THE INFLUENCE OF SOWING SEASON ON CORN YIELD UNDER THE CONDITIONS OF CURRENT CLIMATE CHANGES

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Abstract:

The purpose of this work is to evaluate the corn production obtained following the change of the sowing date. In the current context of current climate changes, adaptation of cultivation technology is essential to obtain satisfactory quantitative and qualitative results. The experimental factors analyzed in this study are sowing season with three gradations (Season I - 6ºC in soil; Season II - 8ºC in soil; Season III - 10ºC in soil); corn hybrids (Turda 248 – control; Turda 165; Turda 201; Turda Star; Turda 332; Turda 344; Turda 335) and the climatic conditions of the two experimental years (2020; 2021). In 2021, production was lower than in 2020, with 922 kg/ha, the climatic conditions during the vegetation period being the decisive factor in the realization of these productions. All analyzed hybrids recorded a higher average yield when sown at 8ºC (10504 kg/ha), compared to the other two sowing seasons. Among the analyzed hybrids, the Turda 335 hybrid achieved the highest production (10862 kg/ha), 48 kg/ha more than the Turda 248 control.

Key words: *sowing season, corn, yield, climatic conditions*

Classification JEL: *Q01, Q15, Q16*

INTRODUCTION

Obtaining quantitatively and qualitatively stable harvests depends categorically on the climatic conditions, the technologies recommended for the cultivation area and the biological used material.

Our country is affected by rising temperatures and variations in rainfall, there being areas where flooding occurs or experiencing extreme droughts, but also areas where both phenomena meet (Șimon, 2021). Also, the climatic evolution shows variations with large amplitudes, being the factor that negatively influences the level and stability of production (Picu, 2003). Moisture is a limiting factor with consequences for plant growth and distribution when associated with high temperature (Zheng, 2000).

For Romania, the minimum amount of precipitation during the corn vegetation period is 250-300 mm, and optimal between 300-380 mm with the following monthly distribution: 60-80 mm in May, 100-120 mm in June, 100-120 mm in July and 40-60 mm in August (Salontai, 1982).

In our country, corn is one of the most widespread crops, but productions remain low for numerous reasons, among which its expansion on slopes exposed to erosion, with soils poor in nutrients and water, can be noted (Cristea, 2009).

Agricultural crops are responsive to extreme climate events, especially those involving variations in temperature and precipitation. Usually, plants need a definite growth rate (DGR) to reach maturity, depending on the daily temperature and the sowing season (Choudhury et all., 2021). To adapt as quickly as possible to climate change, the population began to take action regarding to agricultural technologies, such as changing the sowing date, optimizing the vegetation period of crops, the use of biological material with tolerance to prolonged drought and high temperatures, etc. (Șimon, 2022).

MATERIAL AND METHOD

The purpose of this paper is to evaluate the corn production obtained following the change in the sowing date, and to achieve the objective, an experience was placed at Agricultural Research Development Station Turda (ARDS Turda) on a clayey epicalcareous cambic para rendzina chernozem type soil (after SRTS 2012). The soil profile has the following physical characteristics: clay-clay texture, the clay between 33,45 and 52,21 mm, fine pores, moderately compact, clear transition from one horizon to the other. As a chemical description, the soil has a slightly alkaline neutral pH, neutral to high humus content, well supplied in nitrogen and potassium, average phosphorus content.

The experimental factors are: Sowing Season with three graduations, Sowing Season I - 6ºC in soil; Sowing Season II - 8ºC in soil; Sowing Season III - 10ºC in soil; corn hybrids Turda 248 – Control; Turda 165; Turda 201; Turda Star; Turda 332; Turda 344; Turda 335, created at ARDS Turda and the climatic conditions of the two experimental years 2020 and 2021.

At sowing, a basic fertilization with 150 kg/ha NPK (20:20:0) was applied, and in the phenophase of 4-6 leaves an additional fertilization with 200 kg/ha CAN (27%). The sowing rate was 70,000 plants/ha. The predecessor plant was winter wheat.

