MAIZE UNDER THE CLIMATE CHANGE IMPACT

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Abstract: Research into plant breeding always focused on increasing productivity potential in new developed plant varieties because this criterion ensures the economic efficiency of a crop and finally of the agricultural farm. Lately, however, due to the challenges of climate change, the stability of crop production is strongly affected because of the global warming. One of the most important crops for humankind is maize which becomes nowadays the most productive grain crop worldwide. Maintaining a high production of maize in the conditions of climate change remains a priority for researchers. In order to be able to make the most relevant decisions over a long period of time regarding the future of crop plants due to their importance for food security in the context of climate change, more and more researchers are using different modelling systems in crop science. A study based on the 'Climex' model indicates that the negative effects of global warming will limit maize cultivation in the countries between tropics of Capricorn and Cancer, but also will expand some areas from USA, Mexico, Brazil, China, Africa and Latin America, due to the cold stress reduction. Following the simulations performed until this moment, some measures that will be able to ensure large corn production in the near future despite climate change are breeding cultivars that start filling the grain as fast as possible, creating drought tolerant hybrids, improving irrigation technologies and not least, reconsider favourable areas for maize cultivation.

Keywords: climate changes, corn, favourable areas, global warming, maize, modelling.

INTRODUCTION

Maize or corn (*Zea mays* L.) valuable plant species with a high production potential, with a wide diversity of use as a source of food for humans and animals, and raw material for industrial processing, is cultivated on large areas around the world, but also in Romania. Maintaining a high production of maize even in the conditions of climate change remains a priority for researchers. Thus, not only the yield potential is important, but also the quality of cultivars because, in addition to the nutritional value, corn also has an amazing phytochemical value for human health, like carotene, lutein, zeaxanthin, ferulic acid, anthocyanins, sitosterol, stigmasterol and campesterol. Consumption of phytochemicals prevents the development of some chronic diseases due to their antioxidant activity (Shah *et al*., 2016). For example, carotenoids pigments handle provitamin A activity important for eyes health, but also good for cancer prevention (Michaud *et al*., 2000; Shah *et al*., 2016). Another major use of maize is in animal husbandry like green fodder, the corn plants being very nutritious, quickly growing, highly productive and very palatable (Chaudhary *et al*., 2014). In recent years, starch from corn became an alternative substitute to petroleum-based plastic (Amalia *et al*., 2020). Due to the starch content and its easy conversion to ethanol, corn is more and

more important for the industry of ethanol production, a renewable fuel (Mosier and Ileleji, 2006). Some of the uses of corn can be noted synthetically in Figure 1.

Looking at the origin of maize, Harshberger (1893) believed that corn originates from Mexico, even more so that at first it appeared as a wild plant in the centre of this country at altitudes higher than 1,500 m, in semi-arid regions with rainy summers (Cristea, 2004), where today it still exists in the wild form of teosinte considered to be the ancestor of corn. Time of domestication began 7,000 – 10,000 years ago (Hallauer and Carena, 2009). Currently, corn is one of the species that has a very rich genotypic and phenotypic diversity (Liu *et al*., 2020).

