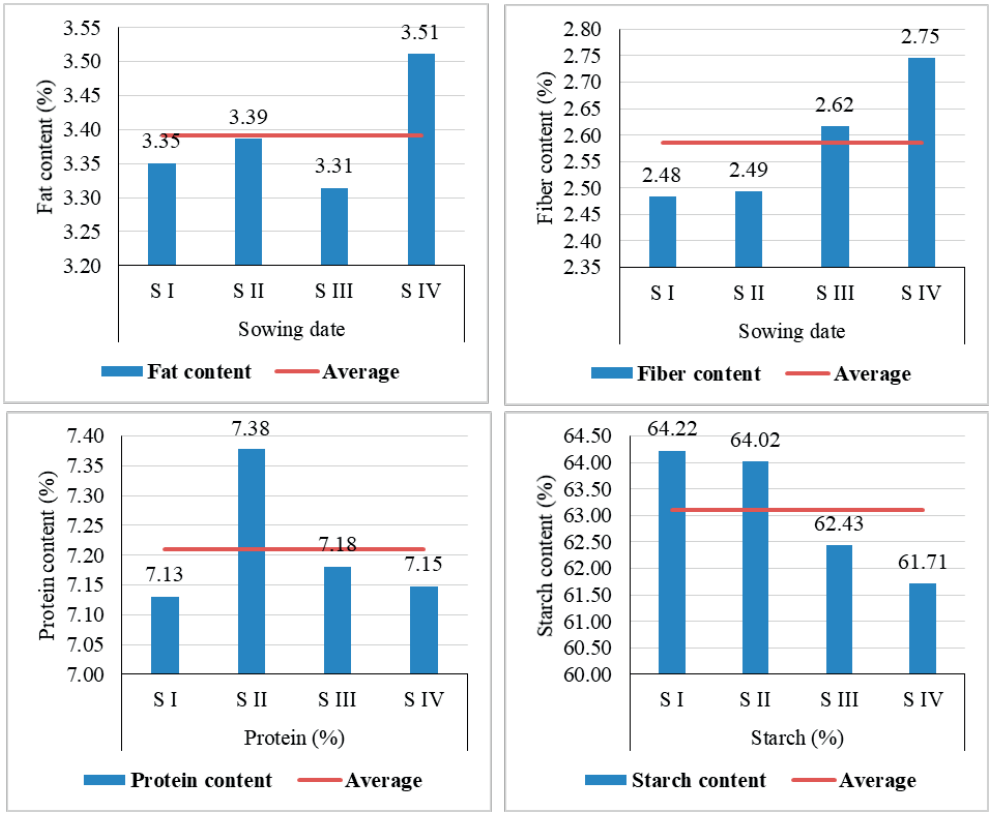


Figure 10. Quality parameters obtained in maize depending on sowing date (RDSA Turda, 2021-2023)

CONCLUSIONS

In general, maize yields were greatly diminished when biological material was sown early, at a soil temperature of 4°C.

The genotypes reacted differently to the 4 sowing dates, depending on the climatological peculiarities of each studied year.

If in the first two years it was obvious the superiority of sowing at temperatures of 8 and 10°C respectively compared to sowing in colder soil, in 2023, the best results were obtained when maize was sown at a temperature of 6°C in the soil.

In 2021, a decrease by almost 2 t/ha and 3 t/ha respectively in yield of Turda 335 hybrid, was obtained when the early sowing variants were experimented compared to sowing on the optimal date.

In the second year, we notice how early sowing leads to a significant decrease in maize grain yield, in the case of the Turda 335 hybrid being 3111 kg/ha, when it was sown on March 30, when the soil temperature was 4°C.

In the third year of experiment, there is a superiority of yields in genotypes sown in the second date, noting the HST 148 hybrid with a yield of 10720 kg/ha.

The number of days form sowing to emergence varied between: 30-32 in the first sowing date, 22-26 in the second sowing date, 13-17 in the optimum sowing date and between 11-14 days when late sowing was experimented.

The number of days form sowing to emergence, in 2022, varied between: 34-36 in the first sowing date, 21-23 in the second sowing date, 9-10 in the recommended sowing date and between 8-10 days when late sowing was experimented.

In terms of quality, similar results were obtained in all experimental variants.