The obtained results were processed statistically by the variance analysis method and establishing the smallest significant difference - LSD - (5%, 1% și 0,1%) (ANOVA, 2015).

Climatic conditions are a determining factor of agricultural production, and the analysis of the evolution of climatic factors is justified in the current context of increasingly visible climatic changes, both globally and in our country. The climatic data presented come from the Turda Weather Station, located on the coordinates: longitude 23°47'; latitude 46°35'; altitude 427 m.

An important aspect regarding the average monthly temperature recorded in recent years is that although the temperatures recorded in recent years indicate a warming of the weather, there are also exceptions that do not have a cyclicity, such as the decrease of temperatures in May (important period in the corn crop), with significant negative deviations of 0,9-1,3ºC from the multi-year average, in conditions where the climate is continuously warming. In the other months,

the temperature values fluctuated from the average, temperatures in the summer months reaching positive deviations of up to 2,9ºC compared to the multiannular average (figure 1).

For a culture dependent on water from rainfall, the rainfall regime and its distribution are vital in plant development and achieving its productivity and quality. In the two years, a deficient water regime was observed in the months of April-May of 2020 and in the months of April and June of 2021, the most pronounced being that of June of 2021.

There is a direct relationship between the rainfall in June and corn yield, which can be observed through the lower productions obtained in 2021, when in June a rainfall deficit of 39.6 mm was recorded (figure 2).

