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CEREALS PRODUCTION BETWEEN CLIMATE CHANGE AND PRICE BOOM IN ROMANIA

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Abstract

The purpose of this research work was to analyze cereals cultivated area, yields, production and price at farm gate in Romania during the last decade, 2012-2021 and also in the year 2022 in order to identify the main trends and causes which affected the performances. The data provided by National Institute of Statistics and Eurostat were processed using indices methods, regression equations and r square, and comparisons between maize and wheat. The results emphasized that, compared to 2012 level, in 2021, Romania achieved 27.79 million tonnes cereals (+116.27%), 14.82 million tonnes maize grains (+149.07%), and 10.43 million tonnes wheat (+96.79%). Maize and wheat represent 92.8% of Romania's cereals production. The high record is explained by the large surfaces cultivated with cereals, accounting for 5.35 million ha in 2021 (-1.6% less than in 2012), of which maize 47.6% and wheat 40.6%, all together 88.2%. Yields are still below the levels achieved by France, Germany, Poland, Italy and Spain, which are its EU main competitors in producing cereals. Compared to 2012, in 2021, cereals yield was 5,188 kg/ha (+120%), maize 5,802 kg grains/ha (+166.16%), wheat 4,797 kg/ha (+78.85%), reflecting the efforts made by farmers to increase production. These results were carried out under the impact of intense climate variations and extreme phenomena like: high air temperatures, heat waves, long droughts, low precipitations. High price volatility for Diesel, seeds, fertilizers, products for plant protection etc had a deep impact on the increase of production costs. Cereals price at the farm gate also increased, under the influence of the unbalance demand/supply ratio in the international market, cereals quotations at the international stock exchange, and hostilities between Russia and Ukraine. Un uncertain future is for the coming agricultural years, when farmers have to strengthen their efforts as their business to survive. They have to set up new technological alternatives for crop structure, cultivated areas, amendments, conservative agriculture, lower farms inputs, environmentally friendly solutions to sustain soil fertility, extend biodiversity, and also to keep production costs under strict control and to assure a lower risk for their business.

Key words**:** *cereals production, climate change, producer's price, farm input prices, Romania*

INTRODUCTION

Romania is one of the most important cereals producers in the EU after France, Germany and Poland [9, 40].
Numerous farms are profiled on cereals cropping being concentrated especially in the South, South East, South Oltenia and West regions of the country [43, 44].
The main cereals cultivated on larger surfaces in Romania are maize and wheat, followed by barley and two-row barley, and rye [46, 47].
High production performances were recorded in many years, but, during the last decade, the long droughts caused by high temperatures and low annual precipitations diminished yields and harvests [32, 35, 36, 43] as cereals are very sensitive to long dry periods and lack of water into the soil and in the period of vegetation [49].
These unfavorable weather conditions affected not only Romania, but also many other European countries in the recent years,

mainly in 2019, 2020, 2021 and more intensively in 2022 [1, 30, 8].

The demand/offer ratio is one of the main factors influencing market price, but in case of cereals their price is also impacted by the volatility of the quotations at the international stock exchange, where price index is compiled using the International Grains Council (IGC) Wheat price index of 10 quotations [54].

In addition, farm inputs price has a deep impact on the level of production costs which are also important in establishing producer's price [24].

In the "era of volatility", cost, revenue and profitability have become uncertain and business management is more and more risky, so that for farmers is being more and more difficult to anticipate the expected profits or losses as long as "the prices of farm inputs like: fertilizers, seeds, pesticides, energy, machinery and land raise from a period to another and even from a week or a day to another" [48, 31, 55].

The increase of prices has been intensified since the fall of the year 2021 and has been deeply amplified in February 2022 when the conflict between Russia and Ukraine emerged.

Under these circumstances, when agriculture is facing a mixture of crises regarding: climate change, fuel, fertilizers, seeds, plant protection products, putting on uncertainty agri-food production, market and food security, farmers and researchers are looking for solutions to diminish the negative effects of climate change and to reduce costs in order to help their business to survive [19, 20].

In this context, the goal of the paper was to study the dynamics of the cultivated area, yield, production to identify the main trends in Romania and the comparison with other EU countries was destined to establish our country's position. A special accent was put on cereals price at farm gate, in case of maize and wheat, as a reflection of production costs and profitability level per kilogram of grains. Also, the evolution of the fuel price was studied being considered that diesel price has a deep impact on farm inputs prices (seeds, fertilizers, plant protection products). The identified causes of the production gaps in the analyzed period 2012-2021 and the year 2022 became a starting point to develop a few suggestions to farmers to help them to maintain and increase production under the condition of climate change.

MATERIALS AND METHODS

The paper was set up using a large range of information sources and statistical data from National Institute of Statistics and Eurostat for the period 2012-2021, and also data about 2022 from Ministry of Agriculture and Rural Development and other sources.

The main aspects approached in this study have been:

-Cultivated area with cereals, at a whole but also by cereal type.

-Maize and wheat yields.

-Cereals, maize and wheat production.

-Maize and wheat price at farm gate.

-Fuel (diesel) price, considered one of the most important cause of the increased price for farm inputs: seeds, fertilizers, products for plant protection etc.

Tables and graphs were used for synthetically illustrate the obtained results which have also been commented.

At the end of the study there were briefly shown the main ideas resulting from this research and there were also presented a few recommendations for farmers to face much better to climate change for sustaining production.

RESULTS AND DISCUSSIONS

Cultivated area with cereals

Romania is recognized among the most important cereals producing countries in the EU. Its performance is favored by the geographical position, soil and climate conditions and tradition in cultivating cereals.

In Romania, cereals are cropped on 33% of the cultivated area. However, there are differences regarding the cultivated areas, yields and production among the regions of development and also between the Northern part and the Southern part of Romania [27].

In the last decade, the cultivated area with cereals fluctuated up and down, the general trend being a decreasing one.

In 2021, cereals were cultivated on 5.351 thousand ha, an area by 1.64% smaller than in the year 2012, when it accounted for 5,440 thousand ha. In this interval, after a slight increase from the year 2012 to 2016, a smaller area was cultivated by farmers in the year 2017, taking into account the fact that, in the previous years, yields were very much affected by drought, especially in 2015 when the air temperature was by +1.96^{0}C higher compared to the average temperature during 1961-1990 [29].

From the year 2018, the surface with cereals increased again and culminated with the peak of 5,569 thousand ha in the year 2019, and then again it dropped to 5,338 thousand ha in the year 2020, as the year 2019 was considered by the meteorologists the warmest year since temperatures are measured [29, 49] (Fig. 1).