Maximum values for fat content (3.51%) and fibre content (2.75%) were obtained, on average, when maize was sown late. While most protein (7.38%) was identified when maize was sown at 6°C in the soil, the maximum starch content (64.22%) was obtained when sowing maize at 4°C.

Compared to the optimal sowing date performed when the soil temperature was 6°C, when emergence was noted 17 days after sowing, on average in 2023, maize genotypes needed 22, 18 and 15 days respectively until emergence when they were first sown, the second and fourth sowing dates respectively.

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REFERENCES

Anapalli, S. S., Ma, L., Nielsen, D. C., Vigil, M. F., Ahuja, L. R. (2005). Simulating planting date effects on corn production using RZWQM and CERES-Maize models. *Agronomy J, 17*(97). 58–71.

Eberhart, S. and Russell, W. (1966). Stability parameters for comparing varieties. *Crop Sci., 6*. 36–40

Eteng, U. E. (2017). Response of Zn Uptake, Grain and Other Yield Components of Five Maize Hybrids as Influenced by Zinc Fertilization Methods in a Marginal Coastal Plain Sand Soil. *International Journal of Research Studies in Science, Engineering and Technology, 4*(12). 37–46.

Haș, V., Copândean, A., Varga, A., Vana, C., Călugăr, R., Mureșanu, F. (2018). Hibridul de porumb "Turda 344" *An INCDA Fundulea, LXXXVI*. 85–95.

Iken, J. E., Amusa, N.A., Obatolu, V.O. (2002). Nutrient Composition and Weight, Evaluation of some Newly Developed Maize Varieties in Nigeria. *J. Food Technol. in Africa, 7*. 27–29.

Markou, M., Moraiti, C. A., Stylianou, A., Papadavid, G. (2020). Addressing climate change impacts on agriculture: Adaptation measures for six crops in Cyprus. *Atmosphere 11*, 483.

Morris, M. L. (2002). Impacts of International Maize Breeding Research in Developing Countries, 1966-1998, Mexico, D.F.:CIMMYT.

Olaniyan, A.B., Lucas, E.O. (2004). Maize hybrids cultivation in Nigeria-A review. *Journal of Food, Agriculture and Environment, 2*. 177–181.

Popescu, A. (2018). Maize and wheat – top agricultural products produced, exported and imported by Romania. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 18*(3). 339–352.

Popescu, A. (2015). Analysis of the evolution and distribution of maize cultivated area and production in Romania. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 15*(3). 253–259.

Rahimi Jahangirlou, M., Akbari, G. A., Alahdadi, I., Soufizadeh, S., Kumar, U., Parsons, D. (2021). Phenotypic traits, grain yield and yield components of Maize cultivars under combinations of management

practices in semi-arid conditions of Iran. *International Journal of Plant Production, 15*. 459–471.

Scott, M.P., Emery, M. (2016). Encyclopedia of Food Grains second edition, Academic Press.

Seleiman, M. F., Al-Suhaibani, N., Ali, N., Akmal, M., Alotaibi, M., Refay, Y., Dindaroglu, T., Abdul-Wajid, H. H., Battaglia, M. L. (2021). Drought Stress Impacts on Plants and Different Approaches to Alleviate Its Adverse Effects. *Plants, 10*, 259.

Srivastava, R. K., Panda, R. K., Chakraborty, A. (2021). Assessment of climate change impact on maize yield and yield attributes under different climate change scenarios in eastern India. *Ecological Indicators, 120*, 106881.

Subedi, K.D. and Ma, B.L. (2009). "Corn crop production: growth, fertilization and yield," in Agriculture Issues and Policies, ed. A. T. Danforth.

Zakaria, O. E., El-Rouby, M. M., Hemeid, M. M. (2020). Grain quality of maize cultivar Giza 168 as affected by levels of irrigation, sowing date, plant density and macronutrients. *Alex. Sci. Exch. J. 41*. 455–470.

Wang, S., Luo, S., Li, X., Yue, S., Shen, Y., Li, S. (2016). Effect of split application of nitrogen on nitrous oxide emissions from plastic mulching maize in the semiarid Loess Plateau. *Agriculture, Ecosystems & Environment, 220*, 21–27.

https://cornindia.com

https://en.wikipedia.org

https://www.madr.ro/culturi-de-camp/cereale.html