

VARIATION OF THE AGRICULTURAL CROPS YIELD DUE TO CLIMATE CHANGE IN CONSTANTA COUNTY COMPARED TO DOBROGEA REGION AND ROMANIA IN THE PERIOD 2010-2019

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Abstract. *The study aimed to analyze the evolution of cultivated surface and yields achieved by the main agricultural crops: wheat, barley, maize, sunflower and rape in Constanta County compared to the yields carried out in Dobrogea Region and in Romania in the period 2010-2019. The climate change especially in terms of higher and higher temperatures, lower and lower amount of precipitations and severe, strong and long length drought were considered responsible of the decline of average production per surface unit in the analyzed period. The results proved that in Constanta County, wheat and maize recorded a high performance compared to the regional decade average and the national decade average. In case of maize crop, Constanta County registered lower yields in almost all the years except 2010 and 2011, both compared to the level in Dobrogea region and in Romania. In case of sunflower crop, in Constanta County, yields were much lower in almost all the years compared to the performance achieved in the Dobrogea region, except 2017 and 2018. Also, rape crop achieved a decline of production per ha in Constanta County compared to the performance in the region of Dobrogea in almost all the years, except 2010 and 2012. For diminishing the effects of climate change on the agriculture of Dobrogea region and especially of Constanta County, farmers have to continue to adapt production technologies, using cultivars and hibrids highly resistant to drought, diseases and pests, choosing a sowing period adapted to the temperature and water reserve into the soil, a corresponding fertilization and plant protection to achieve the desired yields. Also, the Ministry of Agriculture and Rural Development has to urgently implement the program for sustaining agriculture in Dobrogea region recovering the irrigation systems essential for avoiding aridization of the area.*

Keywords: wheat, barley, maize, sunflower, rape, yield, drought, Constanta County

1. Introduction

Cereals and oil seeds plants are the main groups of crops which play an important role in Romania's agriculture (Popescu Agatha, 2012a, 2012b, 2012c, 2015a, 2015b, 2017) [9, 10, 11, 12, 13, 14].

Romania is not only an major producer of cereals and oil seeds but also one of the key exporting member state of the EU.

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Cereals and oil seeds plants are cultivated on the large surfaces and mainly in the South Muntenia, South East, South West and West part of the country (Popescu Agatha, 2018a, 2018b, 2020) [15, 16, 17].

Constanta County and Dobrogea area play an important role in Romania's agriculture. In 2019, in Constanta County, there were cultivated 476,680 ha by 4.57% less than in 2010, and this trend does not fit the general ascending tendency in Romania's cultivated area which accounted for 8,737,275 ha in 2019, being by 11,91% higher than at the beginning of the last decade.

Therefore, the share of Constanta County in Romania's cultivated area declined from 6.39% in 2010 to 5.45% in 2019 (NIS, 2020) [8].

The main agricultural plants cultivated in Constanta County are wheat, barley, maize, sunflower and rape whose cropped surface, all together, in 2019 accounted for 402,247 ha, representing 84.38% of the whole cultivated surface in the area. While the surface cultivated with wheat registered a slight increase, maize was cultivated on a 2.18 times larger surface than in 2010 and sunflower on an area by 11.29% higher than in the first year of the decade. An important decline in the cultivated area was noticed in case of barley (-1.57 percentage points) and mainly in case of rape (- 11.77 percentage points) (Tabel 1).

Table 1. Cultivated area with the main agricultural crops and their share in the cultivated area in Constanta County in 2019 versus 2010

		Wheat	Barley	Maize	Sunflower	Rape
Cultivated area (ha)	2010	180,514	55,055	28,889	78,014	80,168
	2019	181,623	45,092	63,499	86,828	25,205
Share in cultivated area in Constanta county (%)	2010	36.14	11.02	5.78	15.61	16.05
	2019	37.89	9.45	13.32	18.21	4.28

Source: Own calculation nased on the data from NIS, 2020 [8].

These changes in Constanta County agricultural crops structure are closely related to the importance of each crop, its productivity level, the favorability of soil type, climate conditions, market price volatility at the farm gate.

However, climate change impact on agricultural production is more visible year by year in Romania, and especially in Dobrogea region and Constanta County.

As in Dobrogea region, the annual average temperature is much over 11⁰C and the amount of precipitations varies between 351 and 450 mm/year, it is considered that this South East part of Romania has a high level of drought risk (Mateescu Elena, 2016) [6].

