IMPACT OF CLIMATE CHANGE ON SUNFLOWER PRODUCTION

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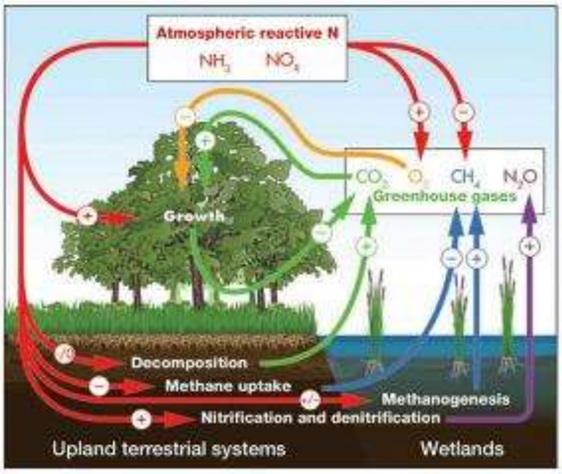
Abstract

Current population growth trends suggest that global food production is unlikely to meet future demand. However, according to projected climate change scenarios, this trend could be mitigated through the use of new drought-tolerant hybrids and sustainable management of crops and natural resources. Climate change is currently one of the main factors affecting agricultural production. These negative impacts are already evident, and projections indicate that this will only intensify in the coming years. This growing concern has sparked interest among domestic and international scientists in conducting detailed analyses of global warming and its effects on agricultural production. Agricultural producers will increasingly face the challenge of finding alternatives to reduce the negative effects of climate change. Agricultural production, particularly crop production, is essentially an 'open-air factory,' carried out in fields and thus highly susceptible to external environmental factors. The aim of this research was to examine the impact of climate parameters on sunflower yields from 2015 to 2023 in the Republic of Serbia. The study also assessed the effects of climate conditions on the economic outcomes of sunflower production, both under optimal growing conditions and in conditions where the effects of climate change were evident.

Keywords: *sunflower, climate change, yield, crops, economic results.*

Introduction

Agriculture represents a very important activity in the Republic of Serbia. Sunflower (Helianthus annuus) is a significant crop in both the Republic of Serbia and the world, with a tendency toward increasing cultivation areas and market importance. Sunflowers are cultivated in Serbia on just over 250,000 hectares (FAO, 2022). The success of stable production largely depends on the sowing time, applied agricultural techniques, hybrid selection, and weather conditions (Stojković et al., 2023). Given that agricultural production is mostly conducted in open fields, environmental conditions significantly affect its success. For the Serbian region, analyses of observed climate changes indicate a clear trend of rising air temperatures across the entire country, while precipitation changes show seasonal and spatial variability (Luković et al., 2014; Milovanović et al., 2017). It is expected that rising air temperatures, changes in the amount and distribution of precipitation, and increased frequency and intensity of drought will lead to higher crop water needs, both in Europe (Rio et al., 2018) and in Serbia (Gregorić et al., 2020). In recent years, we have witnessed frequent occurrences of severe droughts, as well as frequent weather hazards such as strong winds, storms, hail, and similar events. All these occurrences indicate that Serbia is among the countries highly susceptible to the negative effects of climate change (European Environment Agency, EEA, 2017). The increase in air temperature and changes in the distribution and amount of precipitation negatively impact the agricultural production of European countries, water resources, and consequently socio-economic changes due to the frequent changes in the supply of agricultural raw materials, which affect the uncertainty of operations in the food industry, trade, and other associated sectors of the economy and society as a whole (Fronzek et al., 2019). All of this raises concerns that, in the future, agricultural production may not be possible without the use of irrigation. Irrigation is considered the most reliable measure for adapting to climate change (Agovino et al., 2019). However, it has its limitations, primarily due to the scarcity of water resources, which will become increasingly limited and/or highly variable in terms of available water quantities (Idrizović et al., 2020). Research on the impact of climate change in Serbia indicates that the climate will remain favorable for agricultural production (Mihailović et al., 2015). Agriculture in southeastern Europe will be affected by climate change, as confirmed by numerous studies (Webber et al., 2018).