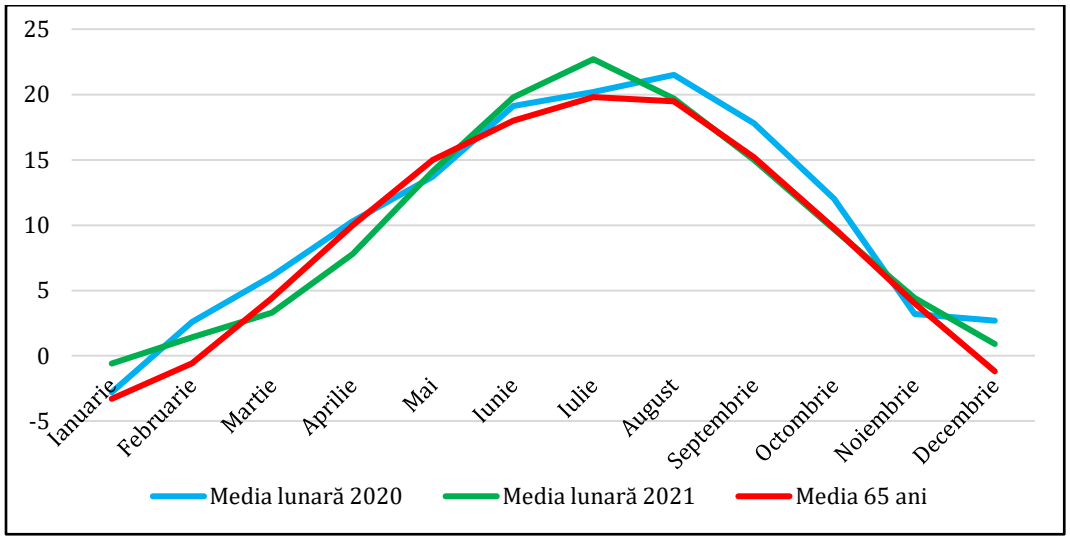

Figure 1. Average monthly temperatures recorded during 2020-2021

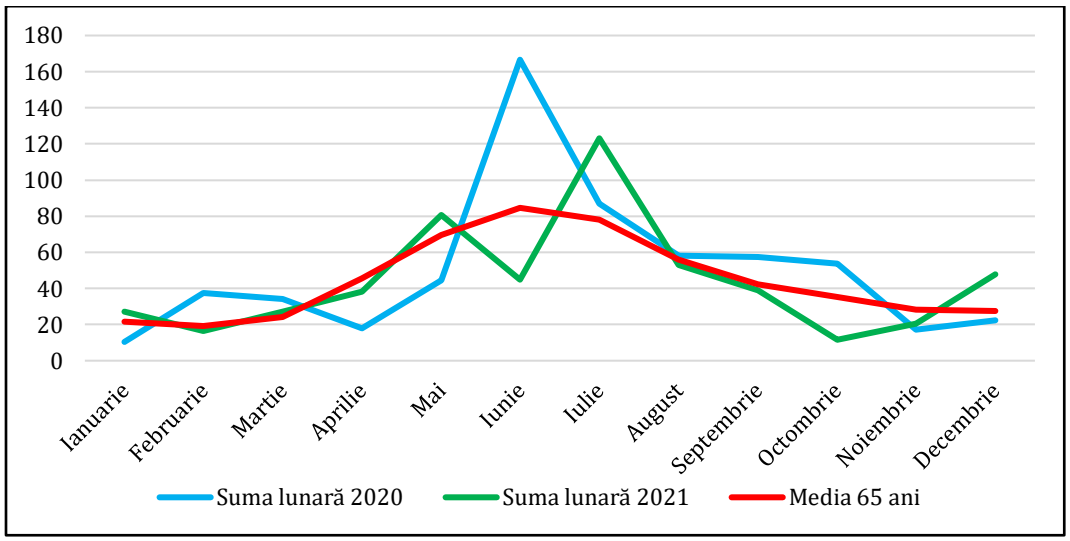

Figure 2. The amount of monthly precipitation recorded in the period 2020-2021

RESULTS AND DISCUSSIONS

The studied hybrids performed very well in terms of tolerance to suboptimal temperatures, all hybrids showing an advanced degree of tolerance to low temperatures, the number of plants per surface unit not being affected, but the temperatures of May, of the two years, which were lower than normal for this period, they affected the growth rate of plants in the first phases of vegetation, slowing the growth process of the plants emergence until that time.

The negative effect of the influence of climatic conditions, from the first part of the vegetation period, was observed in regard to the emergence of culture, thus, in the first season the corn emergence approximately 18-20 days after sowing in the year 2020 and 21-25 days for the year 2021, in the second season, the emergence was noted 20-23 days after sowing for the year 2020 and 12-14 days for the year 2021 and in the third season, emergence was determined 18-19 days after sowing for the year 2020 and 11-13 days for the year 2021 (table 1).

Table 1. Number of days from sowing to emergence

Hybrid	Sowing Season I		Sowing Season II		Sowing Season III	
	2020	2021	2020	2021	2020	2021
Turda 248	20	22	21	12	19	11
Turda 165	18	25	21	13	19	12
Turda 201	20	24	20	13	19	12
Turda Star	19	24	22	13	18	12
Turda 332	19	23	23	14	19	13
Turda 344	19	22	22	14	19	12
Turda 335	20	21	21	14	19	12
Amplitude	18-20	21-25	20-23	12-14	18-19	11-13

Table 2. The sum of useful thermal degrees from sowing to the emergence of plants ($\Sigma t \geq 10^{o}C$)

Hybrid	The sum of useful thermal degrees (°C)					
	Sowing Season I		Sowing Season II		Sowing Season III	
	2020	2021	2020	2021	2020	2021
Turda 248	26.5	27.3	36.8	25.3	51.6	47.3
Turda 165	25.8	32.4	37.4	27.1	53.6	48.6
Turda 201	26.8	30.9	36.3	26.1	51.6	50.0
Turda Star	25.8	30.9	36.8	28.2	49.9	48.6
Turda 332	25.8	28.4	37.9	30.1	53.4	50.2
Turda 344	26.1	27.3	37.4	28.9	53.4	48.6
Turda 335	26.5	25.9	36.8	29.7	53.4	48.6
Amplitudine	25.8-26.8	25.9-32.4	36.3-37.9	25.3-30.1	49.9-53.6	47.3-50.2

During the growing season, average temperatures below 10ºC are considered inactive temperatures, which does not help the optimal development of the metabolic processes of corn, therefore only average daily temperatures exceeding 10ºC are used for this study.