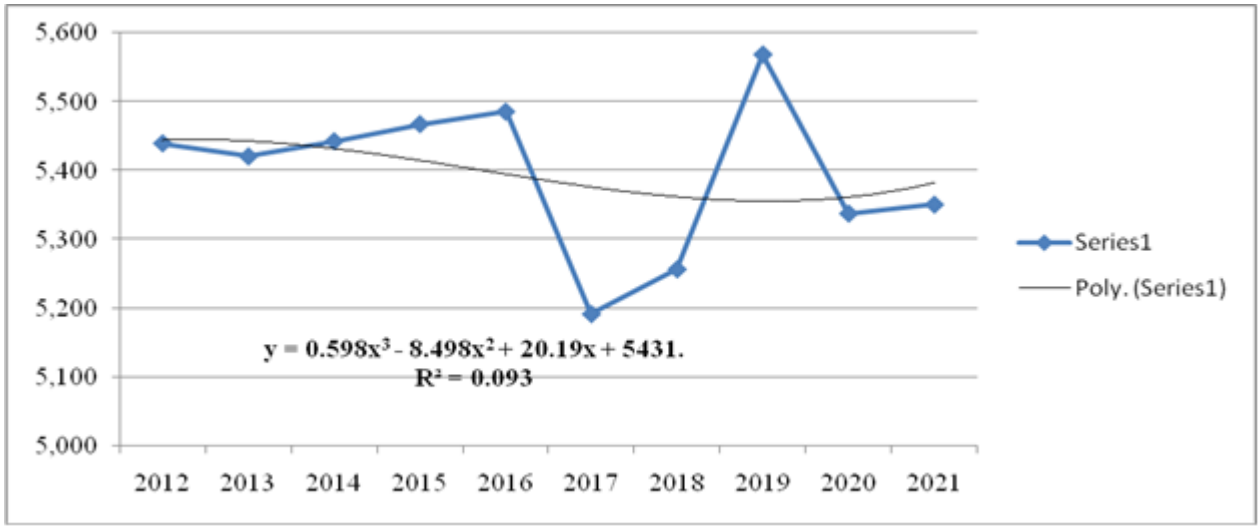

Fig. 1. Dynamics of the cultivated area with cereals in Romania, 2012-2021 (Thousand hectares)
Source: Own design based on the data from [32].

The cereals crops cultivated in the country are: maize for grains, wheat, barley, two-row barley, rye, oats, sorghum and rice.

In 2021 compared to the year 2020, the cultivated area with cereals was 5,237 thousand ha, by 23% smaller [33].

The largest surfaces are covered by maize and wheat.

Maize comes on the top position, but in the studied period, the surface was diminished by -6.7% from 2.73 million ha in the year 2012 to 2.55 million ha in the year 2021.

From this point of view, Romania came on the top position in the EU in the year 2021 [6, 36].

On the 2nd position is wheat, which was cultivated on a larger area from a year to another, and in 2021 it accounted for 2.18 million ha, being by +9.75% higher than in 2012.

For the surface cultivated with wheat in the year 2021, Romania came on the 4th position in the EU after France, Germany and Poland [36].

The surface cultivated with barley increased by +60.9% from 206.9 thousand ha in 2012 to 333 thousand ha in 2021.

Barley and two-row barley registered a diminished cultivated area by -55.2% and respectively -46.6% in the analyzed interval.

Rye was cultivated on much smaller areas, but with a general increasing trend from 8.6 thousand ha in 2012 to 12.1 thousand ha in 2021.

Sorghum registered a decline in cultivated area accounting for -64% from 20 thousand ha in 2012 to 7.3 thousand ha in the year 2021.

Finally, rice was cultivated on a smaller and smaller surface accounting for only 5.4 thousand ha in the year 2021 compared to

11.3 thousand ha in 2012, meaning a reduction by 52.22%.

Therefore, in the cereals crops structure, maize and wheat keep the highest share of 89.3%.

If in 2012, maize represented 50.2% and wheat 36.7%, barley 3.8%, two-row barley 3.9% and the remaining belonged to other cereals, in the year 2021, the weight of these crops was: maize 47.6%, wheat 40.6%, barley 6.2% and two-row barley 2.2%, oats 1.6%, rye 0.2%, sorghum 0.13% and rice 0.11% (Fig. 2).

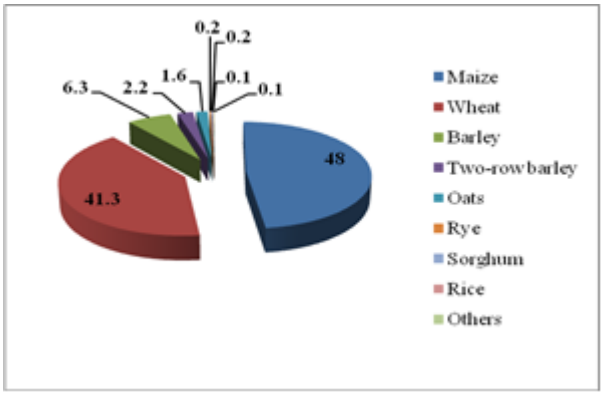

Fig. 2. The share of the cereals crops in the total cultivated areas with cereals in the year 2021 (%)
Source: Own design based on the calculations and [32].

In 2022, the cultivated area with cereals was 5.4 million ha [35].

Taking into account that maize and wheat are the main cereals cultivated in Romania, and in a lower measure barley, in the following paragraphs we discussed especially about these crops [47].

Yields

Average production per surface unit depends on many factors, the main ones being: cereal type, variety or hybrid, soil type, fertility and water reserve capacity, availability of irrigations or not, applied technologies and climate favorability.

The last decade proved a more and more intensive influence of weather conditions which were not favorable leading to deviations of yields from crop production potential with damages and losses for farmers' business.

In the analyzed period, average production of cereals varied between 2,357 kg/ha in 2012 and 5,188 kg/ha in 2021, reflecting and increase by +120%. However, the peak of yield accounted for 5,999 kg/ha achieved in the year 2018.

The highest yield increase was registered by maize, +166.14%, as in the year 2021, it was obtained 5,802 kg/ha grains compared to only 2,180 kg/ha in the year 2021.

In case of wheat, the yield growth in the studied interval was smaller in comparison with maize, accounting for only +78.85%, as in 2021, Romania registered 4,797 kg/ha wheat grains versus 2,682 kg in the year 2012.