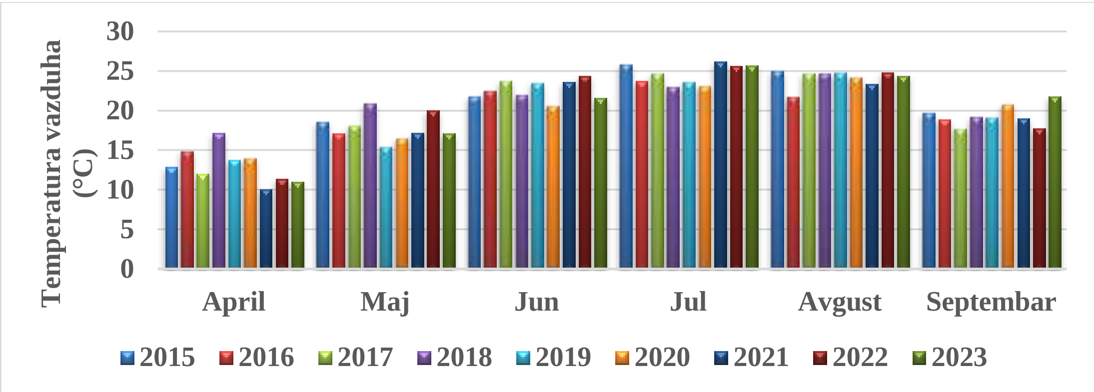
Picture 1. Gases and processes involved in the greenhouse effect. Sources from (Templer et al. 2012).

Material and methods

In order to assess the overall sunflower production in the Republic of Serbia from 2015 to 2023, data from the Republic Hydrometeorological Institute portal was used to gather information on average monthly air temperatures and total monthly air temperatures over the past 9 years (RHMZ, 2023). The average yield of the studied crops for the mentioned period was obtained from the portal of the Republic Statistical Office (RZS, 2023). Based on the data collected from these portals, an assessment was made of the impact of air temperature and total precipitation during the growing season on sunflower yield. Additionally, based on the data from variable cost calculations, the gross margin amounts for sunflower production were determined, and an analysis of the sensitivity of yield and price changes on the gross margin of sunflower production was conducted.

