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Conference Paper

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Provided in Cooperation with:

The Research Institute for Agriculture Economy and Rural Development (ICEADR), Bucharest

Suggested Citation: Cofas, Elena (2018) : The dynamics of maize production in the climate factors variability conditions, In: Agrarian Economy and Rural Development - Realities and Perspectives for Romania. 9th Edition of the International Symposium, November 2018, Bucharest, The Research Institute for Agricultural Economy and Rural Development (ICEADR), Bucharest, pp. 239-245

This Version is available at:

<https://hdl.handle.net/10419/205114>

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THE DYNAMICS OF MAIZE PRODUCTION IN THE CLIMATE FACTORS VARIABILITY CONDITIONS

COFAS ELENA¹

Abstract: *Corn has always been the basic culture of the Romanian peasant. It has extensive uses in human nutrition, in animal feed, in industry, and as a product for export activities. For these reasons, maize occupies more than one third of the country's arable land. Maize is a cereal crop with multiple and distinctive phyto-technical and biological peculiarities, of which we mention: it resists well drought and heat; has few diseases and few pests; can be grown on very different lands and under different climatic conditions; supports monoculture; being a sowing plant, leaves the weeds clean; is a good precursor for many plants; makes good use of organic and mineral fertilizers; reacts very strongly to the application of irrigation; can be sown for fodder and even for the second crop; has a very high multiplication factor; allows convenient production of highly productive hybrids and adapts to cultivation areas, etc. The research aims to analyze the evolution of the production of corn crops during 2007-2017 in correlation with the multi-annual fluctuation of the average air temperature, as well as the annual average rainfall, which reveals significant variability from one year to the next, the trend of evolution evoking an ascending trend from the point of view of the thermal resources compared to the hydric ones. It results that, at the level of the agricultural territory of our country, the natural thermal potential is richer than the water one, the limiting factor with negative effects on the field crop productivity being rainfall water. Productivity of crops shows fluctuations from one year to another, being significantly influenced by the variability of climatic conditions and, in particular, the production of extreme climatic events.*

Keywords: *corn, temperature, precipitation, production, surface*

JEL Classification: *O12, P50, Q18, Q57*

INTRODUCTION

Climate variability influences all sectors of the economy, but farming remains the most vulnerable. Productivity of crops shows fluctuations from one year to another, being significantly influenced by the variability of climatic conditions and, in particular, the production of extreme climatic events. Thus, in Romania, on about 64% of the arable land, the soils are affected, to a greater or lesser degree, by frequent droughts, over long and even consecutive years, respectively by an excess of humidity in rainy years more than 6 million ha). The impact of climatic variability on the growth, development and formation of agricultural crops is quantified by the potential of meteorological parameters to ensure optimal vegetation conditions or produce unfavorable effects depending on the degree of intensity of the disturbing factor, the mode and duration of action, the probability of production and return in time and space, as well as the vulnerability of plant species to the production of extreme events. Each physical, chemical and biological process that determines the growth and development of agricultural crops is regulated by specific climatic requirements, and any deviation from these requirements implicitly determines the variability of agricultural produce.

Corn is one of the most important crops on our planet. Corn has expanded into crops due to particular plant and biological features (Bîlteanu Gh., Bîrmaure V.). Among other things, corn is well tolerant to drought and heat, is characterized by few diseases and few pests, can be cultivated on different reliefs and under different climatic conditions, bears the monoculture, it is a pruning crop, leaving the weeds clean, is an excellent precursor to wheat, makes good use of organic and mineral fertilizers, makes it easy to obtain very productive hybrids and adapts to cultivation areas, reacts strongly to irrigation, etc.

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MATERIAL AND METHODS

In order to obtain a definite situation regarding the influence of climatic factors on the production of corn in Romanian agriculture, particular analyzes were made for the areas Calarasi, Buzau and Fundulea both for the period 2007-2017 and for the 2020-2050 perspective, several climatic scenarios for some of the most important climatic elements that can be correlated with agricultural production in the case of maize crop, namely: percentage of soil water, actual rainfall, percentage of corn production decrease, water requirement and efficiency of use of water.