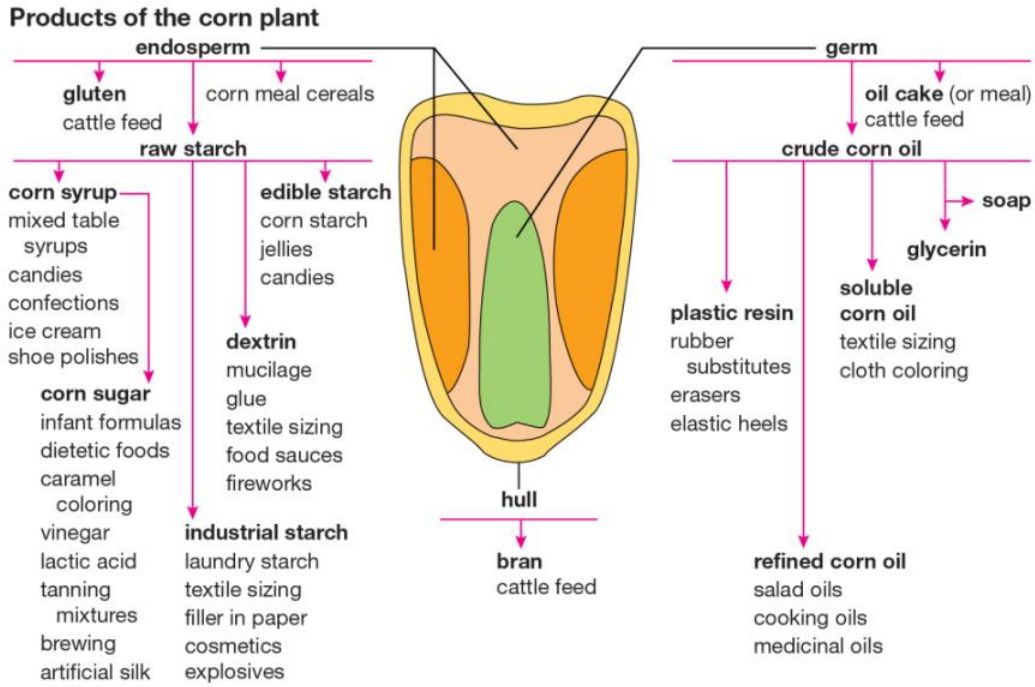

Figure 1. Products of the corn plant
(Source: https://www.britannica.com/plant/corn-plant)

Given the wide range of uses, maize can be considered a multipurpose crop. Regarding the great importance of this culture for people's daily lives, more and more attention is being paid to corn in the context of climate change, which has already begun to affect the production of cultivars. Given that the demand for food is increasing worldwide, it is confirmed once again that the main objective of researching programs must be the production capacity of the new varieties, increasingly difficult thing to do because of the effects of global warming which restricts favourable areas for plant crop. Main negative effects of climate change are the increase of air temperature, changes in the rainfall distribution and quantity, but also appearance of the extreme meteorological phenomena (MADR, 2015).

Considering the presented context, this paper aims to synthesize the situation of maize crops in our country, Europe and worldwide, to present the utility of using models

to predict maize yield in the context of climate change and to identify some relevant solutions for stopping the decline of production due the global warming.

MAIZE IN THE PRESENT

Globally corn ranks first place in production (Figure 2). Due to the importance of corn, over time, a series of measures have been taken to increase production, including the initiation of works to improve new sources of germplasm represented by local populations, commercial hybrids, synthetic and composite populations, exotic populations and so on (Ona, 2014).

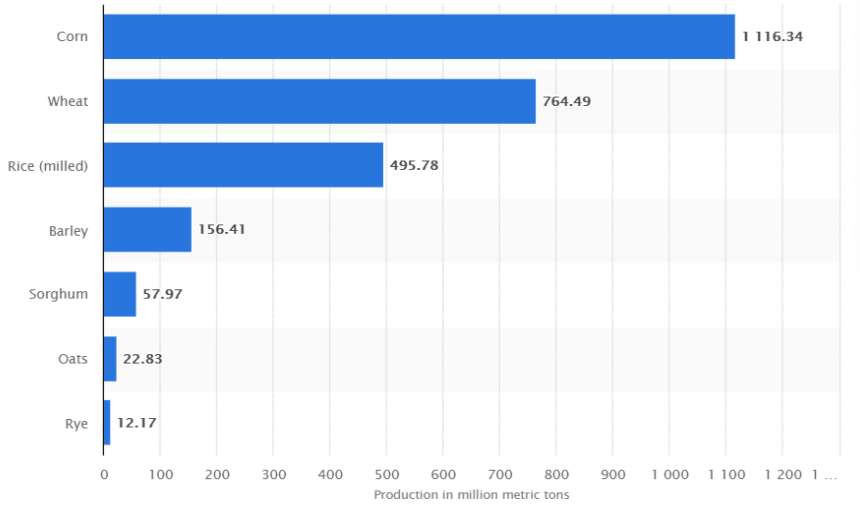

Figure 2. Worldwide production of grain in 2019/2020
(Source: https://www.statista.com/statistics/263977/world-grain-production-by-type/)

