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THE PRODUCTION TENDENCIES OF MAIN GRAIN CROPS IN BULGARIA UNDER CONTEMPORARY AGROMETEOROLOGICAL CONDITIONS AND CLIMATE CHANGES

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Abstract

Global and regional climate change is disturbing all sectors of the national economy. The most affected is agriculture, which takes place under open sky. Bulgaria is located in area with insufficient atmospheric and soil moisture. Climate change cause changes in agro-meteorological conditions and agro-climatic resources, depending on the geographical location. All agro technical activities - sowing, soil cultivation, fertilization, plant protection and harvesting, are highly dependent on weather conditions. The crops development, quantity and quality of production are determined to a great extent by the weather conditions, in particular, by those which have an adverse effect on plants and production processes such as drought, torrential rain and hail. Agricultural production is connected with many risks. Therefore, solving problems in this production area must be linked to agro-climatic and agro-meteorological research to improve agro-technologies with aim to mitigate the effects of climate change and adapt the agriculture sector to these changes. The purpose of this study is to define trends in production and average yields of basic agricultural crops in Bulgaria over the last two decades in climate change and different weather conditions.

Key words*: climate change, planning region Bulgaria, production, yields, trends.*

INTRODUCTION

Bulgaria is a country with great opportunities and traditions in agricultural production. However, in climatic terms, it falls into the zone of unstable humidity (Kouzmova, 2003). The average annual precipitations in Bulgaria are 550-600 mm, which, however, there are extremely unevenly distributed, and during the critical period for agricultural crops, they are extremely insufficient.

Another unfavourable moment is related to climate change in the direction of warming and drought, which have led to changes in the agroclimatic resources of a large part of the country's agricultural territories. This leads to fluctuations in the yields by years, their decrease and sometimes their complete compromise. Indicative of this was the drought in Bulgaria in 2000 (Kouzmova, 2001; Bogoev and Kouzmova, 2002).

The level of average yields is extremely important for the final economic results. It is noteworthy that the yields from some agricultural crops are significantly lower than biologically possible. The reasons for this are complex and related to both technology non-compliance and global warming and climate change.

The purpose of this study is to analyse the area under cultivation, production and yields of main agricultural crops in Bulgaria over the last two decades and to define trends against the background of contemporary agrometeorological conditions and climate change.

MATERIALS AND METHODS

The period analysed in this study was 2001-2018. The data collected by Ministry of Agriculture, Food and Forestry on areas under cultivation (ha), production (tons) and yields (kg/ha) from 6 main crops for the country (wheat, barley, grain maize, sunflower, rapeseed, alfalfa) by years and by planning regions.

The regions used in the study are in accordance with the European Union Regulation on the general classification of territorial units for statistical purposes (NUTS) (Mihailov and Kouzmova, 2019): Northeast (NE), Northcentral (NC), Northwest (NW), Southeast (SE), Southcentral (SC) and Southwest (SW).
Meteorological information from Synoptic station-Plovdiv has been collected over the last three decades (1990-2018) for one of the most intensive agricultural regions in Bulgaria Plovdiv. The main factors of the climate are the air temperature and sum of precipitations, based on which the main agro-climatic indicators by months, years and average for 29-years period are determined: average monthly air temperature, absolute maximum and absolute minimum air temperatures, monthly and seasonal sum of precipitations. For comparison, the climate norms published in the Climate Reference Book of Bulgaria, Volumes 3 and 6 are used.
The data were processed on Excel using the approved methods in agroclimatology: statistical methods, correlation and regression analysis (Gulinova, 1974).