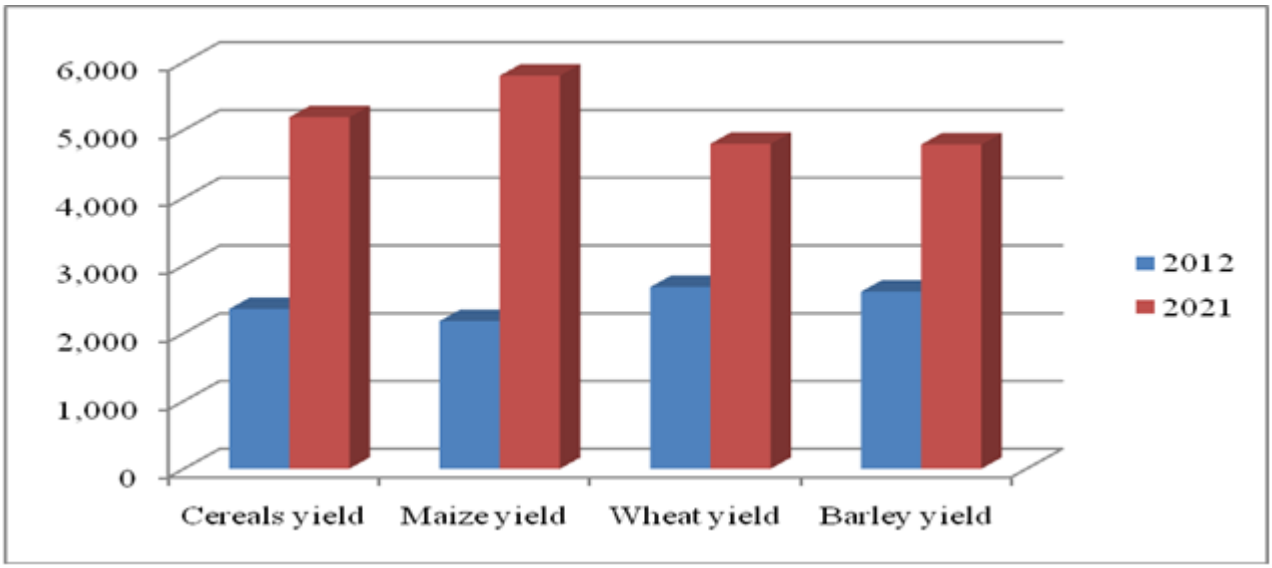

Fig. 3. Cereals, maize, wheat and barley yields in 2021 versus 2012 in Romania (kg/ha)
Source: Own design based on the data from [32].

Despite that it is cultivated on a smaller surface, barley has relatively good yields which must be specified. In 2021, barley yield accounted for 4,786 kg being by +83.16% higher than in 2012, when this crop produced only 2,613 kg (Figure 3).

In case of cereals yield, in the analyzed interval, the highest performance of 5,999 kg/ha was achieved in the year 2018 compared with the lowest level of 2,357 kg/ha in 2012.

In case of wheat, the most favorable year was 2017 when it was obtained 4,888 grains per ha in comparison with the lowest yield of 2,966 kg per ha carried out in the year 2020, the minimum level in the whole analyzed decade.

In case of maize, the highest yield was 7,644 kg grains per ha achieved in the year 2018 versus the lowest level of 2,180 kg in the year 2012.

Barley was more productive in the year 2021, reaching 4,786 kg/ha compared to the lowest yield of 2,613 kg registered in the year 2012.

The dynamics of cereals yield is shown in Fig. 4 and the dynamics of maize and wheat yield in Romania is presented in Figure 5.

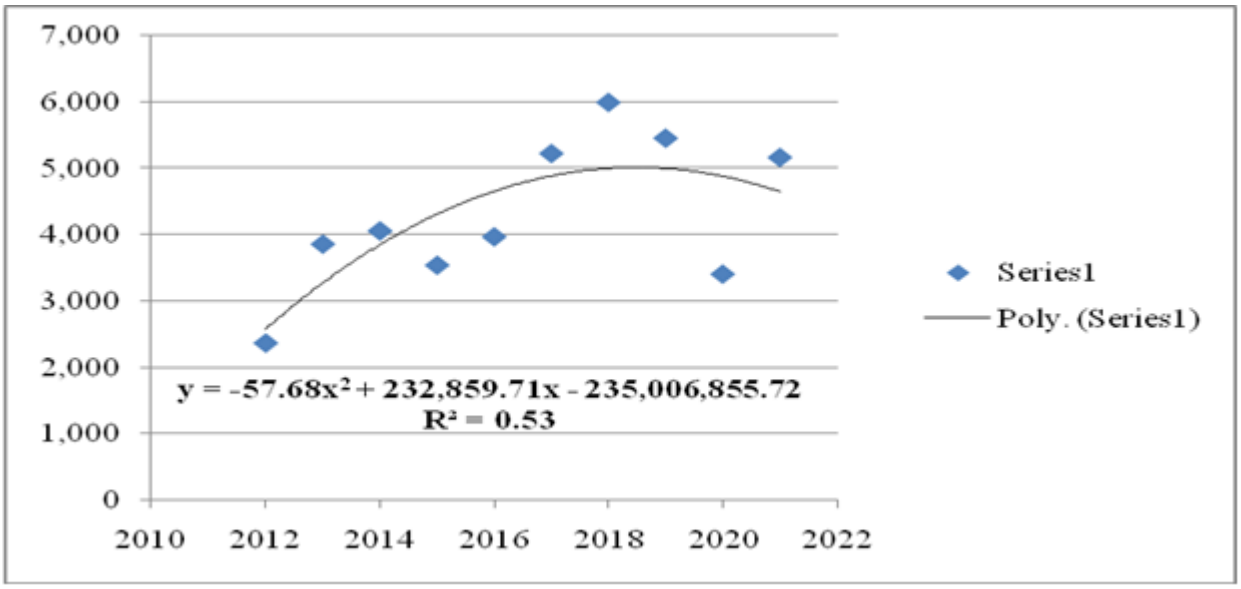

Fig. 4. Dynamics of cereals yield in Romania, 2012-2021 (kg/ha)
Source: Own design based on the data from [32].

