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EVALUATION OF THE IMPACT OF SOWING SEASON AND WEATHER CONDITIONS ON MAIZE YIELD

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Abstract

Climate change has become the biggest global challenge to agriculture and food production. In the context of current environmental changes, the aim of this study is to identify the optimal sowing season that leads to obtaining high and constant yields. The study followed the reaction of 7 native maize hybrids to cultivation in 3 different sowing seasons, over a period of 3 years. The data obtained show us that the best yield results are obtained on mid-early hybrids (9327-9843 kg/ha). Sowing maize too early, are obtained lower yields than for maize sown at 10ºC in the soil, with a very significant difference of 1337 kg/ha. Favorable climatic conditions in 2020 and 2021 emerge from the average yields obtained in the two years, 10343 kg/ha (2020) respectively 9424 kg/ha (2021). The climatic conditions of 2022 were less favorable, summer drought having a negative effect on average maize yield, which was 6924 kg/ha.

***Key words**: sowing season, maize hybrids, yields, climate change.*

INTRODUCTION

Climate change has become the biggest global challenge, causing problems in crop development and yield, leading to threats to food security for the growing population (Bennetzen et al., 2016).

Considering the importance of agriculture in the global economy and food, the response of plants to climate change is and will be studied through different approaches.

Maize is a cereal with a high production capacity, but also with a wide spread area, being less influenced by climate change, having a high resistance to drought, heavy rains, diseases and pests, with an accessible technology, agrotechnical and harvesting works being able to be fully mechanized (Haș et al., 2018). In Romania, maize is the most extensive crop (Popescu, 2018), with a use in human and animal nutrition, that is why it is necessary to consider the achievement of a balance between the production capacity in the choice of corn hybrids and grain quality indicators (Scott et al., 2006).

It is considered a drought-resistant plant, but it responds differently to water deficit depending on the stages of development (Cakir, 2004). From sowing to harvesting, maize is subjected to many stress factors, both biotic and abiotic, these factors together make up an ecosystem (Popa et al., 2021).

For the maize crop, the following phases are distinguished as critical for water: the sprouting phase - ripening in milk-wax (7-10 days before sprouting, 10-20 days after flowering) (Botzan, 1966). Moisture stress occurring at critical growth stages (anthesis and grain filling) causes yield losses in maize (Basir et al., 2018).

The most critical period of corn for water stress is 10 to 14 days before and after flowering, with grain yield reduced two to three times more when water deficit coincides with flowering compared to other growth stages (Grant et al., 1989).

Crop production is influenced by weather effects and agrotechnical conditions, so its variability can be difficult to predict (Doré et al., 1998; Marin et al., 2012; Rusu, 2014), but by using high-yielding biological material, sowing at the right moment and using advanced agricultural practices it can be increased to a certain extent (Qureshi et al., 2007).

Each plant species has a certain temperature threshold necessary to start the activity, for maize the basic temperature is 10ºC (Rao Prasada, 2008), following that it will grow with the development of the plants and the progress in the vegetation. During the vegetation period, the temperature required by maize is between 10

and 30ºC, temperatures lower or higher than these thresholds can have negative effects on crop development.
According to the data of the National Meteorological Agency (ANM), the evolution of the heat intensity in Romania, during 1961-2010, shows an upward trend, which started in 1981, a trend that continues today (Sin & Popescu, 2015).
Seeding of the maize crop earlier than 10ºC soil temperatures may be limited by cooler soil temperatures and soil moisture conditions (Kucharik, 2008), the emergence and normal development of plants can be affected by soil and climate conditions.
Climatic changes, especially the increase in temperatures and the lack of precipitation, during the period of the formation of reproductive organs are the main cause leading to significant production losses, the adaptation of agricultural technologies being among the most accessible methods of reducing the impact of global warming on the structure of agricultural plants.
Climatic variability and unfavorable spring conditions mean that farmers to cannot sow at the optimal moment every year, there is a need to study the reaction of the maize crop to different sowing dates (season) in order to identify when maize can be sown without suffering large production losses.
Considering these aspects, the aim of the work is to study the behavior of some native corn hybrids when changing some technological elements (sowing season) as well as the interaction of these factors on the corn culture.