RESULTS AND DISCUSSIONS

In recent decades, more and more often we hear about record high temperatures, record floods and droughts, storms and a record number of tornadoes. Northern Europe is already wetter and Southern Europe is drier than in previous centuries. The world's largest insurance companies have paid a lot of money in recent decades for damage caused by natural disasters. Even more troubling are the forecasts of scientists who say that these weather anomalies will become more intensive, causing disease and death to the population. Heat waves and flooding will become a normal climate event, not an exception. More and more people will have to leave their homes and emigrate, pressured by the natural disasters.
Climate change and the related impact on the lives and human health is a global problem that national and international organizations are fully aware and try to find a solution.
In Bulgaria, the problem of water scarcity is becoming more tangible. Bulgaria is relatively poor in surface water resources. According to WWF data from December 7, 2018, they make up only 0.3% of the country's territory, which ranks it among the countries with the least resource in the world. However, Bulgaria falls in latitudes that are sensitive to climate change (WWF-Rivers in Bulgaria, 2018).
The quality and quantity of crop production are to a large extent conditioned by unfavorable meteorological conditions such as drought, heavy precipitations, hailstorm, etc.
Agriculture is one of the most vulnerable sectors of global warming and climate change. Any agro-technical activity, such as sowing, soil cultivation, harvesting and, ultimately, the yield obtained, are highly dependent on the conditions in which they are carried out. In turn, the development of agricultural crops is also dependent on these conditions.
The world economic losses and human life due to extreme weather events have increased many times over. In the last 30 years, weather conditions in Bulgaria have also been a prerequisite for natural disasters, both in terms of extreme temperatures and heavy precipitations.
Climate change in Bulgaria and what are the parameters of these changes are always topical issues, but at certainly, usually when there is a large deviation from the normal weather conditions, they emerge with renewed vigor. Over the last three decades, both in the atmospheric circulation and in the air temperature, there have been significant differences from the period up to the 1970s. In a significant part of research on climate change focuses on changes in temperature and precipitation. There is also a tendency for heavy rainfall to increase, even when precipitation total generally decrease (Spiridonov and Balabanova, 2017).
The results of the last three decades in Plovdiv show that global warming is a fact. It’s most noticeable mainly in winter (January and February), early in the spring (March), and in the summer (June, July and August), when the deviation of air temperatures from the climatic norms is above 1°C (Figure 1). About normal are average monthly temperatures only in November, December and April. The average annual air temperature over the last three decades has been about 1°C above the normal (0.9°C). The whole period since 1990 till now, the average annual air temperatures in Plovdiv have been higher than normal, except for 1993,

which turned out to be the coldest year and 2008, when the average annual temperature was around the normal (according by 0.4°C and 0.1°C below the normal). The warmest year turned out to be 2000, with an average annual temperature of 1.5°C above the normal, and absolute maximum of 44°C was registered in July 2000. The temperatures during the summer of 2007 were also high with an absolute maximum of 42.6°C.

However, minimum air temperatures increased significantly faster than the maximum throughout the all year (Figure 2). The lowest temperature was recorded in the coldest year of 1993, when an absolute minimum temperature of –27.5°C was recorded in January. However, the absolute record for Plovdiv since 1942 has not been exceeded (–31.5°C).

A different trend is observed for rainfall, which gradually increases but fluctuates greatly by years (Figures 3 and 4). The driest year was 2000, which is the warmest year for the entire 30 years period, with only 251.6 mm precipitations (47% of normal), followed by 1993, which, in addition to being the most the coldest year turned out to be one of the driest years (321.1 mm or 59% of normal). Most precipitation fell in 2007. 842.4 mm (156% of normal), however, these are not evenly distributed throughout the year. There is an increase in the spring-summer precipitations, at the expense of the winters, which are decreasing (Figure 4). This feature shows that increases torrential summer precipitations, which also damage agricultural crops, create a risk of flooding, as we had in Plovdiv also in June 2019 (196. 7 mm, which is 322% of the normal for the month).