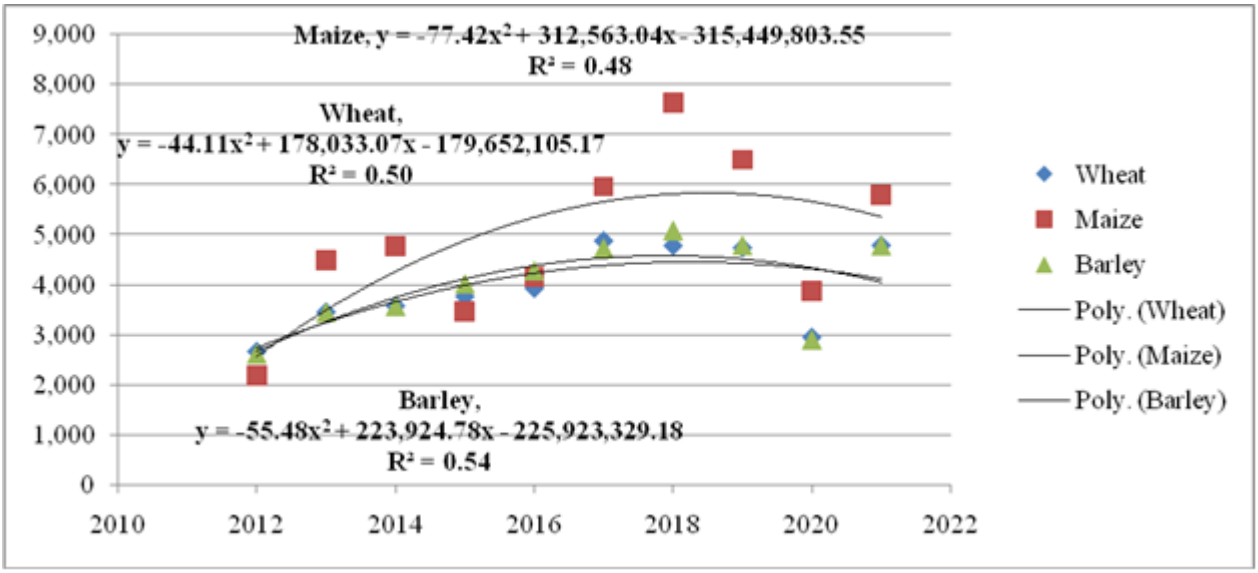

Fig. 5. Dynamics of maize, wheat and barley yield in Romania, 2012-2021 (kg/ha)
Source: Own design based on the data from [32].

Having in mind that in this decade the climate change has had a deep impact on yield level, we could consider that Romania achieved a reasonable performance on large surfaces cultivated with cereals.

However the negative impact of bad weather conditions varied from a cereal crop to another regarding if it was about an winter or spring crop, and also on the moments of plant growing from sewing till harvesting.

The extreme meteorological phenomena have intensified their frequency and impact, so that in the last three years 2018, 2020 and 2021 yields and productions were very much affected in many regions of Romania, especially in the South and South Eastern part, in the South Oltenia, West and Moldova.

The low precipitations in autumn when it is the time for sewing winter wheat, barley, and two-row barley, the lack or not sufficient snow layer during winter season, spring with pale rains, and then summer with high temperatures, heat waves, long and strong drought, water shortages have been the most important factors of climate stress on cereals crops, but also on other plants.

From a meteorological point of view, the reality is that the most dried year was 2015 in the interval 2012-2021. In the next years after 2015, yields increased, so that in 2018 there were obtained records for cereals yield, 5.999 kg, and for maize, 7,644 kg, but wheat registered a lower yield than in 2017, when this crop achieved the highest performance of 4,888 kg

In 2022 wheat yield is estimated about 4.3 tonnes/ha, by 25% smaller than in 2021 [34].

In the year 2021, Romania came on the 3rd position after France and Italy for maize yield [6].

Analyzing the production performance per surface unit in Romania compared to the other main cereals producing countries in the EU: France, Germany, Poland, Italy and Spain, we may easily notice that cereals, wheat and maize yields are smaller than in these countries.

Therefore, cereals, wheat and maize outputs of Romania are high due to the larger cultivated areas than in the countries mentioned above (Table 1).

Table 1. Cereals, wheat and maize yields in Romania versus the other main cereals producing countries in the EU in the year 2020 (kg/ha)

	Cereals	**Wheat**	**Maize**
France	6,384	6,680	7,935
Germany	7,130	7,819	9,587
Poland	4,705	5,239	7,076
Italy	5,627	3,925	11,268
Spain	4,502	4,253	12, 258
Romania	3,453	2,966	3,977
-Diference vs France	-2,931	-3,714	-3,958
-Difference vs Germany	-3,677	-4,853	-5,610
-Difference vs Poland	-1,252	-2,273	-3,099
-Difference vs Italy	-2,174	-959	-7,291
-Difference vs Spain	-1,049	-1,287	-8,181

Source: Own calculation based on the data from [26].

Cereals production

In 2021, cereals output accounted for 27.29 million tonnes, being by +116.77% higher than in the year 2012, when there were harvested 12.92 million tonnes.

However, in 2018, cereals production achieved its peak of 31.55 million tonnes and also in the year 2019, it reached 30.41 million tonnes. The production differences in 2020 and 2021 have been caused by climate change.

Wheat production recorded its maximum performance in the year 2021, accounting for 10.43 million tonnes, being by +96.43% higher than in 2012.

Maize output accounted for 14.82 million tonnes in 2021, by + 149.07% higher than in the year 2012. But, if we consider the peak of

18.66 million tonnes maize grains achieved in the year 2018, this means that in the year 2021 maize production was by 20.6% smaller (Figure 6). Regarding the contribution of maize and wheat to cereals production, in 2021, maize accounted for 53.3% and wheat for 37.5%, all together meaning 90.8% of total cereals production.