Estimating the impact of foreseeable climate change on the growth, development and training of agricultural crops is based on the use of crop simulation models (CERES-Maize for maize) (National Meteorological Administration) in combination with climate predictions of global / regional climate models at various future resolutions and stairs (e.g., 2020-2050, 2070-2100). The magnitude of the effects of the various climate scenario projections is determined by the interaction between the existing local climatic conditions, the severity of climatic parameters predicted by climate scenarios, the effect of CO₂ growth on photosynthesis and the genetic type of the plant.

In order to identify the changes in the observed climate regime in Romania, the series of annual and annual values (certain parameters) were analyzed at the stations in the areas Calarasi, Buzau and Fundulea with complete observations for the period 2007-2017 for the average air temperature and the rainfall quantities, as well the ranges of indices referring to extreme events (maximum amount of time with rain / without rain, maximum rainfall in 24 hours, daily precipitation over certain thresholds). The analysis of changes in the mid-time of the aforementioned time series is made with regard to the identification of the long-term linear trend or the average jump (which indicates the regime change), the statistical significance of these is calculated using non-parametric tests Mann-Kendall (Busuioc A., H. von Storch) and Pettitt (Boroneant C., Rimbu, N.). These tests use calculation methods, of which the most well-known are: a) the dynamic method represented by the regional climatic models, which are coupled with the global climatic models; and b) the statistical method based on certain statistical relations established on the basis of observation data between climate variables at local / regional scale and large scale atmospheric variables. The results of this analysis are summarized below in the climatic scenarios presented, namely the projections of changes in the Romanian climate regime (air temperature and atmospheric precipitation) for the period 2020-2050 compared to the current period 2007-2017.

RESULTS AND DISCUSSIONS

Maize is a plant that has a good adaptability to intense lighting conditions and high daytime temperatures with low photoresponsiveness. The main climatic factor of corn crop is temperature. The thermal requirements of the plant are relatively high throughout the vegetation period, although they are quite different from one vegetation stage to another. The optimum maize growth temperature is 28-30°C, but it also uses moderate temperatures. It is believed that in the growth, blooming and filling phases of the grain, temperatures of 10°C cause plant growth to cease, yellowing or whitening of the plant. Very high temperatures above 32°C are considered as critical temperatures for corn. Through the sweat process, the plant loses a very large amount of water, dehydrating, even if the plant has a reservoir of water in the soil. At higher temperatures (48°C for 6 hours) and under relatively low humidity conditions (below 30%) the maize plant is irreversibly dry. As it advances in vegetation, the requirements of maize are rising as against temperature. To ensure a good growth rate, average temperatures should not fall below 13°C in May and below 18°C in June, July and August. When the temperature is high during the day and low during the night, the growth rate of maize plants is reduced, the growing season is prolonged and the production decreases.

Of the country's agricultural territory, on 76% of the area the heat factor is favorable and very favorable to maize crops, which can ensure high yields. The amount of heat, however, varies greatly in agricultural areas, very distant averages of annual average temperatures from less than

7°C to more than 11°C give a high degree of temperature variation in the period of growth and development of maize plants in different areas.

The main climatic factors that determine the level of vegetal production, including corn production, are: heat (temperature), light and water (precipitation). Of the climatic factors involved in plant growth and the formation of agricultural production, light and natural heat are inseparable elements, the values of which generally follow the same curve. Therefore, temperature and precipitation were used in calculations and determinations. In order to determine which production levels these climatic factors can provide in different areas, a synthetic unit of these factors, called the hydrothermal index, is given by the formula:

$$I.ht = (Pmm \times T) : 1000,$$

where I.ht = hydrothermal index,

Pmm = annual average precipitation of the area (in mm/season),

T = average annual temperature (in ° C - degrees Celsius).

At the same time, experimentally and statistically, it has been determined that in the case of the application of appropriate technologies, an I.ht. it corresponds to a production quantity of 1-1.5 tonnes of corn.