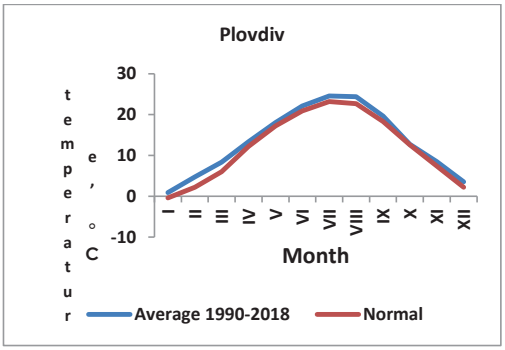


Figure 1. Changes in mean monthly air temperatures in Plovdiv

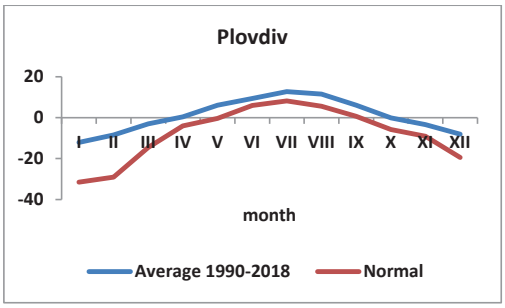


Figure 2. Changes in average of monthly absolute minimum temperatures in Plovdiv

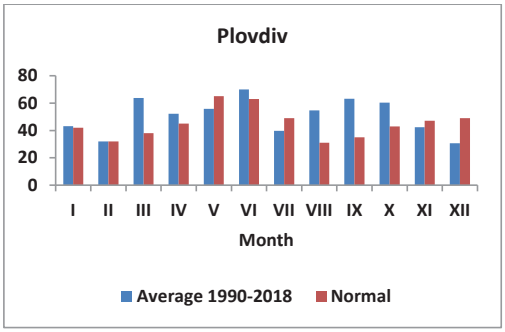


Figure 3. Changes in monthly sum of precipitations in Plovdiv

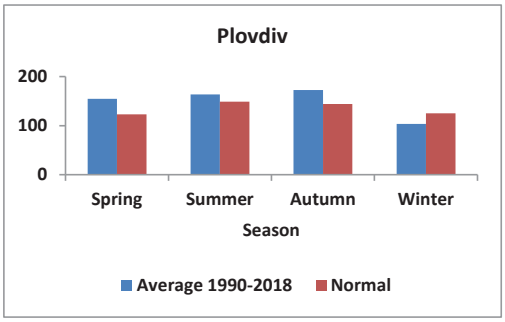


Figure 4. Changes in seasonal sum of precipitations in Plovdiv

Grain and oilseed technical crops have historical and strategic importance for the food needs of the population, the enlargement of national economy and overseas trade of our country (Ivanov et al., 2013).

Production of main cereals and oilseeds crops depends on the area under cultivation and yields. The analysis of the area under cultivation with main crops in Bulgaria shows that the highest positive trend is observed in sunflower and rapeseed (Figures 5a and 5b),

while in barley there is a significant negative trend (Figure 5c). Wheat and grain maize do not show an increase in areas under cultivation in the long term period, but rather stabilization. There is no mathematically proven variation in areas under cultivation of wheat and grain maize. In alfalfa, there is a significant decrease until 2010, after which a sharp increase (positive trend) is observed (Figure 5d).

Unlike the area under cultivation, the trend in yield is positive in all agricultural crops (Figure 6 a, b, c, d, e, f). With the exception of alfalfa, extremely close correlation and regression dependencies were found.

The increase in yield has a direct impact on the total production of these crops (Figure 7 a, b, c, d, e).