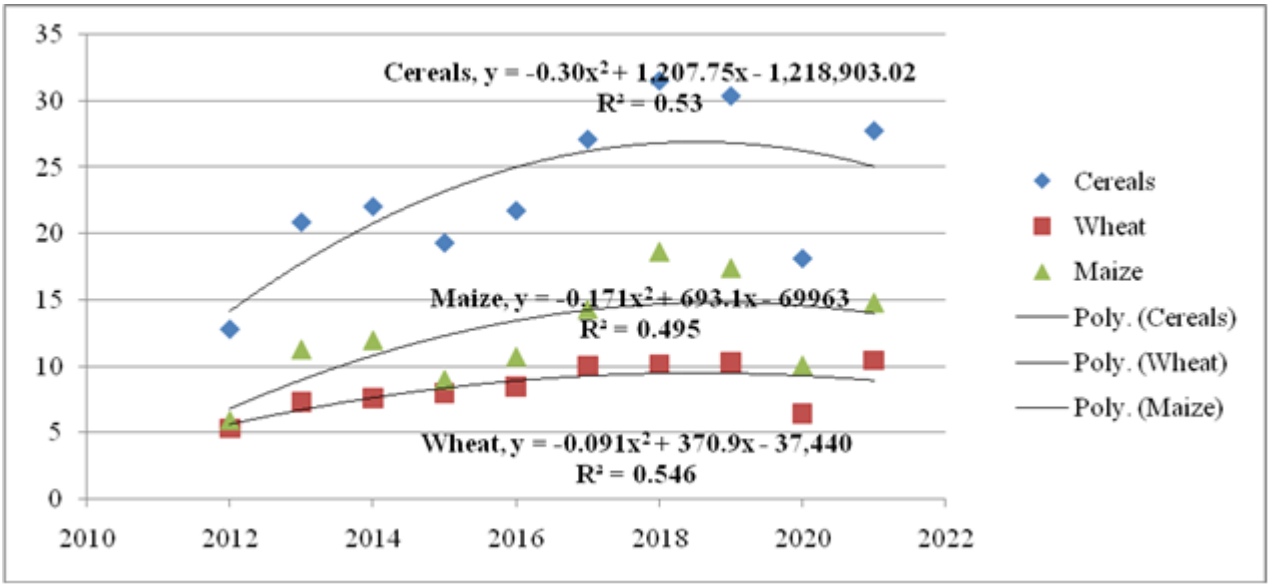

Fig. 6. Dynamics of cereals, maize and wheat production in Ronania, 2012-2021 (Million tonnes)
Source: Own design based on the data from [32].

The good performances in production registered during the last decade are explained by the efforts made by farmers to improve technologies, more exactly to use certified seeds from varieties and hybrids of high production potential, resistant to drought, diseases and pests, enlarging the irrigated surfaces etc to face much better to the challenges of the climate change.

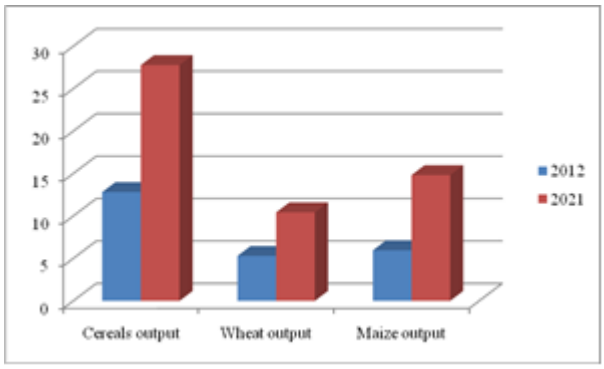

Fig. 7. Cereals, maize and wheat output in 2021 versus 2012 (Million tonnes)
Source: Own design based on the data from [32].

However, the last year 2019, 2020and 2021 were very stressing for cereals farming, due to the higher and higher temperatures, low precipitations and long drought and pedological drought.

The comparison between the performance in cereals output in 2021 versus 2012 is reflected in Fig. 7.

In the year 2021, Romania was on the 4th position in the EU for cereals production of 27.8 million tonnes, representing 9.3% of the EU cereals output accounting for 297.5 million tonnes.

Romania is a competitive cereals producing country for France which achieved 66.9 million tonnes (22.5%), Germany 42.4 million tonnes (14.3%) and Poland 34 million tonnes (11.4%) [10]. (Fig. 8)

In 2021, Romania came on the top position in the EU for maize production, but on the 4th for wheat production after France, Germany and Poland. But, for the year 2022, the expectations are not similar [36].

Till October 10, 2022, Romania harvested 9.2 million tonnes wheat, representing 88.2% of the level recorded in 2021 and 4.3 million tonnes maize, representing 29% of the production obtained in the year 2021 [5, 35].

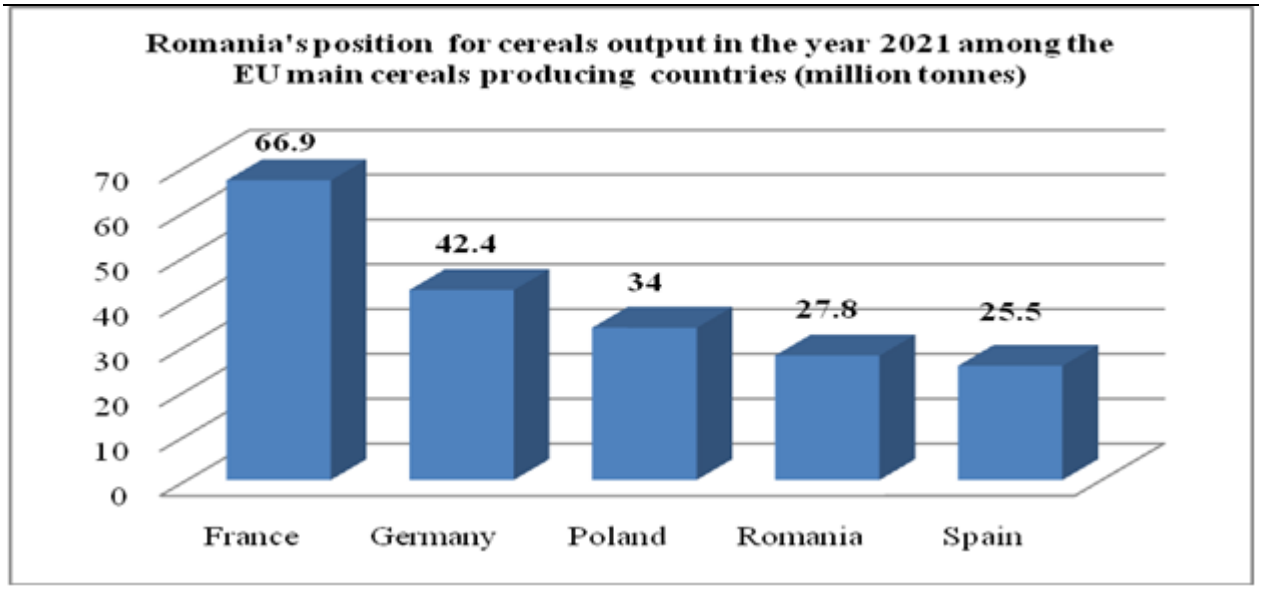

Fig. 8. Romania's position among the EU main cereals producing countries - Cereals output (Million tonnes)
Source: Own design based on the data from [10].

Till September 2022, a surface of 504,018 ha was affected by drought in 37 counties of Romania. Maize was affected on 149,101 ha, representing (30%) and also autumn wheat and triticale on 189,265 ha (38%), and the remaining belonged to other spring and fall crops.

However, in the year 2022, wheat production is sufficient to cover the domestic need and also to sustain export, while maize output will be able just to assure the internal requirements, and in very small amount export compared to the previous year [3].

Cereals price at the farm gate

In the analyzed period cereals price had periods when it remained relatively stable or went up and down, but with slight differences, in close relation to offer and demand ratio for cereals as raw material, international trade and cereals quotations at the stock exchange, and exchange rate, climate change, and other specific factors like the recent hostilities between Russia and Ukraine [28, 24].