MATERIALS AND METHODS

The research has been developed during 2018-2021, at the Turda Agricultural Research and Development Station, on a type soil chernozem, characteristic to Transylvanian Plateau. As a chemical description, the soil has a weakly alkaline neutral pH, neutral to high humus content, well supplied in nitrogen and potassium, medium supplied in phosphorus.
In order to achieve the proposed objectives, a bifactorial experiment was organized, with the following factors: factor A - sowing season with three graduations: sowing season I - when 6ºC are recorded in the soil for three consecutive days; sowing season II - when 8ºC are recorded in the soil for three consecutive days; sowing season III - when 10ºC are recorded in the soil for three consecutive days; factor B - maize hybrids with seven graduations: Turda 248 (FAO 300); Turda 165 (FAO 270); Turda 201 (FAO 340); Turda Star (FAO 370); Turda 332 (FAO 380); Turda 344 (FAO 380); Turda 335 (FAO 380); factor C - climatic conditions in the experimental years: 2020; 2021 and 2022.
At sowing, was executed a fertilization with 150 kg/ha NPK (20:20:0), and in the phenophase of 4-6 leaves an additional fertilization with 200 kg/ha CAN (27%). The sowing density 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% and 0.1%) (ANOVA, 2015).
Climatic conditions are one of the most important factors that influenced the productivity of an agricultural crop, an analysis of climate factors being justified in the context in which climate change has become a global problem. The climatic data presented come from the Turda Weather Station, located on the coordinates: longitude 23º47'; latitude 46º35'; altitude 427 m.
Although there is an annual increase in the average temperature, in the spring it is observed that the temperatures are lower than normal, which leads to a slower warming of the soil and indirectly to the delay in the moment when agricultural crops can be sown under suitable conditions.
With the beginning of summer, important increases in temperature are observed, temperatures that are not beneficial to agricultural crops, especially in periods when low amounts of precipitation are recorded. The most important increases for the average temperature are found in the period June-July, with up to 3.3ºC deviation from the normal of the period (Table 1).
The rainfall regime of the three years was variable, with a deficit of precipitation in the periods when the crop has the highest consumption (July), the most important lack of precipitation being observed in 2022, while in June and July the total was 67.3 mm, less than half the normal amount for this period (Table 2).

Table 1. Average air temperature during the period 2020-2022

Experimental years	Average air temperature (ºC)						
	Month/decade	April	May	June	July	August	September
2020	Decade I	8.7	12.1	17.4	20.9	22.9	19.1
	Decade II	11	16.5	19.2	18.4	20.6	19.3
	Decade III	11.1	12.5	20.8	21.1	21	15.1
	Monthly average	10.3	13.7	19.1	20.2	21.5	17.8
	Average 65 years	10.0	15.0	18.0	19.8	19.5	15.2
2021	Decade I	5.9	12.8	16.9	21.6	21.5	15.9
	Decade II	7.8	14.3	18.6	24.0	21.2	17.1
	Decade III	9.8	15.1	23.9	22.4	16.7	12.1
	Monthly average	7.8	14.1	19.8	22.7	19.7	15.0
	Average 65 years	10.0	15.0	18.0	19.8	19.5	15.2
2022	Decade I	7.4	14.7	20.4	23.0	23.0	17.0
	Decade II	7.6	16.9	20.1	21.2	22.5	14.1
	Decade III	11.4	17.1	22.9	24.9	21.4	11.9
	Monthly average	8.8	16.3	21.1	23.1	22.3	14.3
	Average 65 years	10.0	15.0	18.0	19.8	19.5	15.2