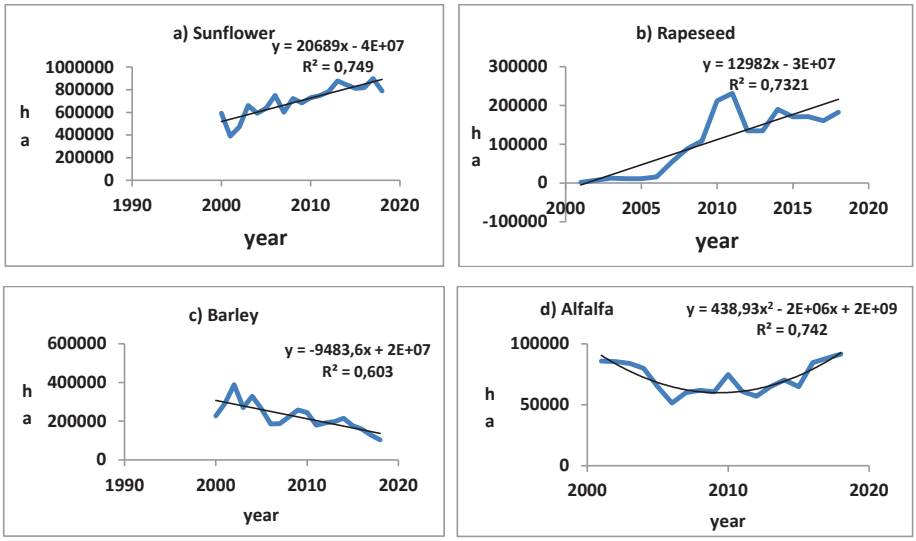
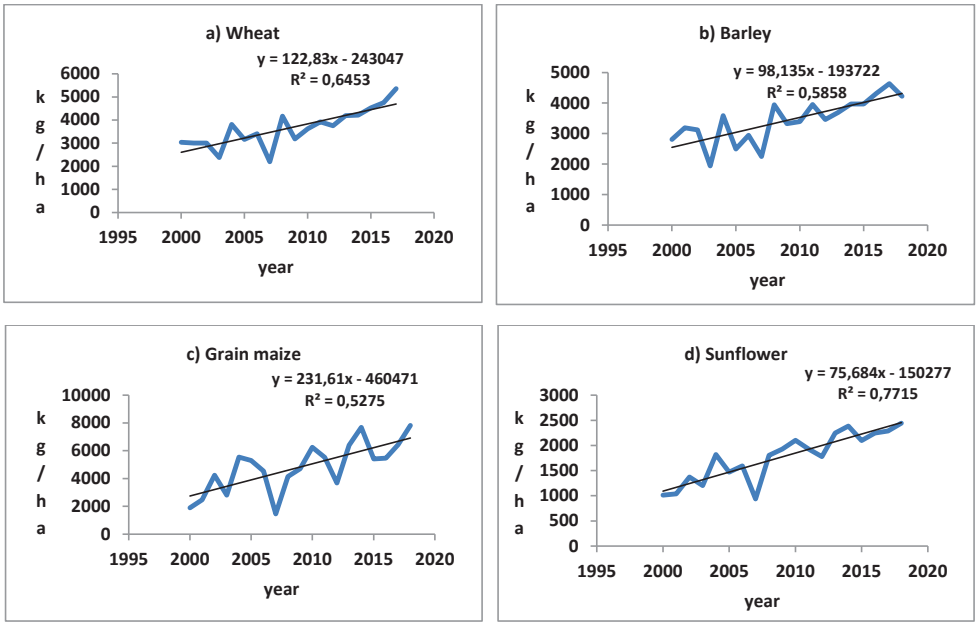


Figure 5. Trends in area under cultivation (ha) of main crops for the period 2001-2018:
a) sunflower; b) rapeseed; c) barley; d) alfalfa
Source: Data by Ministry of Agriculture, Food and Forestry