Even if the number of days from sowing to emergence was greater, the fact that in the spring of the two years the average temperatures were lower than normal led to a different sum of the useful thermal degrees for the three sowing season of the two years, thus in 2020 the sum of the degrees had an amplitude of 25.8-26.8ºC for sowing season I, of 36.3-37.9ºC for sowing season II and of 49.9-53.6ºC for sowing season III. In the year 2021 the amplitude of the sum of degrees was higher for sowing season I (25.9-32.4ºC) and lower for Sowing Season II (25.3-30.1ºC) and III (47.3-50.2ºC) compared to 2020 (table 2).

Climatic conditions during the vegetation period of the crop are the most important factor in achieving production, the accumulation of an amount of precipitation of 413.2 mm between May and September makes 2020 a favorable year for obtaining an average production of 10343 kg/ha, with a distinctly significant difference of 922 kg/ha compared to 2021, in which the amount of precipitation during the vegetation period was 340.9 mm (table 3).

Due to a higher rainfall regime during the growing season, the average production value for cultivated hybrids is higher in 2020, as he also states Wang et all., in 2014, precipitation is the dominant climatic factor in achieving maize production.

The water available to plants in the surface layer is in reality much lower than the calculated value, because for the most part it is subject to the process of evaporation from the soil surface and decreases with increasing temperature, having a direct effect on the production achieved.

Table 3. Influence of climatic conditions on corn yield

Experimental Year	Yield		Diference (kg/ha)	Signifiance
	kg/ha	%		
2020 (Control)	10343	100	0	Control
2021	9421	91	-922	00
LSD (p 5%) 317	LSD (p 1%) 732		LSD (p 0,1%) 1329	

Of the 3 sowing seasons, in the sowing season in which corn was sown at 8ºC, temperature recorded in the soil, the highest production was achieved (10504 kg/ha), with a very significant difference of 272 kg/ha from optimal sowing season for the Transylvanian Plateau, considered control (10ºC in the soil), and the smallest increase in production was achieved at the time of sowing season when sowing was executed at 6ºC in the soil, with a very significant difference of 1321 kg/ha compared to the Control, where a production of 10231 kg/ha was obtained (table 4).

Changing the sowing date can also have an effect on the life cycle of specific pests and the manifestation of the attack produced by them, in research conducted by Obopile et all., (2008) in a study of corn sown at different seasons, corn sown later was found to have a higher degree of pest attack.

In our country, sowing in different periods was taken into account to avoid periods of water and heat stress that usually coincide with critical periods for crops, but sowing too early can lead to crop losses because as stated Mhizha et all., in 2012, critical growth stages may coincide with periods of extended mid-season drought, but also with the low spring temperatures.

Araya et all., 2017 hypothesize that the shortening of the maize vegetation period (reducing days to maturity with 9-18%) due to high temperatures, it could cause production to decrease by an average of 18-33%.

Table 4. Influence of sowing season on corn yield

Sowing Season	Yield		Diference (kg/ha)	Significance
	kg/ha	%		
Sowing Season III (10ºC in soil) (Control)	10232	100	0	Control.
Sowing Season I (6ºC in soil)	8911	87	-1321	000
Sowing Season II (8ºC in soil)	10504	103	272	***
LSD (p 5%) 90	LSD (p 1%) 131		LSD (p 0,1%) 197	

The grain yield achieved in 2020-2021, among the hybrids studied, the hybrid Turda 335 stood out, which achieved an average yield of 10862 kg/ha (in two experimental years and three different sowing season), the difference of 48 kg/ha compared to Control (hybrid Turda 248) being without statistically significance. An average production of 10653 kg/ha was recorded for the hybrid Turda 344, with a difference of -160 kg/ha compared to the Control, with statistically significant difference. The other hybrids analyzed did not match the yield value recorded by the Control, very significant differences in their production being included between 627 kg/ha (Turda 332) and 2274 kg/ha (Turda 201) (table 5).