Table 2. The amount of precipitation for the period 2020-2022

Experimental years	Rainfall (mm)						
	Month/decade	April	May	June	July	August	September
2020	Decade I	0	10.2	16	23	3.6	6.6
	Decade II	0.8	11.2	115	51.6	53.6	0
	Decade III	17	23	35.6	12.2	0.8	50.8
	Monthly average	17.8	44.4	166.6	86.8	58	57.4
	Average 65 years	45.6	69.4	84.6	78.0	56.1	42.4
2021	Decade I	8.1	4.4	7.2	56.7	7.4	1.5
	Decade II	18.5	32.2	25.6	63.9	7.5	11.0
	Decade III	11.8	44.2	12.2	2.5	38.0	26.6
	Monthly average	38.4	80.8	45.0	123.1	52.9	39.1
	Average 65 years	45.6	69.4	84.6	78.0	56.1	42.4
2022	Decade I	10.6	14.5	14.1	23.1	27.6	69.9
	Decade II	1.5	24.2	27.1	0.2	1.2	32.3
	Decade III	30.4	44.2	0.6	1.9	65.8	17.7
	Monthly average	42.5	82.9	41.8	25.2	94.6	119.9
	Average 65 years	45.6	69.4	84.6	78.0	56.1	42.4

RESULTS AND DISCUSSIONS

Temperature is an important environmental agent that influence the rate of growth and development of maize plants. Sowing maize at temperatures lower than 8-10ºC can lead to significant production decreases, following the results obtained in the period 2020-2022, for the maize crop sown at 6ºC in the soil, it is observed that the production decreased by 14% compared to the sowing season of 10ºC in the soil (Table 3).

Maize plants developed in conditions where the temperatures are lower immediately after emergence grow more difficult, and at very low temperatures they fail to assimilate the nutrients, having to go through a longer time to form each individual leaf.

As Parker et al. (2016) also state, very early planting increases the likelihood of poor seeding conditions due to cold, wet soils, resulting in a negative impact on plant emergence, but other authors such as Coelho et al. (2021) hypothesized that adjusting the sowing date is an effective strategy for mitigating the adverse effects of climatic factors by optimizing the climatic conditions during the crop growth period. Norwood (2001) stated that the yield of maize sown in early May is higher than that of maize sown in April. Some authors state that a longer growing season due to earlier sowing of the crop allows greater utilization of resources such as solar radiation, water and nutrients (Andrade et al., 2000; Tsimba et al., 2013), but other authors say that when corn is sown outside the optimal season, yield decreases are observed

(Zhou et al., 2017), as it happened in present research (-1337 kg/ha compared to the control). In addition to the genetic factor, culture technologies adapted to regional ecological conditions can make an important contribution to limiting production losses (Popa et al., 2021), but which can be variable depending on the environmental conditions during the vegetation period.

Table 3. The influence of the sowing season on maize yield

Experimental variant	Yield kg/ha	%	+/- (kg/ha)	Significance
Sowing season III (control variant)	9351	100	0	c.v.
Sowing season I	8014	86	-1337	000
Sowing season II	9327	100	-24	-
LSD (p 5%)	*77*			
LSD (p 1%)	*127*			
LSD (p 0.1%)	*238*			

The all seven analyzed hybrids behaved differently during the studied period, although they belong to close maturity groups, the highest productions are recorded in hybrids Turda 248, Turda 332, Turda 344 and Turda 335 (Table 4). Following the results obtained in the three years of study, we can state that the mid-early hybrids capitalize very well on the environmental conditions, the yields results being higher than those of the other hybrids, by up to 20-25%, a fact observed in 2022 and by Haș et al., which states that after the year 2000, the sum of the active temperatures during the corn vegetation period increased constantly, exceeding the multiannual average, the mid-early maize hybrids fully exploiting the area's thermal resources.

Environmental conditions during the growing season did not negatively influence the number of emerged plants per unit area, even if lower temperatures were recorded in the first part of the growing season, as observed by Domokos et al. (2022), early sowing did not reduce the percentage of plants that emerged compared to the optimal sowing date, but it influenced the dynamics of emergence, as that it increased the number of days with suboptimal temperatures.