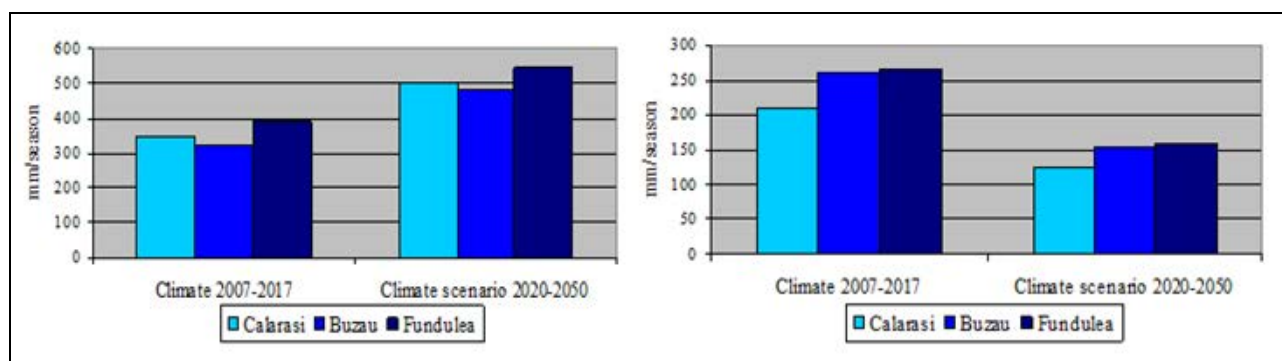


Fig. 1. Water deficiency in soil and the amount of precipitation

Using climatic factors, the "climatic polygon" (C. Chirita, C. Paunescu, D. Teaci) of Romania was drawn up. Research and practice have established that corn can be cultivated with good results in areas where the annual average temperature is above 7°C, in which the sum of the useful temperature degrees during the growing season of the respective crops is achieved. Of course, there is a wide variation of areas from this point of view and proper of the right varieties and hybrids. Romania's large agricultural areas in Dobrogea, Bărăgan, South Plain, Western Plain, Transylvania and Moldova have an average annual temperature of between 8.2 and 11.2 ° C and average precipitation between 359 and 631 mm. From a thermal point of view, all large agricultural areas are therefore favorable to corn crops. Under the "climatic polygon" hydrothermal indexes were calculated and their isolates were drawn up. It is noted that in the maize areas (with an average annual temperature above 7°C and with annual average precipitation 359-631 millimeters), hydrothermal index values are between 4 and 7 under natural, non-irrigated conditions.

It follows that climatic factors could provide unmanned production of 4,000-10,500 kilograms/ha of corn grains, of course if these climatic conditions are agreed with edifices (corrected), varieties and hybrids used and applied technologies. In areas with an average annual temperature of 9° C, evapotranspiration during vegetation is increasingly intense. For corn, in order to get the best out of the heat and light from these areas and to obtain large productions, it is necessary to fill the water from precipitation up to the limits of 800-900 mm. In the case of the addition of precipitation with irrigation water, hydrothermal index values in the respective zones amount to 9-11.5 for maize. Thus, improved climatic factors allow production to reach: 9,000-18,000 kilograms/ha.

It is clear that the climatic factors - heat and, implicitly, light - best meet the needs of the plants, the limiting factor being water, which, if completed, can double the crop compared to that achieved by the natural condition of the climatic factors. The concrete situation of the agricultural

land and agricultural land in terms of favoring climatic factors is the following: almost 11.5 million hectares of agricultural land are in areas with an average annual temperature above 8°C; about 8 million hectares in areas with an average annual temperature of 9° C; about 2 million in areas with average temperatures between 7 and 8° C and the rest (1.2-1.5 million hectares of mountain meadows) in areas with less than 7° C annual average - about 6.5 million agricultural land, of which: 5.5-6 million arable hectares are in areas with less than 500-550 mm annual rainfall; 4.5-4.9 million hectares in 500-600 mm precipitation areas and about 3.5-3.9 million hectares in areas with annual rainfall of over 600 mm (Marinica I., Constantin (Oprea) D.M., Marinica A., Vătămanu V).