The annual average producer's price, that is at the farm gate has slightly increased in case of wheat and declined in case of maize in the analyzed decade 2012-2021.

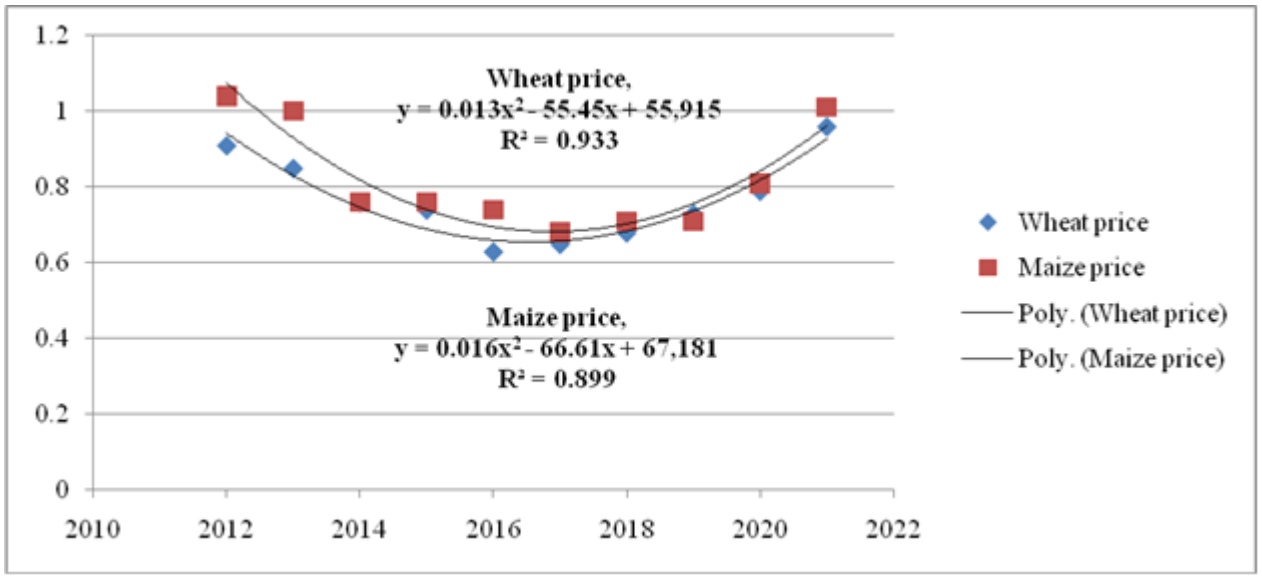

Fig. 9. Variations of annual average wheat and maize price at farm gate, 2012-2021, Romania (Lei/kg)
Source: Own design based on the data from [32].

In 2021, wheat price at the farm gate was Lei 0.96 per kg, by +5.49% higher than in 2012 and by +21.5% higher than its level in the year 2020.

The maize price accounted for Lei 1.01 per kg in 2021, being by -2.9% smaller than in 2012, but by +24.69% higher than in the year 2020 (Figure 9).

Producer's price varies depending on the pedoclimatic area, farm size, technologies applied, production costs, demand/offer ration and also due to the drought which was more and more longer during the last years. The growth of farm inputs price for seeds, diesel, fertilizers has been noticed even since the year 2020, and become more accentuated in the year 2021, and in 2022, the farmers were facing a real price boom.

Prices have increased not only in Romania, but also in the EU countries and even at the world level. In 2021, the cereals output price raised by an average 28.4%, but by cereal type the growth differed as follows: +34.4% for maize grains and +26.4% for wheat [10].

The monthly average price for wheat and maize grains at farm gate

Wheat price, after a relatively long period of small variations between the maximum level of Lei 0.79 in February and April, and the minimum of Lei 0.68 per kg in September 2019, started to increase since the beginning of the year 2020 in the months of April and May, and then in October to December. It continued its growth in the year 2021 in the first six months exceeding Lei 0.9 per kg and then in September it passed over Lei 1 per kg starting from September till December.

In the year 2022, wheat price has exploded since February, after the beginning of the conflict between Russia and Ukraine. It has continuously raised from Lei 1.16 per kg in January to Lei 1.6 per kg, the maximum level, stagnating at Lei 1.59 in May, June, July, August due to the harvest and the transport crises from Ukraine to the importing countries. In September 2022, it reached Lei 1.54 per kg wheat (Figure 10).

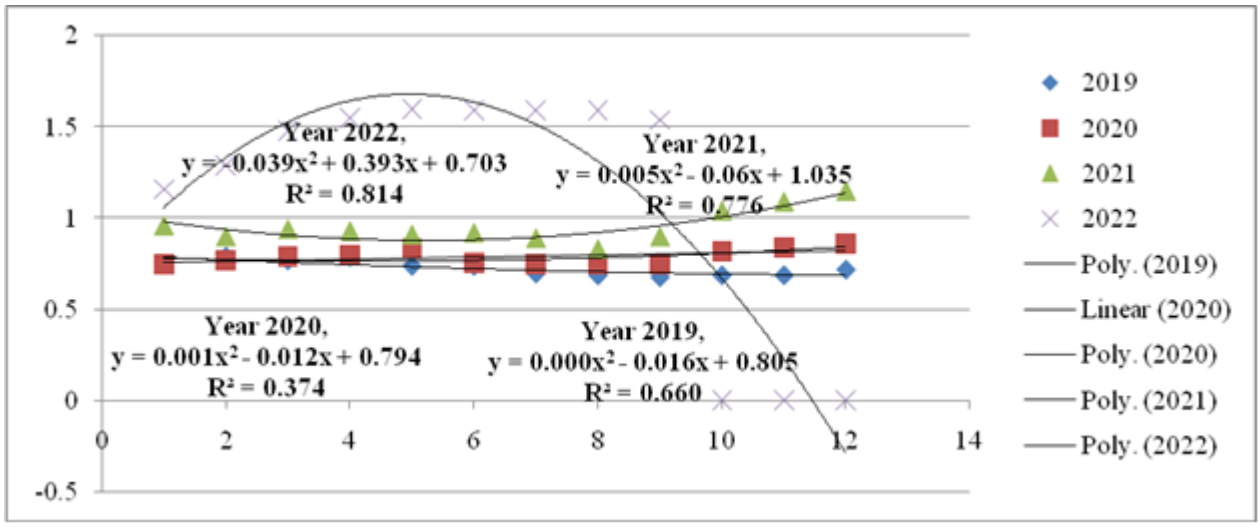

Fig. 10. Monthly average wheat price at farm gate, Romania, 2020-2022 (Lei/kg)
Source: Own design and calculations based on the data from [32].