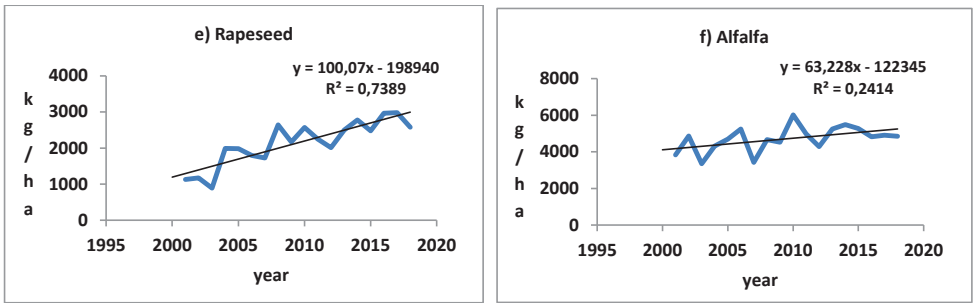
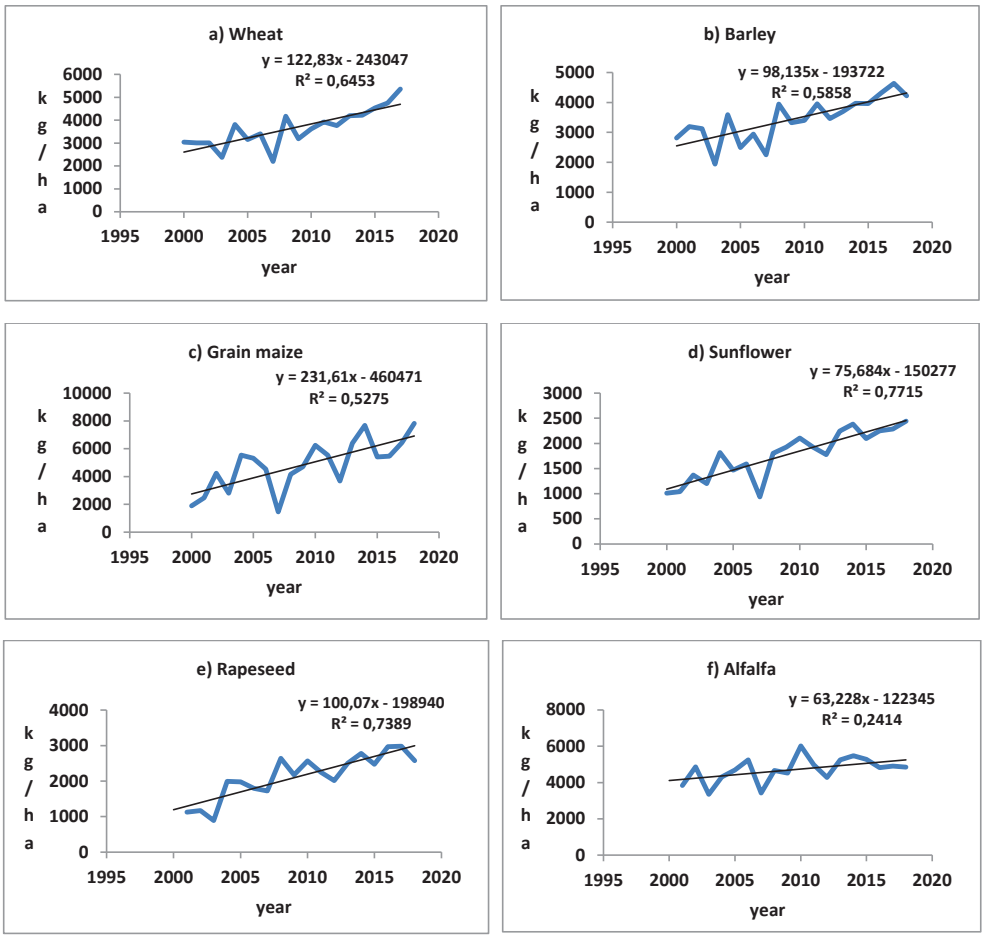


Figure 6. Trends in crop yields (kg/ha) for the period 2001-2018:
a) wheat; b) barley; c) grain maize; d) sunflower e) rapeseed; f) alfalfa
Source: Data by Ministry of Agriculture, Food and Forestry



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a) wheat; b) barley; c) grain maize; d) sunflower e) rapeseed; f) alfalfa
Source: Data by Ministry of Agriculture, Food and Forestry