Table 5. Yield achieved by corn hybrids grown in different seasons

Hybrid	Yield		Diference (kg/ha)	Significance
	kg/ha	%		
Turda 248 (Control)	10814	100	0	Control.
Turda 165	8822	82	-1992	000
Turda 201	8539	79	-2274	000
Turda Star	9299	86	-1515	000
Turda 332	10187	94	-627	000
Turda 344	10653	99	-160	0
Turda 335	10862	100	48	-
LSD (p 5%) 138	LSD (p 1%) 184		LSD (p 0,1%) 238	

The average productions obtained in the two years of research show us that the hybrids Turda 248, Turda Star and Turda 344 achieved the highest productions when the sowing was

carried out in the second sowing season (at 8ºC in soil), the differences from the third sowing season (at 10ºC in soil), considered Control, were highly significant.

The behavior of all the hybrids sown in the first sowing season (at 6ºC in the soil) was not very good, yield differences from the Control being statistically assured as highly significantly negative, only the Turda 335 hybrid registering a significant negative difference compared to the third sowing season. The Turda 201 hybrid registered very significant yield declines in the two sowing season (I and II) compared to sowing season III, yield differences being between 443 and 887 kg/ha.

The most important yield reductions were observed in corn hybrids Turda 165 (-1207 kg/ha), Turda Star (-1287 kg/ha), Turda 332 (-1378 kg/ha), Turda 335 (-2948 kg/ha) when where cultivated in the first sowing season (table 6).

Table 6. Influence of sowing season and hybrid interaction on corn yield

Hybrid	Yield		Diference (kg/ha)	Signifiance
	kg/ha	%		
Sowing Season III* x Turda 248 (Control)	10669	100	0	Control
Sowing Season I** x Turda 248	10126	95	-543	000
Sowing Season II*** x Turda 248	11647	109	978	***
Sowing Season III x Turda 165 (Control)	9172	100	0	Control
Sowing Season I x Turda 165	7966	87	-1207	000
Sowing Season II x Turda 165	9327	102	155	-
Sowing Season III x Turda 201 (Control)	8983	100	0	Control
Sowing Season I x Turda 201	8096	90	-887	000
Sowing Season II x Turda 201	8539	95	-443	000
Sowing Season III x Turda Star (Control)	9545	100	0	Control
Sowing Season I x Turda Star	8259	87	-1287	000
Sowing Season II x Turda Star	10092	106	547	***
Sowing Season III x Turda 332 (Control)	10622	100	0	Control
Sowing Season I x Turda 332	9244	87	-1378	000
Sowing Season II x Turda 332	10694	101	72	-
Sowing Season III x Turda 344 (Control)	10697	100	0	Control
Sowing Season I x Turda 344	9697	91	-1000	000
Sowing Season II x Turda 344	11566	108	870	***
Sowing Season III x Turda 335 (Control)	11935	100	0	Control
Sowing Season I x Turda 335	8987	75	-2948	000
Sowing Season II x Turda 335	11664	98	-271	0
LSD (p 5%) 239	LSD (p 1%) 322		LSD (p 0,1%) 426	

* Sowing Season III (10ºC in soil) **Sowing Season I (6ºC in soil) *** Sowing Season II (8ºC in soil)

Yield losses by changing the sowing period can reach up to 25%, when sowing is in the first season and up to 9% in the case of sowing in the third season, depending on the biological material used. Soler et all., (2007) reported a 55% yield loss in four corn hybrids due to seeding delay, in pluviometric conditions, without irrigation. Liaqat et all., (2018) also recorded a reduction in grain yield in corn hybrids, produced by delayed sowing.

CONCLUSIONS

Climatic conditions as well as biological material have a significant influence on production, by achieving higher pluviometric conditions, the yield of corn in 2020 registered a distinctly significant increase in production of 922 kg/ha, compared to 2021. The biological material performed well in all experimental variants, but the Turda 335 hybrid made the best use of the environmental conditions encountered in the variant where the corn was sown at 10ºC.

Changing the sowing season has an influence on the development of the corn crop, especially by the fact that in recent years spring temperatures have been lower than the multiannual average, and the corn crop failed to develop properly in the first part of the growing season.

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