The monthly average price at farm gate for maize grains was in general smaller than wheat price, and also in the months of the years 2019, but again in 2020 and 2021 till the month of July, when it equals wheat price of Lei 0.89 per kg and then, maize price exceeds wheat price in August and September, the last period reflecting the loss of production in 2022 due to the long period of drought, high temperatures and heat waves which affected the crop during its period of vegetation.

If in 2019, monthly average maize price varied in general between Lei 0.67 per kg, the highest level in May and July, and Lei 0.6 per kg in October and November, the lowest level, in the year 2020, it ranged between Lei 0.76/kg in December and Lei 0.64/kg in

February. In the year 2021, the price was Lei 0.8/kg in January and increased reaching the maximum level of Lei 1.02/kg in December. Its growth goes on in the year 2022, reaching a peak of Lei 1.42/kg in July and them it declines in August, accounting for Lei 1.4/kg and in September for Lei 1.37/kg (Figure 11).

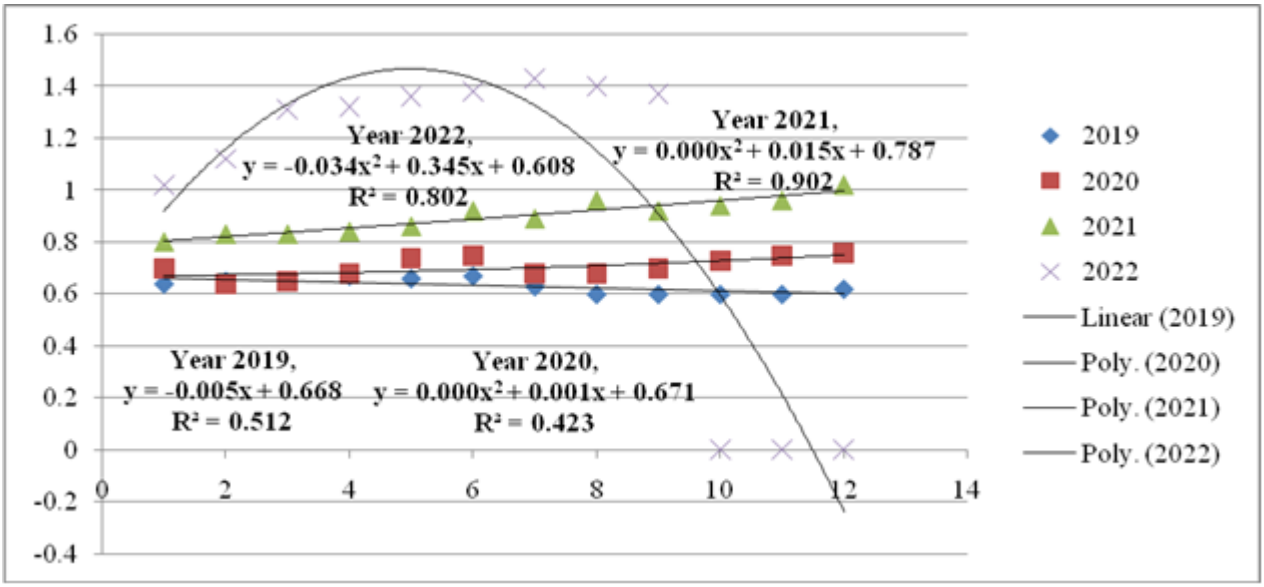

Fig. 11. Monthly average maize price at farm gate, Romania, 2020-2022 (Lei/kg)
Source: Own design and calculations based on the data from [32].

Compared to cereals price at the farm gate in the year 2015 considered equal to 100, in 2022, price increased at the EU level by +37.03% and in Romania by +39.97%. In other countries, it had different growth rates, its volatility depending on demand/offer ratio but also by the international markets [11, 45].

The main causes why cereals price increased are the following ones:

-***The growth of diesel price*** from Lei 5.39 per liter in January 2019 to Lei 5.93 in June 2019, then, a slight decline to Autumn. In 2020, diesel price registered another decrease up to a minimum of Lei 0.47 in May, but since January 2021 it increased to Lei 4.87 and continued this trend reaching Lei 6.42/liter in November and December.

In the year 2022, diesel price continued its ascension reaching a peak of Lei 9.22 per liter in July, and in November declined a little to Lei 8.56 [38, 56]. (Figure 12). The crisis of diesel price is explained by the quotations on the international stock exchange [55].

Also, diesel price increased due to the raise in excise taxes, and according to the fiscal code, the price must be adjusted with the inflation rate, which in Romania reached over 15% at present.

Another cause of the increased diesel price is the conflict between Russia and Ukraine.

However, according to the European Commission, Romania comes on the 9th position regarding diesel price after Bulgaria, France, Hungary, Luxemburg, Malta, Poland, Portugal and Slovenia.

Compared to the 2015 level of fuel price considered equal to 100, in the EU, price indices showed an increase starting from 2018, accounting for +11.96%, then in 2019 for +12.27%, and in 2021 for +15.82%.

In Romania, the fuel price index went up in lower proportions than at the EU level as follows: + 6.25% in 2018, +7.55% in 2019 and +6.57% in 2021 [15].

Diesel price has a deep impact on transportation costs for farm inputs, and also for consumption for the farm machinery for carrying out the agricultural works from land preparation, sewing, fertilization treatments for plant protection ill harvesting.