Evolution of cultivated areas can be followed in Figure 3. Worldwide surfaces have a continuous growth, in 2019 the cultivated area reaching 197,204,250 ha. This may also be due to the fact that corn is finding more and more uses in people's daily lives. In the other analysed regions (Europe, European Union and Romania) cannot be observed the same ascending slope of increase of the cultivated surfaces, but rather an alternation of the increases and decreases of the areas.
In 2010 Romania reached the lowest level of area cultivated with corn, only 2,094,249 ha with almost 64% less than the maximum area from 1961, of 3,428,400 ha. In the European Union, 2004 followed by 2003 were the years with the largest maize areas over 10 million hectares. Europe had the biggest area sown with maize in 2013 (18,865,423 ha), currently maintaining a relatively close level of over 18 million.

Analysing worldwide the highest corn yield by countries, can be noted that over 50% of the world market is owned by the United States of America together with China. European Union ranks 4th place on the global corn production, after Brazil.

In the United States, corn is by far the most widespread crop because the multitude of uses. Besides its economic importance, maize is an important species also for the

scientists that study the origin and evolution of cultivated plants due to its great variability (Figure 4), being a very valuable material (Haskell, 1948).

For the most advanced studies and researches of maize, an area from the Midwest USA known as 'Corn Belt' stands out (Green *et al*., 2018). Since 1850s this region dominated maize production in the country.

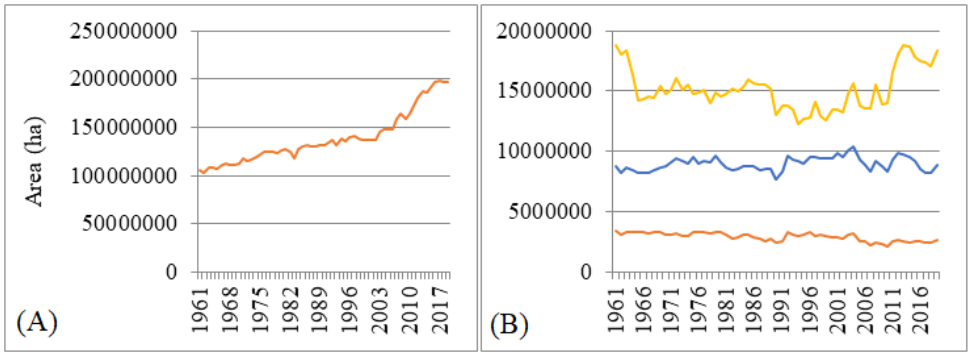

Figure 3. Evolution of maize areas from 1961 to 2019 (A) Worldwide (B) Europe (yellow), European Union (blue) and Romania (orange)
(Own calculation on the basis of data from FAO Statistics)

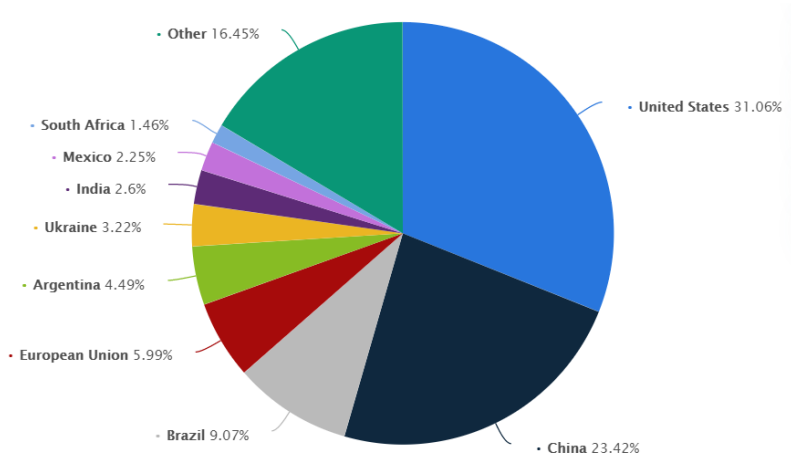

Figure 4. Distribution of global corn production in 2019/2020
(Source: https://www.statista.com/statistics/254294/distribution-of-global-corn-production-by-country-2012/)