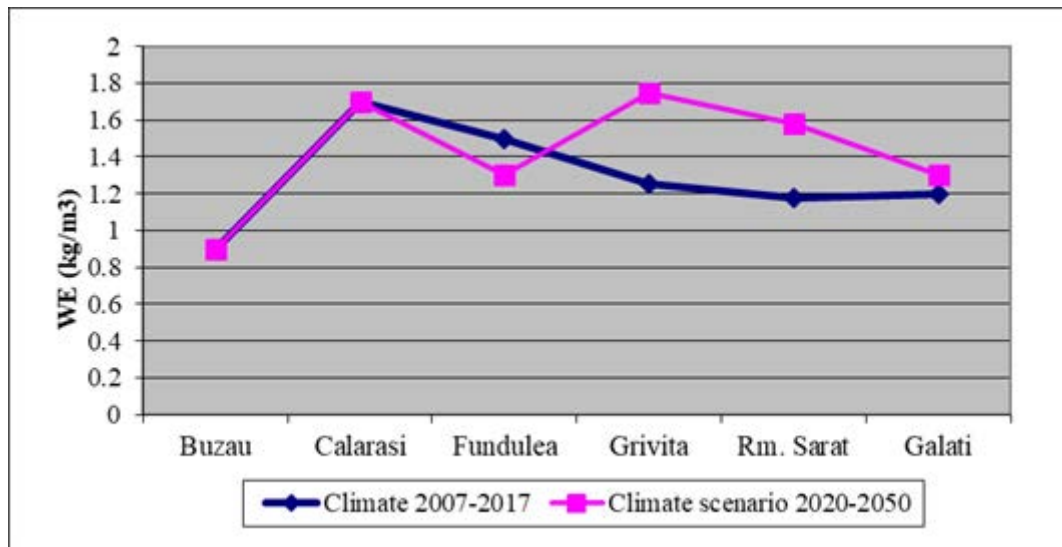


Fig. 2. Water efficiency - corn crop

We can easily deduce that the heat factor (implicitly light) is favorable and very favorable to corn crops on 76% of the agricultural territory of the country, as it can ensure high yields. The amount of heat varies greatly in agricultural areas, very distant averages of annual average temperature from less than 7°C to over 11°C offer high temperature variations in the growth and development period of plants in different areas. In some of these, heat is a limiting factor for corn production. Although natural precipitations along with the temperature (hydrothermal index) in our agricultural areas generally provide conditions for potentially high yields, we still have large areas and large agricultural areas where water is a limiting factor for corn production. Filling water through irrigation in precipitation areas between 350 and 600 mm leads to a substantial improvement in hydrothermal indices and to the possibility of double or triple corn harvest.

The heat factor and, implicitly, the light can be modified to a lesser degree, but their degree of recovery can be greatly improved by the measures we can apply, such as zoning corn crops, allocating it to the territory taking into account the heat required to reach maturity and ensure great productions. The location on areas and micro zones must be avoided with abundant heat and light of hybrids requiring a lower amount of temperature and not making good use of the heat and light available in the area; creating and using hybrids with a larger foliar surface with rapid vegetative growth; selecting a proper density of plants per unit area and line orientation so that all plants receive the maximum possible heat and light and the assimilated organic mass production is maximum per unit area.

We can conclude that, on more than 75% of Romania's agricultural territory, climatic factors are favorable to corn crops, and by correcting the water factor in large agricultural areas they become very favorable, ensuring very high potential outputs. However, climatic factors (through the hydrothermal index) can only determine or measure the favorable climate for agricultural crops and the level of possible productions. These are largely related to edifying factors and their interaction with climatic factors.