Table 4. Average yield of maize hybrids sown in the three sowing seasons

Experimental variant	Yield kg/ha	%	+/- (kg/ha)	Significance
Average (control variant)	8897	100	0	c.v.
Turda 248	9570	108	673	***
Turda 165	7851	88	-1046	000
Turda 201	7667	86	-1230	000
Turda Star	8384	94	-513	000
Turda 332	9327	105	430	***
Turda 344	9637	108	740	***
Turda 335	9843	111	946	***
LSD (p 5%)	*125*			
LSD (p 1%)	*167*			
LSD (p 0.1%)	*220*			

Variation in environmental conditions during the growing season can have a major effect on yield, factors such as water stress, heat or lack of nutrients during the growing season can reduce grain yield, a fact also observed by Edmeades et al., in the year 2000, however, the response to stress depends on the intensity, duration of exposure to stress and the stage of development of the culture as observed by Wajid et al. (2004), following to his executed experiences.

Important stages in a crop's development may coincide with extended mid-season drought periods, which have become a frequent occurrence in recent times, resulting in a reduction in biomass production and yield, as also observed by Raes et al. (2006).

As Hanif & Ali (2014) state, the change in the rainfall regime concurrently with the increase in temperatures during the summer is expected in the future, and by changing the sowing date, an attempt is made to avoid the interaction of the two meteorological phenomena during the vegetation period with maximum humidity requirements, with in order to reduce production losses.

The increase in temperature associated with the lack of precipitation in the summer of 2022 influenced the acceleration of the growth processes and implicitly the reduction of the period of accumulation of reserve substances in the grain, which lead to the reduction of the yield, the difference in production achieved in 2022 being -1973 kg/ha compared to the average of the three years studied and -3419 kg/ha compared to 2020, the year when the highest average yield of the analyzed hybrids was achieved (Table 5).

Using combined empirical forecasting models, Tigchelaar et al. (2018) showed that maize production may decrease by 20-40% and 40-60%, respectively if the temperature increases by 2 and 4ºC.

The climatic conditions of the first two years met the water and heat requirements for maize so that the average yield achieved by the seven hybrids was between 9424 and 10343 kg/ha, with a difference between 6 and 16 percent compared to the average of the years.

Table 5. The average production of maize obtained during the period 2020-2022

Experimental variant	Yield		+/-	Significance
	kg/ha	%	(kg/ha)	
Average years (control variant)	8897	100	0	c.v.
2020	10343	116	1446	***
2021	9424	106	527	***
2022	6924	78	-1973	000
	LSD (p 5%)	*74*		
	LSD (p 1%)	*98*		
	LSD (p 0.1%)	*126*		

It is known that plants need light, water and heat to grow, the requirements being different from one species to another, for maize, it needs a warm soil to germinate and grow (Bunting, 1968), corn growth at temperatures below 10ºC being slow (Lehenbauer, 1914), but from our experiment it can be seen that the seven analyzed hybrids recorded average yields between 7095 (hybrid Turda 165) and 8967 kg/ha (Turda 248) as it the maize was sown at a temperature of 6ºC in the soil, satisfactory yields obtained that the highest yield was of 8375 kg/ha (Turda 165) and 10041 kg/ha (Turda 248) in the period they were sown at 10ºC (optimal temperature in the soil) or 8ºC in the soil (Table 6).

In similar studies Baum et al (2018) observed that in early sowing seasons there are yield increases in late maturing hybrids compared to early and mid-early hybrids. From the interaction of the two factors it is observed that the hybrids from the FAO 380 group as well as the hybrid Turda 248 records the highest yields in all three sowing seasons, with statistically significant differences compared to the control.

Following the analysis executed on the effect of the interaction between the studied hybrids and the three sowing seasons, we can state that the genotypes behave differently in similar environmental conditions, the yields differences between the experimental variants being quite high. Maize is a thermophilic plant, with different temperature requirements depending on the vegetation stage of the plant, from 10ºC in the soil during the germination-emergence period and up to a maximum of 30ºC, the completion of the development stages in optimal conditions being limited many times of the potential of biological material to adapt to variations in temperature and precipitation.

The studied hybrids are adapted to the climatic conditions of the Transylvanian Plateau and have a good tolerance to the low temperatures in the first part of the vegetation period, their development following earlier sowing not being greatly affected by the low temperatures, only needing a larger number of days to go through the development stages.