Figure 5. Maize phenotypic variability
(Original photo)

MAIZE YIELD UNDER THE CLIMATE CHANGE

Yield of agricultural crops remains one of the main reasons for the farmers, because this criterion ensures the economic efficiency of a crop and finally of the agricultural farm. Therefore research into plant breeding has always as its main objective the increase of crop productivity in the new developed plant varieties (Cairns *et al*., 2012). Lately, however, due to the challenges of climate change, the stability of crop production is strongly affected because of the global warming. One of the most important crops in the world is maize which become nowadays the most productive grain crop worldwide (Figure 2), followed in order by wheat, rice, barley, sorghum, oats and rye. For this reason and because is a water-dependent culture (Mulungu and Ng'ombe, 2019), corn is highly analysed in the context of climate change.

In order to be able to make the most relevant decisions over a long period of time regarding the future of crop plants due to their importance for food security in the context of climate change, more and more researchers are using different modelling systems in crop science. Kogo *et al*. (2019) inventory over 30 different models only for maize, mostly centred on plants growth and yields (Table 1).

Table 1

Models used for stimulation of maize yield under climate change

Model	No. of Articles	Model	No. of Articles	Model	No. of Articles
CERES-Maize	59	CROPWAT	2	SPACSYS	1
APSIM	30	ISAREG	2	FASSET	1
statistical	12	MAISPROQ	2	SICTOD	1
Cropyst	10	MaxEnt	2	LINTUL5	1
WOFOST	9	4M crop	1	WINISAREG	1
AquaCrop	8	Agro-IBIS	1	GAEZ	1
DSSAT	8	AgroMetShell	1	MCWLA	1
InfoCrop	8	AirMS	1	SuperEPPS	1
EPIC	4	ARMOSA	1	SIMETAW	1
GLAM	3	BISM	1	CLIMEX	1
CMSM	3	WHCNS	1		

(Source: Kogo *et al*., 2019)

Using a statistical model to estimate the influence of climate change effects on maize yield, Zampieri *et al*. (2019) concluded that the drought and heat stress constantly growing will cause maize yield losses in the most regions of the world. The authors estimate that the raising of the global temperature by only two degrees will cause important decreases of the maize production.

According to the researches is considered that the highest production will be obtained for the cultivars that start filling the grain as fast as possible (Wolf and Van Diepen, 1994). Other measures that can be taken to stop reducing maize grain production can be the breeding of drought tolerant hybrids and improvement of irrigation technologies (Mulungu and Ng'ombe, 2019). Also, perhaps a viable solution would be to reconsider areas favourable for maize cultivation. A study based on the CLIMEX model indicates that the negative effects of global warming will limit maize cultivation

in the countries between tropics of Capricorn and Cancer, but also will expand some areas from USA, Mexico, Brazil, China, Africa and Latin America, due to the cold stress reduction (Ramirez-Cabral *et al*., 2017).

CONCLUSIONS

Can be noted a growing trend of corn cultivated areas in the world, this demonstrating the need to cultivate maize and its usefulness in people's daily lives. Negative effects of climate change cause declines in grains production, so researches are using modelling systems in order to be able to make the most relevant decisions over a long period of time. Following the simulations performed until this moment, some measures that will be able to contribute to high corn production in the near future despite climate change are breeding cultivars that start filling the grain as fast as possible, creating drought tolerant hybrids, improving irrigation technologies and not least, reconsider favourable areas for maize cultivation.

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