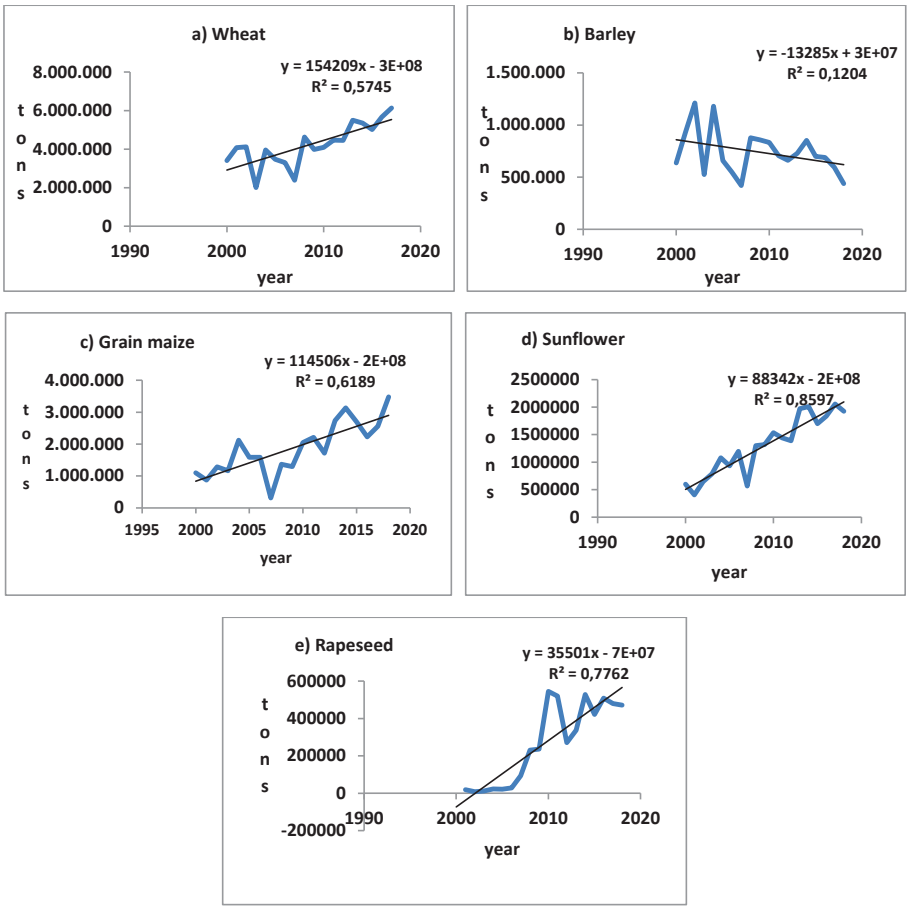

Figure 7. Trends in production (tons) of main crops for the period 2001-2018:
a) wheat; b) barley; c) grain maize; d) sunflower e) rapeseed
Source: Data by Ministry of Agriculture, Food and Forestry

There is no proven correlation in alfalfa.
Against the background of the general trends, differences in planning regions according to NUTS have been found. Tables 1, 2 and 3 presented average data for 18 years period for areas under cultivation (Table 1), production (Table 2) and yields (Table 3) by planning regions.

Table 1 Average area under cultivation of main crops in Bulgaria by planning regions (2001-2018)

Planning regions	Area under cultivation, ha					
	wheat	barley	grain maize	sunflower	rapeseed	alfalfa
NW	263663	29461	102030	148040	26789	7029
NC	307362	50001	98016	162149	23548	16030
NE	393283	45475	143642	190411	29292	20137
SE	258924	61160	8392	115113	23149	9451
SW	54466	6940	8364	18939	1539	3300
SC	168872	28873	11824	76592	7177	14954
Total	1446570	221911	372267	711243	111493	70902

Source: Data by Ministry of Agriculture, Food and Forestry

Table 2. Average production of main crops in Bulgaria by planning regions (2001-2018)