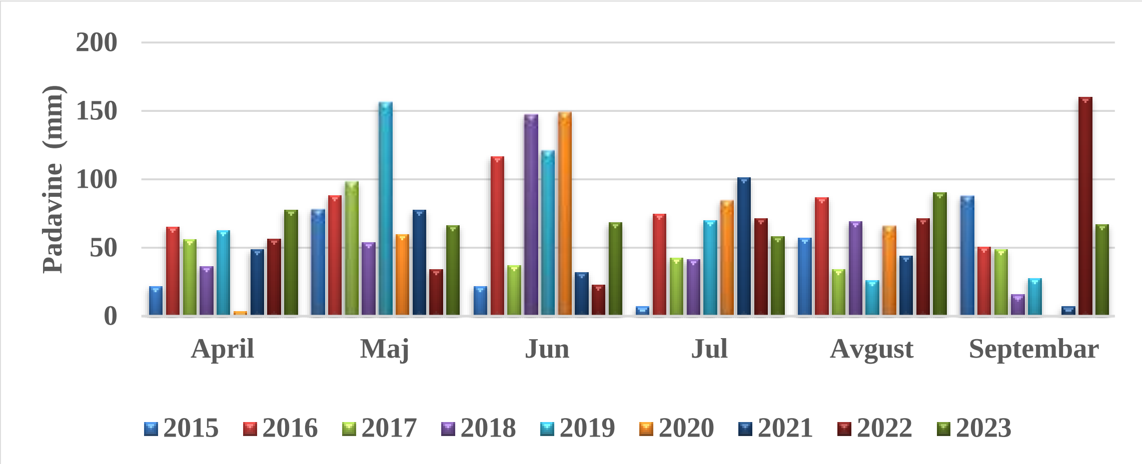
Results and discussion

Crop production is often referred to as a “factory under the open sky,” which is why environmental conditions have a significant impact on production success. Climate change, based on observed climate parameters, indicates negative consequences, but it is also possible to expect some positive effects on agriculture (Stričević et al., 2019). In Serbia, an increase in the average daily temperature of 1.2°C, exceeding global averages, has been recorded. This increase is particularly notable during the summer period, along with a lack of precipitation, which is one of the limiting factors for the growth of the most important crops (Lalić et al., 2013). Studies have shown that the water requirements for certain crops in Serbia (orchards, grasses, sugar beets, soybeans) will increase by the end of the century (Stričević et al., 2019). The average long-term air temperatures in Serbia during the period from 1921-1940 were 10.2°C, while in the period from 1961-1990, they were 10.1°C. Precipitation amounts were approximately similar, ranging from 721 to 734 mm. Each crop type has a critical period for water and heat, with some having longer, and others shorter durations. For sunflowers, these critical phases are during the phenological stages of intensive growth, flowering, and grain filling. Sunflower is a significant oilseed crop grown worldwide due to its diverse uses in the food, industrial, and pharmaceutical sectors. It is known for its high oil content, nutritional value, adaptability to various climate conditions, and environmental benefits. Sunflower is an annual plant with a growing period of 90-130 days, during which it undergoes both vegetative and generative phases of growth and development: germination and emergence, leaf development, appearance of flower buds (buttoning), the stage where the flower bud elongates above the top leaf, bud opening, flowering phase, and maturation phase. Sunflower is a heavy consumer of water. In addition to 250 mm of winter reserves (in our region), it requires about 300 mm of rainfall during the growing season. Its greatest water needs are during the periods of intense growth and flowering (about 65% of the total water absorbed). In many years, insufficient rainfall leads to poorer flowering and reduced grain yield. The sum of active temperatures (above 10°C) required for sunflower growth and development ranges between 1,600 and 2,800°C. Newly emerged plants can withstand frosts down to -6°C. The optimal temperatures for flowering, seed formation, and filling are between 20-25°C. Very high temperatures (> 35°C), especially combined with a lack of rainfall from flowering to maturation, negatively affect seed and oil yield.



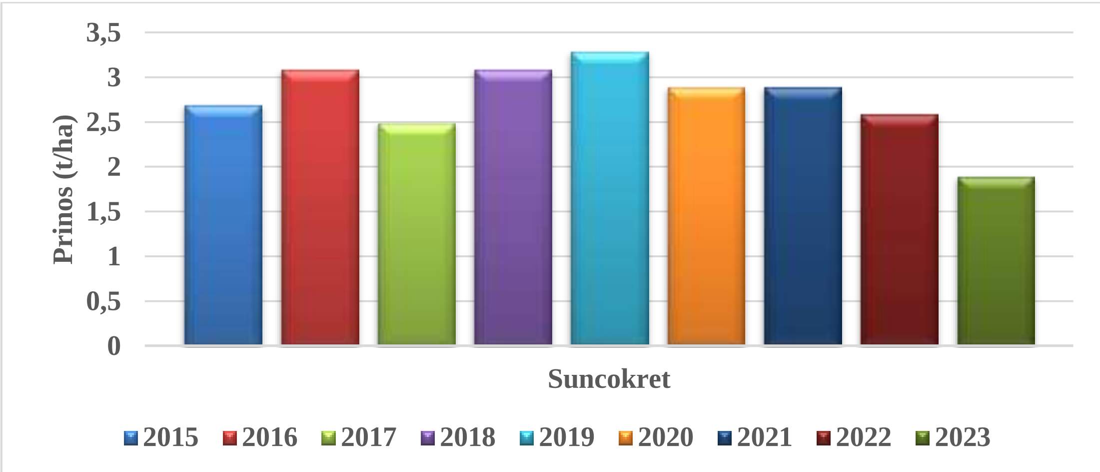
Graph 1. Average monthly air temperatures during the growing season of spring crops (RHMZ, 2023).

Based on the data from Graph 1, we can conclude that average air temperatures during the growing season of spring crops did not vary significantly over the years. The greatest variation was observed in April, and a similar trend was seen in May, but with smaller temperature fluctuations. The summer months of June, July, and August exhibited fairly consistent average monthly air temperatures over the past 9 years, with a slight increase in the last 3 years, except for June 2023, when temperatures were slightly lower than in 2021 and 2022. The highest average monthly air temperature during the observed period was recorded in July 2021, at 26.3ºC, while the lowest temperature was recorded in April of the same year, at 10.2ºC. The highest air temperature during the sunflower growing season occurred in 2018, averaging 21.27°C, while the lowest was in 2016, at 19.90°C. In the vegetative growth stages of sunflower, from 12-16 BBCH to 18-32 BBCH, average temperatures in April and May did not deviate much from the optimal range, which was favorable for proper germination and plant growth. The greatest temperature variations occurred in April, where a decrease in average daily temperatures has been observed in the last three years. The optimal temperature for the stages of seed formation, filling, and maturation is between 22-23°C. Average temperatures from June to August were higher than the optimal range: June by 2.73°C, July by 1.70°C, and August by 1.29°C.