Table 6. Influence of interaction between hybrids and sowing season on maize yield

Experimental variant	Yield kg/ha	%	+/- (kg/ha)	Significance
Average (control variant)	8014	100	0	c.v.
Turda 248 x Sowing season I	8967	112	953	***
Turda 165 x Sowing season I	7095	89	-919	000
Turda 201 x Sowing season I	7135	89	-878	000
Turda Star x Sowing season I	7308	91	-705	000
Turda 332 x Sowing season I	8743	109	730	***
Turda 344 x Sowing season I	8538	107	524	***
Turda 335 x Sowing season I	8309	104	296	**
Average (control variant)	9327	100	0	c.v.
Turda 248 x Sowing season II	10041	108	715	***
Turda 165 x Sowing season II	8084	87	-1243	000
Turda 201 x Sowing season II	7623	82	-1703	000
Turda Star x Sowing season II	9087	97	-240	0
Turda 332 x Sowing season II	9549	102	222	*
Turda 344 x Sowing season II	10407	112	1080	***
Turda 335 x Sowing season II	10496	113	1169	***
Average (control variant)	9351	100	0	c.v.
Turda 248 x Sowing season III	9702	104	351	***
Turda 165 x Sowing season III	8375	90	-976	000
Turda 201 x Sowing season III	8243	88	-1109	000
Turda Star x Sowing season III	8758	94	-594	000
Turda 332 x Sowing season III	9689	104	338	***
Turda 344 x Sowing season III	9967	107	616	***
Turda 335 x Sowing season III	10725	115	1374	***
	LSD (p 5%)	*196*		
	LSD (p 1%)	*260*		
	LSD (p 0.1%)	*335*		

From the material selected for this experiment, the hybrids Turda 248, Turda Star and Turda 344 are noted, which register very significant and distinctly significant increases in production when they are sown at a temperature of 8ºC in the soil.

For the Turda 201 hybrid is not recommended for sowing below the temperature of 10ºC in the soil, the productions achieved with these variants having low values compared to the control, with statistically assured differences as very significant (Table 7).

Following the results obtained, Nagy (2009) finds that due to the distribution of Precipitation during the vegetation period, the change of the sowing season has no influence on the performance of the hybrids, but the results obtained by Tahir et al. (2008) show us that between the maize hybrids cultivated in different sowing season there are significant yields differences.

Table 7. Influence of the interaction between sowing season and hybrids on maize yield

Experimental variant	Yield kg/ha	%	+/- (kg/ha)	Significance
Sowing season III x Turda 248 (control variant)	9702	100	0	c.v.
Sowing season I x Turda 248	8967	92	-735	000
Sowing season II x Turda 248	10041	104	339	**
Sowing season III x Turda 165 (control variant)	8375	100	0	c.v.
Sowing season I x Turda 165	7095	85	-1280	000
Sowing season II x Turda 165	8084	97	-291	0
Sowing season III x Turda 201 (control variant)	8243	100	0	c.v.
Sowing season I x Turda 201	7135	87	-1107	000
Sowing season II x Turda 201	7623	93	-619	000
Sowing season III x Turda Star (control variant)	8758	100	0	c.v.
Sowing season I x Turda Star	7308	84	-1449	000
Sowing season II x Turda Star	9087	104	329	**
Sowing season III x Turda 332 (control variant)	9689	100	0	c.v.
Sowing season I x Turda 332	8743	90	-946	000
Sowing season II x Turda 332	9549	99	-140	-
Sowing season III x Turda 344 (control variant)	9967	100	0	c.v.
Sowing season I x Turda 344	8538	86	-1429	000
Sowing season II x Turda 344	10407	104	440	***
Sowing season III x Turda 335 (control variant)	10725	100	0	c.v.
Sowing season I x Turda 335	8309	78	-2415	000
Sowing season II x Turda 335	10496	98	-229	0
LSD (p 5%)	*213*			
LSD (p 1%)	*292*			
LSD (p 0.1%)	*404*			

CONCLUSIONS

The obtained results reveal the fact that early sowing in the climatic conditions of the Transylvanian Plateau, even if it manages to avoid the negative impact of the stress factors during the vegetation period, does not manage to bring a benefit of yields, the average yields recorded when crop is sow at 6ºC in the soil are only being significantly lower than those obtained in the other two sowing season.