Year by year, Constanta County is facing increased temperatures, the decline of rainfalls, water deficit into the soil, a long period of drought, the tendency to aridization and desrtification which destroy soil structure, fertility and

productivity (Prăvălie et al, 2014, Prăvălie and Bandoc, 2015, Sandu et al., 2010) [18, 19, 20].

During the last decade, 2010-2019, the extreme droughts were registered in the years 2011-2012, 2014-2015, 2016, 2018, and 2019. The year 2019 was an atypical one, characterized by a long and severe drought which started in spring, continued in summer, autumn, and in winter, then in spring, summer and autumn of the year 2020. For this reason, it was named "the warmest year since measurements are made in Romania, that is during the last 140 years since 1900 till present" (Mateescu et al, 2009, Mateescu, 2016, Mateescu, 2019) [4, 5, 6].

Facing with drought during the last decades, farmers have learned from their own experience and using the research results regarding how to fight against drought by adapting production technologies, they found solutions year by year trying to diminish the negative effects of this terrible phenomenon which affect agriculture in Constanta County and in Dobrogea region (Manole et al., 2018a, 2018 b, 2018c) [2, 3, 4].

However, the insufficient irrigated agricultural surface in Constanta County, which accounts nowadays for only 13,000 ha compared to 421,319 irrigated arable land in 1990, and in addition the lack of protective forestry curtains, have amplified the effects of the drought on agricultural production performance, environment, biosystem, and farmers' income (Ciobanu Diana, 2020) [1].

The purposes of this study were: (i) to study the dynamics of yields of the main agricultural crops: wheat, barley, maize, sunflower and rape in Constanta County in the decade 2010-2019 in order to identify the main trends; (ii) to compare the average decade yield in Constanta County with the average decade yield achieved in Dobrogea region and in Romania in order to quantify the differences which have to prove the effect of drought; (iii) to evaluate the annual losses of yield in Constanta County from the yield level in Dobrogea region and at the national level and (iv) to establish the suitable recommendations that farmers and authorities have to follow to diminish the effects of drought in Constanta County.

2. Materials and Methods

The study is based on the empirical data collected from National Institute of Statistics, 2020 and are processed using the following methodology:

The average value of agricultural crop production during the decade 2010-2019 which was calculated with the formula:

$$\bar{y} = \frac{\sum_{t=1}^n y^t}{n}$$

Mean at the decade level, $\bar{Y} = \frac{\sum_{i=1}^n y_i}{n}$

Absolute differences between average decade yield in Constanta County, Dobrogea region and Romania, $\Delta = \bar{y}_{CT} - \bar{y}_{Dobrogea}$; $\Delta = \bar{y}_{CT} - \bar{y}_{Romania}$;

Absolute differences between average crop yield in Constanta County, Dobrogea region and Romania, $\Delta = y_{CT} - y_{Dobrogea}$; $\Delta = y_{CT} - y_{Romania}$.

3. Results and Discussions

3.1. Yield level for the main agricultural crops in Constanta County

In the analyzed decade, in Constanta County, agricultural yields increased for all the crops in 2019 compared to 2010 by + 80.8% for wheat, by +63.14% for barley, by+14.27% for maize, by + 72.95% for sunflower and by +13.38% for rape.

The lowest yields were recorded especially in the year 2012 for barley 2,674 kg/ha, for maize 1.430 kg/ha and for sunflower 1,126 kg/ha. In 2010, wheat registered the smallest yield 2,626 kg/ha and in 2011, rape 1,342 kg/ha (Table 2).

Table 2. Yields for the main agricultural crops in Constanta County, 2010-2019 (kg/ha)

	Wheat	Barley	Maize	Sunflower	Rape
2010	2,626	2,914	4,925	1,538	1,875
2011	4,307	4,036	5,025	1,343	1,342
2012	3,039	2,674	1,430	1,126	1,690
2013	2,921	2,836	3,273	1,495	1,720
2014	3,279	3,063	3,575	1,834	2,167
2015	3,785	4,176	2,894	1,597	2,301
2016	4,008	4,617	3,191	1,502	2,293
2017	5,413	4,475	5,786	3,180	2,211
2018	5,677	5,207	8,124	3,715	2,288
2019	4,748	4,754	5,628	2,660	2,126
2019/2010 %	180.80	163.14	114.27	172.95	113.38
Decade Mean	3,980.3	3,875.2	4,385.1	1,999	2,001.3

Source: Own calculations based on the data from NIS, 2020 [8].