Graph 2. Total monthly precipitation during the growing season of spring crops (RHMZ, 2023)

Based on the data from Graph 2, we can say that the total monthly precipitation amounts do not exhibit a clear pattern and vary significantly from year to year. The highest average precipitation was recorded in September 2022, measuring 160.8 mm, while the lowest amount during the studied period was measured in September 2020, with only 1.2 mm of rain on average for the month. The year 2020 was particularly unfavorable for crop production because insufficient rainfall in April slowed and unevenly affected the germination and emergence of spring crops.



Graph 3. Sunflower yield in the period 2015-2023 (RZS, 2023).

The sunflower yield during the observed period was significantly more uniform (with the exception of 2023), ranging from 1.9 to 3.3 t/ha. Although 2023 was not an extremely dry year, high air temperatures during June, July, and August led to a decrease in sunflower yields. In 2017, a satisfactory amount of rainfall occurred in May, June, and July, which coincided with the critical water period for sunflowers, resulting in a high yield that year. Research is being conducted to identify alternative preventive measures, including changes in sowing dates, variety selection, and the application of breeding methods (Popović et al., 2014), as well as various plant cultivation systems aimed at preserving soil moisture.

Table 1. Analysis of the sensitivity of the gross margin of sunflower production to changes in yield and price (average in the period 2015-2023)

		Price (din/kg)				
		-20%	-10%	Average	10%	20%
Yield (kg/ha)		**34.58**	**38.91**	**43.23**	**47.55**	**51.88**
-20%	**2,136.00**	16,398.07	25,632.00	34,865.93	44,099.86	53,333.79
-10%	**2,403.00**	25,632.00	36,020.17	46,408.34	56,796.51	67,184.68
Average	**2,670.00**	34,865.93	46,408.34	**57,950.75**	69,493.16	81,035.57
10%	**2,937.00**	44,099.86	56,796.51	69,493.16	82,189.81	94,886.46
20%	**3,204.00**	53,333.79	67,184.68	81,035.57	94,886.46	108,737.35

Source: Editing by the author

In Table 1, the results of the sensitivity analysis of the gross margin from sunflower production to changes in yield and price for both 10% and 20% variations (for both increases and decreases) are presented. The average price of sunflower during the period from 2015 to 2023 was 43.23 din/kg, while the average yield was 2,670.00 kg/ha. The average gross margin from sunflower production during the analyzed period was 57,950.75 din/ha. The sensitivity analysis of the gross margin from sunflower production established that even with a decrease in price and yield by 20%, the gross margin remains positive, amounting to 16,398.07 din/ha. Even in 2023, when the price of sunflower was 37.5 din/kg and the yield was 1,900.00 kg/ha, the gross margin would still remain positive at 13,776.65 din/ha. Based on this, it can be concluded that although affected by climate change, specifically drought, sunflower yields in certain years with pronounced drought can be significantly lower (by up to 30%), and with prices approximately 15% lower than the averages during the analyzed period of 2015-2023, the gross margin from sunflower production remained positive.

Conclusion

Based on the analysis of climate parameters and sunflower yields, a constant increase in average monthly temperatures in June, July, and August has been observed, which adversely affects the development of sunflowers and other spring crops. The total monthly amounts of precipitation show significant irregularity; insufficient rainfall in June, July, and August—when most crops are in their generative growth stages, representing a critical period for water—can lead to stunted growth, lack of fertilization, and reduced yields. It can be concluded that it is essential to work on developing new genotypes that would be adapted to the emerging conditions, to conduct research aimed at expanding the irrigation network, and to implement alternative agronomic methods to mitigate stress conditions with fewer consequences. Although the impact of climate change, specifically drought, is significantly expressed through reduced sunflower yields, the gross margin during the analyzed period from 2015 to 2023 remained positive. Specifically, agricultural producers who cultivated sunflowers did not incur losses and achieved positive economic results.

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