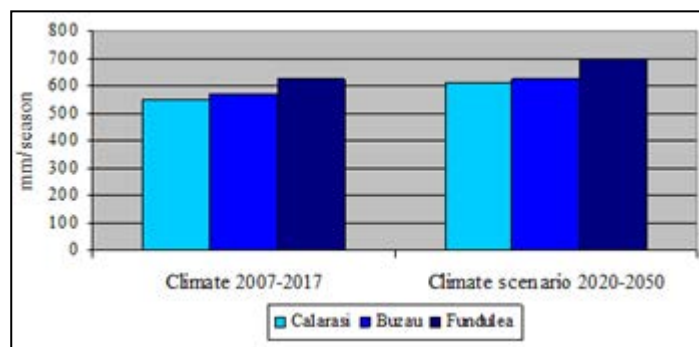


Fig. 3. Water requirement of corn crop

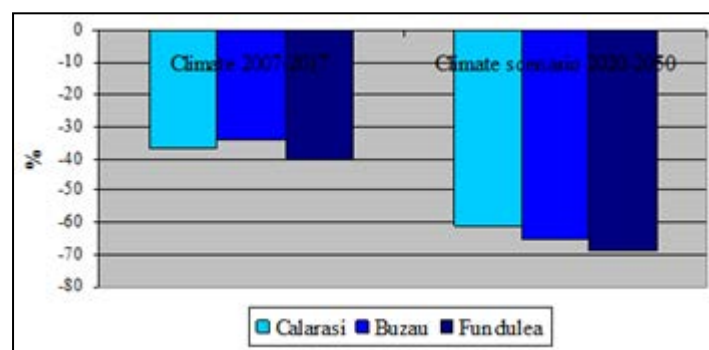


Fig. 4. The percentage of corn production

From the point of view of the interactions between climatic and climatic factors, the following situations can be encountered in Romania:

→ Areas with a corresponding natural hydrothermal index and favorable edifying factors. Example: Calarasi area - 560 mm precipitation + 250 mm groundwater intake; 10.5°C average annual temperature; wet groundwater chernozem with favorable physical and chemical properties; soil with favorable attributes; $I.ht = (810 \text{ mm} \times 10.5) : 1000 = 8.5$, which means a potential maize production of 12,700 kg/ha.

→ Areas with a corresponding natural hydrothermal index, but with unfavorable edifying factors. Example: Buzau area - 850 mm annual rainfall; 10.3°C average annual temperature; podzolic soil with unfavorable features; soil with unfavorable features; $I.ht = (850 \text{ mm} \times 10.3) : 1000 = 8.7$, ie 3 tonnes of maize, production actually achieved without soil improvement work. Although the hydrothermal index is practically the same for Calarasi and Buzau (8.5 and 8.7), the production at Buzau was three times smaller than in Calarasi due to unfavorable edifices of the podzolic soil.

→ Areas with inappropriate natural hydrothermal index, but with favorable edema factors. This area covers most of the areas of Dobrogea, Bărăgan, South Plain and other areas not yet equipped for irrigation, except for land with a good groundwater intake. Example: Fundulea area with 300 mm annual precipitation; 11.2°C average annual temperature; chernozem soils with favorable properties; soil with favorable attributes; $I.ht = (300 \times 11.2) : 1000 = 4.7$ (4,500-7,000 kg/ha of corn, possible production under natural conditions). If irrigation improves the water factor by adding up to 800 mm, $I.ht$ becomes $(800 \times 11.2) : 1000 = 8.9$ and production can grow to over 13,000-14,000 kg/ha.

→ Areas, micro-zones or plots with inadequate natural hydrothermal index and unfavorable edifying factors.

These situations can occur in all regions of the country - in large areas, in low-temperature areas (below 6-7°C average annual) and with abundant rainfall (over 750-800 mm), where the hydrothermal index is quite high due to large amounts of rainfall, but corn and other crops do not produce grains or mature because of the lack of the amount of temperature required (Marinica I., Constantin (Oprea) D.M., Marinica A., Vătămănu V.). In these areas there are also cold, compact, impermeable soils with low aera, acidified pH, poor in nutrients. To increase production, you can

act by completing the soil nutrition reserve, eliminating excess water, correcting acidity, improving the composition of natural flora or herb mixtures.