The highest grain yields were achieved in the year 2018: 5,677 kg/ha wheat, 5,207 kg/ha barley, 8,124 kg/ha maize, 3,715 kg/ha sunflower seeds and in 2015, 2,288 kg/ha rape seeds.

In the studied decade, the average production per surface unit was: 3,980.3 kg/ha wheat, 3,875 kg/ha barley, 4,385.1 kg/ha maize, 1,999 kg/ha sunflower and 2,001.3 kg/ha rape. Therefore, maize is a high performance crop, followed by wheat and barley, while rape and sunflower have a lower productivity (Table 2).

3.2. Comparison between the average yield achieved in the period 2010-2019 by Constanta County and the average decade yield in Dobrogea region and in Romania

In the last decade, Constanta County carried out a higher production performance in case of wheat and barley than the decade average in Dobrogea region and at the national level.

In case of maize, Constanta County achieved a decade average by - 414.7 kg/ha lower compared to the national level and by -98.7 kg/ha lower compared to the regional level.

In case of sunflower, the decade average was by -135.6 kg/ha smaller than the decade average in Romania and by +83.4 kg/ha higher compared to the regional average (Table 3).

Table 3. Average decade yields for the main agricultural crops in Constanta County, compared to Dobrogea region and Romania's performance, 2010-2019 (kg/ha)

	Wheat	Barley	Maize	Sunflower	Rape
Constanta county	3,980.3	3,875.2	4,385.1	1,999	2,001.3
Dobrogea region	3,713.4	3,281.0	4,483.8	1,915.6	1,911.2
Romania	3,821.5	3,449.2	4,799.8	2,134.6	2,308.7
Difference versus Romania	+158.8	+426	-414.7	-135.6	-307.4
Difference versus Dobrogea region	+266.9	+594.2	-98.7	+83.4	+90.1

Source: Own calculation based on the data from NIS, 2020 [8].

In case of rape, in Constanta County, the decade average yield was by -307.4 kg/ha lower than the national average and by +90.1 kg/ha higher than the decade average in Dobrogea region.

This proves that during the analyzed decade, the climate conditions affected very much agricultural yield in Constanta County in case of maize, which was not a

competitive crop both at the regional and the national level, having a lower productivity.

Sunflower and rape have also registered a lower productivity in Constanta County (Table 3).

3.3. Differences regarding maize crop yield versus the yield in Dobrogea region and Romania

Compared to the average production in Dobrogea region, maize yield in Constanta County was lower in the years 2013, 2014, 2018, 2017, 2015, 2016, which are the unfavorable years for this crop in this area. The yield losses varied between -579 kg/ha in 2013 and -20 kg/ha in 2016. The best agricultural year in Constanta County compared to the average maize yield at the regional level was 2019 (Table 4).

Table 4. Differences in maize yield in Constanta County compared to the yield in Dobrogea region and Romania, 2010-2019 (kg/ha)

	Maize Yield (Kg/ha)			Differences between Constanta County and	
	Constanta County	Dobrogea Region	Romania	Dobrogea Region	Romania
2010	4,925	4,237	4,309	+688	+616
2011	5,025	4,541	4,525	+484	+500
2012	1,430	1,374	2,180	+56	-750
2013	3,273	3,852	4,488	-579	-1,215
2014	3,575	4,143	4,770	-557	-1,195
2015	2,894	2,980	3,462	-86	-568
2016	3,191	3,211	4,159	-20	-968
2017	5,786	6,065	5,959	-279	-173
2018	8,124	8,472	7,644	-348	+480
2019	5,628	4,600	6,502	+1,082	-974

Source: Own calculations based on the data from NIS, 2020 [8].

Making a comparison between the annual maize yield achieved in Romania in the last decade, we may easily notice that Constanta County carried out lower yields, the unfavorable years being, in the decreasing order of yield differences: 2013, 2014, 2016, 2019, 2015 and 2017, which show that Constanta County was very much affected by climate factors compared to other areas of the country, which resulted in a diminished productivity, lower farmers' income and a reduced

contribution of Constanta agriculture to the agriculture of Dobrogea region. The yield losses ranged between -1,215 kg/ha in the year 2013 and -173 kg/ha in the year 2017 (Table 4).