Planning regions	Production, tons					
	wheat	barley	grain maize	sunflower	rapeseed	alfalfa
NW	762260	107730	559407	312106	68864	33681
NC	955946	175465	514636	328499	65202	78187
NE	1264731	163501	714297	373308	75875	92424
SE	718073	200435	35865	189387	50297	43406
SW	129804	16604	33313	27498	3318	15895
SC	440492	81406	53848	108227	14884	73891
Total	4271306	745140	1911365	1339024	278439	337483

Source: Data by Ministry of Agriculture, Food and Forestry

Table 3. Average yield of main crops in Bulgaria by planning regions (2001-2018)

Planning regions	Yield, kg/ha					
	wheat	barley	grain maize	sunflower	rapeseed	alfalfa
NW	3603	3520	4847	1871	2243	4648
NC	4001	3733	5058	1997	2358	4925
NE	4153	3798	5069	1956	2327	4756
SE	3390	3323	4379	1531	1883	4598
SW	2678	2378	3944	1333	1803	4904
SC	2997	2885	4649	1408	1866	4980
Total	3686	3466	4994	1815	2205	4763

Source: Data by Ministry of Agriculture, Food and Forestry

The highest yields of wheat and barley were obtained in the NE region and the lowest in the SW region. The highest yields of grain maize, sunflower and rapeseed were obtained in the NE and NC planning regions, and the lowest in the SW region. The highest yields of alfalfa were obtained in the SC and NC planning regions, and the lowest in the SE region.

The largest production of all crops, except barley, is concentrated in the NE region and the smallest in the SW region. The largest production of barley is concentrated in the SE region.

In barley, the highest yields on average in the country and by planning region were in 2017, with the exception of the NE region, where the highest yields were in 2016 and 2018. The lowest yields on average in the country and in most of the planning regions were obtained in 2007. An exception to this trend is SE and SC, where the minimum is in 2003.

The highest yields for grain maize average in the country and by planning region were established in 2018 and 2014. The lowest yields on average in the country and in the regions of Northern Bulgaria with continental climate (NE, NC, NW) were obtained in 2007, while in the regions of Southern Bulgaria (SE, SC, SW) - in 2012.

The highest yields of sunflower average in the Bulgaria and by planning regions were established in 2018, with the exception of NC, where the maximum is 2013. The lowest average yields for the country and by planning regions in 2007. Only in the SE area the minimum yield is in 2001.

The highest rapeseed yields on average in the country and in most of the planning regions were obtained in 2016 and 2017. In the SW region the maximum is in 2012 and 2014 and in the SC region in 2010. The lowest yields in the country and in most of the planning regions were obtained in 2003. In the SW region the maximum was in 2002, in the SC region in 2006.

The highest alfalfa yields on average in the country and in SE, NW and NC were obtained in 2010, in NE - 2014, in SC - 2002, in SW - 2008. The lowest yields on average in the country and in SE and SC were obtained in 2003, in other planning regions they were in 2007.

CONCLUSIONS

The nature of climate change has been identified and it has been proven that warming in Plovdiv is a fact. It is most sensitive in the

winter months, early in the spring (March) and in the three summer months (June, July and August). However, the minimum air temperatures rise much faster than the maximum.

A positive trend in yields over the last two decades in all main agricultural crops in Bulgaria, with the exception of rapeseed where there is no statistically proven addiction.

There is a trend to increase the production of main cereals wheat, grain maize and sunflower as well as rapeseed, but the most rapidly growing production of sunflower and rapeseed.

The greatest production of all agricultural crops (wheat, grain maize, sunflower, rapeseed, and alfalfa) without barley is concentrated in the Northeast (NE) region, and at least in the Southwest region (SW). Barley production is concentrated in the Southeast region (SE).

The highest yields of all crops, excluding alfalfa, are in the Northeast (NE) and Northcentral (NC) regions, while alfalfa yields - in the Central part of Bulgaria: Southcentral (SC) and Northcentral (NC) regions.

It is necessary to continue research by looking link between planning regions and climate change.

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