Table 1. Data on the evolution of maize areas and maize production in Romania

Specification	UM	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Surface	mii ha	2524.7	2441.5	2338.8	2098.4	2589.7	2730.2	2518.3	2512.8	2528	2497	2640
Average production	Kg/ha	1526	3215	3409	4309	4525	2180	4488	4770	3509	4014	5800
Total production	mii to	3853.9	7849.1	7973.3	9042.0	11717.6	5953.4	11305.1	11988.6	8871	10024	14500

Source: INS Data - Plant productions of main crops (2007 – 2017)

In Romania, over the period 2007-2017, the multi-annual fluctuation of the average air temperature and the annual average rainfall rates reveal significant variability from one year to the next, the trend of evolution evoking an upward trend in terms of thermal resources compared to those of water (Baciu, M., Busuioc, A., Breza, T). It results that, at the level of the agricultural territory of our country, the natural thermal potential is richer than the water one, the limiting factor with negative effects on the field crop productivity being rainfall water. A peculiarity is presented in 2017, according to the data presented by the Ministry of Agriculture. In this respect it should be mentioned that the total production of grain maize registered in 2017 in our country was 45% higher than that of the previous year 2016 (Soare E., Dobre I.). Thus, with an average production per hectare of nearly 6000 (5800) kg/ha, Romania managed to record a record production of more than 14.5 million tonnes in 2017. The production recorded in 2017 was the highest ever obtained, given that in 2016 maize production was about 10 million tons, with 4 tons harvested per hectare. Another record production was recorded in 2014, when 11.3 million tons of corn was harvested in Romania, with an average production of 4480 kg/ha.

CONCLUSIONS

In the coming decades, the implications of global warming in the industrial economy, water supply, agriculture, biodiversity will be very obvious. Globally, heating thus has the effect of increasing the frequency and intensity of extreme events, especially drought and floods. The causes that lead to the occurrence of these phenomena are obviously related both to the climate and to the human interventions, namely irrational use of land and water resources, improper agricultural practices, deforestation, overburdening and, last but not least, air and soil pollution. Climate data from the last century highlights a progressive warming of the atmosphere and a significant reduction in rainfall, which is considered to be limiting to the development and productivity of agricultural crops, as well as the use of water resources. These changes may have significant consequences on the growth and development of crops during the vegetation period, depending on the degree of intensity of the disturbing factor, the mode and duration of action, and the vulnerability of the plant species to the occurrence of extreme weather events.

In the long run, measures to prevent and mitigate the effects of climate change include reforestation programs, pollution reduction, restoration and modernization of anti-erosion works, as well as the expansion of sandy soil improvement and improvement, etc. At the same time, educating the population and raising awareness about environmental protection are major requirements in developing climate change adaptation strategies. The solutions and recommendations for the development of actions and procedures to prevent and mitigate the effects of climate variability in agriculture must fully embrace the whole set of known measures (agrotechnical, cultural, irrigation, etc.) and rapid intervention actions to locate and limit the spread of extreme phenomena in order to avoid accentuating the consequences.

However, addressing climate change impacts requires specialized scientific data and analysis, risk management in agriculture, including mainly actions on the management and conservation of environmental resources, as well as taking correct decisions in the future. The

foundation and development of agricultural management options for adapting and reducing the negative impacts of possible climate change on crop systems may recommend specific technological measures: modification of the sowing date, use of genotypes with high resistance to high temperatures / drought, modification of land use practices, the change of crop rotation and, last but not least, the application of irrigation.

From the above it can be seen that in the agricultural areas of Romania it is possible to produce large quantities of corn. However, the conclusion is that in some areas large production is achieved only if the hydrothermal index - ie the water element - is corrected by arranging the respective lands for irrigation. In other areas, interventions are needed to improve edema factors in order to obtain high yields of corn. In many cases, on large surfaces, measures are needed both to improve the hydrothermal index and edema factors.

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