Sowing maize at a soil temperature of 8ºC can be an alternative option for sowing maize, some of the studied hybrids registering slightly higher yields compared to those obtained in the variant when sowing was executed at 10ºC temperature in soil

The modification of certain technological steps in order to achieve satisfactory yields can be a method of adaptation to climate change if the requirements of the plants for biological factors are respected.

Since weather conditions are not easy to predict and their effect on agriculture can be devastating, it is necessary to draw up sustainable management strategies in order to adapt to future climate changes.

REFERENCES

Andrade, F., Otegui, M., Vega, C. (2000). Intercepted radiation at flowering and kernel number of maize. *Agron. J.*, *92*: 92-97.

Baum, M. E., Archontoulis, S. V., Licht, M. A. (2018). Planting date, hybrid maturity, and weather effects on maize yield and crop stage. *Agron. J.*, *111*, 303–313.

Basir, A., Aziz, A., Khan, M., Khan, I. (2018). Phenology and growth traits response of maize (*Zea mays* L.) genotypes to semi-arid conditions. *Pure Appl. Biol*., *2*, 169-173.

Bennetzen, E. H., Smith, P., Porter, J. R. (2016). Agricultural Production and Greenhouse Gas Emissions from World Regions-The Major Trends over 40 Years. *Glob. Environ. Chang*., *37*, 43–55.

Botzan, M. (1966). *Culturi irigate*. Ed. Agro-Silvică, București.

Bunting, E. S. (1968). The influence of date of sowing on development and yield of maize in England. *J. Agric. Sci*., *71*, 117-125.

Cakir, R. (2004). Effect of water stress at different development stages on vegetative and reproductive growth of corn. *Field Crops Research*, *89*(1), 1-16.

Coelho, A. E., Sangoi, L., Junior, A., Fioreze, S. L., Junior, M. (2021). Growth patterns and yield of maize (*Zea mays* L.) hybrids as affected by nitrogen rate and sowing date in southern Brazil. *Crop Pasture Sci.*, *71*, 976-986.

Domokos, Z., Lobonțiu, I., Șimon, A., Duda, M. M., Ceclan, O. A. (2022). Results of the research on the influence of sowing date on the chemical composition of maize grain at RDSCB Tg. Mureș. *Life Science and Sustainable Development-Journal*, *Vol. 3*, No. 2: 41-48.

Doré, T., Meynard, J. M., Sebillotte, M. (1998). The role of grain number, nitrogen nutrition and stem number in limiting pea crop (*Pisum sativum*) yields under agricultural conditions. *Eur. J. Agron*., *8*: 29-37.

Edmeades, G. O., Bolaños, J., Elings, A., Ribaut, J. M., Bänziger, M., Westgate, M. E. (2000). The role and regulation of the anthesis-silking interval in maize. M. Westgate K. Boote editors, Physiology and modeling kernel set in maize. CSSA Spec. Publ. 29, CSSA and ASA, Madison, 43-73.

Grant, F. R., Jackson, B. S., Kiniry, J. R., Arkin, G. F. (1989). Water deficit timing effects on yield components in maize. *Agronomy Journal, 81*: 61-65.

Hanif, M., Ali, J. (2014). Climate scenarios 2011-2040. Districts Haripur, Sawabi, Attock and Chakwal-Pakistan, Publication Inter-Cooper-ation Pakistan: 27.

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

Haș, V., Tritean, N., Copândean, A., Vana, C., Varga, A., Călugăr, R., Ceclan, L., Șimon, A. (2022). The impact of climate change and genetic progress of performance of old and recent released maize hybrids created at the ARDS Turda. *Romanian Agricultural Research*, No. 39: 99-110.