3.4. Differences regarding sunflower and rape yields versus Romania's yield

Comparing sunflower yield in Constanta County with Romania's yield for this crop, we may notice that in almost all the years of the decade 2010-2019, yields in this county were much lower, except the year 2017 and 2018, when Constanta County achieved higher production levels (Table 5).

Table 5. Differences in sunflower seeds and rape yields in Constanta County compared to the yield in Romania, 2010-2019 (kg/ha)

	Sunflower yield (kg/ha)			Rape yield (kg/ha)		
	Constanta County	Romania	Differences versus Romania	Constanta County	Romania	Differences versus Romania
2010	1,538	1,797	-59	1,875	1,755	+120
2011	1,343	1,798	-455	1,342	1,882	-540
2012	1,126	1,310	-184	1,690	1,496	+194
2013	1,495	1,993	-498	1,720	2,408	-688
2014	1,834	2,187	-353	2,167	2,604	-437
2015	1,597	1,765	-168	2,301	2,499	-198
2016	1,502	1,955	-453	2,293	2,835	-542
2017	3,180	2,917	+263	2,211	2,798	-587
2018	3,715	3,041	+674	2,288	2,546	-258
2019	2,660	2,783	-123	2,126	2,254	-138

Source: Own calculations based on the data from NIS, 2020 [8].

Taking into account the negative variation of yield, the unfavorable years for sunflower crop in Constanta County, in the decreasing order, were: 2013, 2011, 2016, 2014, 2012, 2015, 2019 and 2010, when yield losses varied between -498 kg/ha in 2013 and -59 kg/ha in 2010.

In case of rape, the seeds yield was lower than the national yield in the years: 2013, 2017, 2016, 2011, 2014, 2018, 2015, 2019, the losses ranging between -138 kg/ha in 2011 and - 688 kg/ha in 2019 (Table 5).

Conclusions

(1) Agriculture of Constanta County is extremely important for Romania as it brings a substantial contribution to Romania's agricultural output in general, and especially to cereal and oilseeds production.

(2) Unfortunately, climate change with which Constanta County is facing: high temperatures, decline in the amount of precipitations, pedological drought have affected during the last decade cultivated surface and mainly production performance per hectare, which have led to substantial production losses, the decrease of the farmers' income, the increase of the risk for not covering production costs and going to fail.

(3) In the analyzed decade, 2010-2019, Constanta County obtained good wheat and barley production per ha, higher than the average yield in Dobrogea region and in Romania.

(4) In case of maize, Constanta County registered a lower productivity both compared to the average production per surface unit in Dobrogea region and at the national level.

(5) Also, in case of sunflower and rape crops, Constanta County achieved lower yields in comparison with the decade average in Dobrogea region.

(6) It is worth mentioning that farmers have paid a high attention to the weather forecast warnings, and they took important measures and found alternatives for adapting production technologies for each crop to diminish the impact of climate change factors, and especially to drought. In this respect, they tried to use varieties and hybrids of high production potential and resistant to drought, diseases and pests, they changed the sowing moment and the sowing depth in relationship with the soil temperature and moisture, and applied a suitable fertilization and plant protection.

(7) The year 2019 was characterized by a very strong drought which has continued in the year 2020. The insufficient amount of precipitations, the high temperatures over 32°C for a long period of time, and coupled with the lack of irrigation systems in Constanta County have led to lower yields.

(8) Many farmers were in the situation not to be able to cover production cost by the obtained yields, many of them being in danger to fail, because they had to pay the suppliers of agricultural inputs, to reimburse money to banks and leasing companies, to pay the rent to lessors.

(9) To fight against drought and to avoid production losses and the transformation of Constanta County and Dobrogea region into an arid area and desert, the following recommendations are suggested:

- farmers to continue to adapt production technologies to climate change, using cultivars and hybrids highly resistant to drought, diseases and pests, choosing a sowing period adapted to the temperature and water reserve in the soil, a corresponding fertilization and plant protection to achieve the desired yields;
- forest curtains against drought, desertification and for crop protection are compulsory to be created;
- irrigation systems for supplying water from the Danube - Black Sea Channel are compulsory to be installed;
- investments from the public budget are required for assuring water supply through the main channels and pumping stations;
- farmers have to rebuild the secondary installations which have to allow them the access to irrigation water source;
- the aids offered by Government to support farmers who registered damages and losses due to pedological drought like in the year 2020 have to be set up according to production and not according to the cultivated area.

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