Kucharik, C. J. (2008). Contribution of planting date trends to increased maize yields in the central United States. *Agron. J., 100*, 328-336.

Lehenbauer, P. A. (1914). Growth of maize seedling in relation to temperature. *Physiol. Res., 1*, 247-288.

Marin, D. I., Rusu, T., Mihalache, M., Ilie, L., Bolohan, C. (2012). Research on the influence of soil tillage system upon pea crop and some properties of reddish preluvosoil in the Moara Domneasca area. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, 42*(2): 487-490.

Nagy, J. (2009). Effect of sowing date on the yield and quality of maize hybrids with different growing seasons. *Acta Agronomica Hungarica, Vol. 57*, Issue 4: 389-399.

Norwood, C. A. (2001). Dryland corn in western Kansas: Effects of hybrids maturity, planting date and plant population. *Agron. J., 93*, 540–547.

Parker, P., Shonkwiler, J., Aurbacher, J. (2016). Cause and consequence in maize planting dates in Germany. *J. Agron. Crop Sci., 203*: 1-14.

Popa, A., Rusu, T., Șimon, A., Russu, F., Bărdaș, M., Oltean, V., Suciu, L., Tărău, A., Merca, N. C. (2021). Influence of biotic and abiotic factors on maize crop yield in Transylvanian Plain conditions. *Scientific Papers, Series A. Agronomy, Vol. LXIV,* No. 2: 103-113.

Popescu, A. (2018). Maize and Wheat-Top Agricultural Products Produced. Exported and Imported by Romania. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural Dev., 18*: 339-352.

Qureshi, A. S., Qadir, M., Heydari, N., Turral, H., Javadi, A. (2007). A review of management strategies for salt-prone land and water resources in Iran. International water management Institute, Colombo, Sri Lanka.

Raes, D., Geerts, S., Kipkorir, E., Wellens, J., Sahli, A. (2006). Simulation of yield decline as a result of water stress with a robust soil water balance model. *Agricutural Water Management, 81*: 335-357.

Rao Prasada, G. S. L. H. V. (2008). Agricultural Meteriology. Prentice-Hall of India Private Limited, New Delhi.

Rusu, T. (2014). Energy efficiency and soil conservation in conventional, minimum tillage and no-tillage. *International Soil and Water Conservation Research, 2*: 42-49.

Scott, M. P., Edwards, J. W., Bell, C. P., Schussler, J. R., Smith, J. S. (2006). Grain composition and amino acid content in maize hybrids representing 80 years of commercial maize varieties. *Maydica, 51*: 417-423.

Sin, Gh., Popescu, A. (2015). *Schimbări climatice globale, grija pentru resurse naturale*. Editor Cristian Hera, Ed. Academiei Române.

Tahir, M., Tanveer, A., Ali, A. (2008). Comparative yield performance of different maize (*Zea mays* L.) hybrids under local conditions of Faisalabad *Pakistan. Pak. J. Life Soc. Sci.*, No. 6: 118-120.

Tigchelaar, M., Battisti, D. S., Naylor, R. L., Ray D. K. (2018). Future warming increases probability of globally synchronized maize production shocks. *Proceedings of the National Academy of Sciences, 115*(26), 6644-6649.

Tsimba, R., Edmeades, G. O., Millner, J. P., Kemp, P. D. (2013). The effect of planting date on maize: Phenology, thermal time durations and growth rates in a cool temperate climate. *Field Crops Res., 150*: 145-155.

Wajid, A., Hussain, A., Ahmed, A., Rafiq, M., Goheer, A. R., Ibrahim, M. (2004). Effect of sowing date and plant density on growth, light interception and yield of wheat under semiarid condition. *Intl. J. Agric. Biol., 6*: 1119-1123.

Zhou, B., Yue, Y., Sun, X., Ding, Z., Ma, W., Zhao, M. (2017). Maize kernel weight responses to sowing date-associated variation in weather conditions. *Crop J., 5*, 43-51.

***ANOVA (2015). PoliFact and Duncan's test pc program for variant analyses made for completely randomized polifactorial experiences, USAMV Cluj-Napoca, Romania.

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