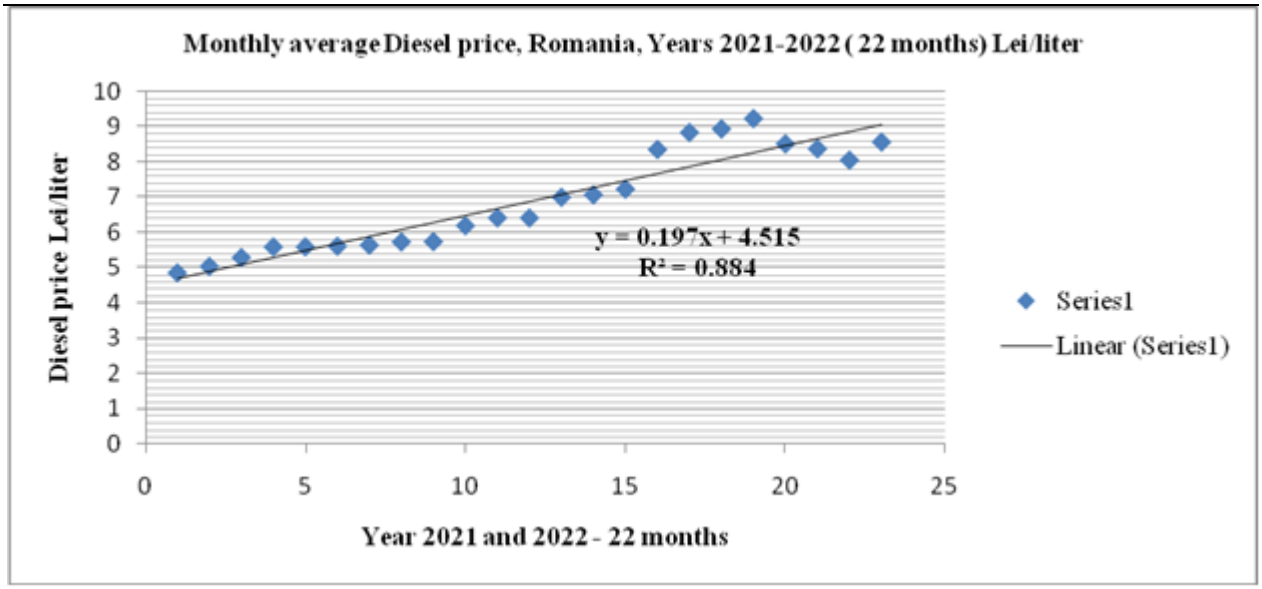

Fig. 12. Monthly average Diesel price - Lei/liter Romania, 2021-2022 (22 months)
Source: Own design based on the data from [38].

-The increase of the market price for certified seeds coming from varieties and hybrids of high production potential value, resistant to drought, diseases and pests. Most of the farmers are interested to buy certified seeds as they are obtained in secure conditions and are severely controlled regarding their high genetic and biological value and germination rate which contribute to the increase of production. The high price is a big challenge for farmers, but they need to assure the biological material to produce [17].

Compared to the level of the average seeds price registered in 2015 at the EU level, in the year 2021 it was noticed an increase by +10.88%. But in Romania, seeds price indices level was much higher by: +41.8% in 2018, +34.88% in 2019, +51.04% in 2020 and + 45.71% in 2021 [12].

-The market price for fertilizers, especially for Nitrogen-based fertilizers has also increased in close connection to the energy crisis. The process for obtaining fertilizers needs gas which represents 70% of the fertilizers production costs.

At the EU level, taking into consideration the average price of fertilizers in 2015 equal to 100, in the year 2021, NPK fertilizers price raised by +9.87%.

In Romania, starting from the year 2017, NPK fertilizers recorded a higher price by +22.4%, +0.57% in the year 2020, +13.17% in 2019 and +28.88% in 2021 [13].

-The energy crisis. Gas price has boosted after the conflict emerged between Russia and Ukraine and the economic sanctions imposed to Russia by the EU countries. Due to this critical situation, the industry producing fertilizers reduced its production and even, in some cases, the companies were closed. Therefore, the demand higher than offer led to a price growth.

At present, the price reached Euro 2,500-3,000/MWh and in this Winter is expected to reach Euro 5,000.

In the coming future, the lack of fertilizers and reduction of their consumption will have a negative impact on the intensive agriculture [25, 37].

-The increased price for the products for plant protection (herbicides, insecticides, pesticides, fungicides) has also went up, due to the price inputs to produces these products.

Compared to the average price at the EU level in the year 2015, considered equal to 100, the price indices for plant protection products were higher in the coming years by +1.14% in 2016 up to +3.12% in 2021.

In Romania, the price growth rate for this category of products ranged between +14.64% in 2019 up to +43.98% in 2021 [14].

Regarding only the herbicides price, compared to the its level in 2015 considered

equal to 100, in the EU, herbicides became more expensive by a rate ranging between +0.88% in 2016 up to +5.13% in 2021.

In Romania, herbicides price indices reflected a higher increase varying between +1.39% in 2017 up to +55.3% in 2021 [16]. This is explained by a higher demand of herbicides in this country as

weeding rate is higher than in other EU countries.

The main causes related to climate change in terms of meteorological phenomena**,** which affected cereals production in Romania in the period 2012-2021, were the following ones:

- *High temperatures and heat waves* during the vegetation period;

-*Long and severe droughts and pedological drought*.

-*Low precipitation levels* in general and in some regions rare huge and fast rainfalls followed by floods which caused damages to crops, households, humans and animals.

-*A low snow layer or missing* in some regions during the last winters.

In the agricultural year 2021/2022, the air thermal regime during the day exceeded the multiannual averages in the reference period 1991-2020 by $+3.6^0$C. In addition, the low precipitations level in Autumn 2021 has led to a long drought in the most regions of Romania and also in Spring 2022 being installed the pedological drought which affected both the crops sewed in autumn and in spring due to the lack of water soil reserve [1].

The year 2022 has brought a good wheat production, but a smaller maize production, and this was caused in some parts of Romania, like: Dobrogea, Moldova, Oltenia, Banat, Crisana, Transilvania, Maramures and Muntenia. An important decline of production due to drought was noticed on 400 thousand ha, which 201,089 ha cultivated with wheat and triticale and 70,754 ha with maize [2].

-*The hydric stress* caused by the low water reserve into the soil, the drying of water resources.

- *The lack or not sufficient irrigation system* in Romania in many areas where water is needed.

How farmers have to diminish the impact of climate change in Romania

Farmers could have a large variety of alternatives which should be used either separately or in a close interrelationship between them for obtaining a higher economic effect as follows:

-To diversify crop structure;

-To adopt multi culture and diminish the share of monoculture for avoiding erosion, nitrogen in water, to store carbon into the soil and sustain biodiversity [4];

-To establish a corresponding cultivated and balanced share of crops;

-To diminish the cultivated area;

-To increase yield using certified seeds from new cultivars and varieties and hybrids of high production potential, and resistant to drought, diseases and pests.

-To establish a rationale crop rotation or amendments [57];

-To implement new technologies friendly with the environment;

-To adopt technologies with fewer inputs in order to reduce production costs and achieve high quality agro-products [19];

-To adopt irrigations to sustain crop production in the regions where water is in deficit (Dobrogea, Moldova etc) [58].

-To quantify yields;

-To calculate and optimize production costs for each crop keeping under control variable costs which have a high impact of production costs and implicitly on gross margin, besides gross product; to select the crops which assure a higher gross margin [38, 39, 41];

-To digitize the farm activities using modern tools for managing crops, production, drought and diseases and pest attack [18];

-To reduce the amount of chemical fertilizers below the imposed threshold by the EU regulations or replace it with bio-fertilizers [50, 51];

-To diminish the amount of pesticides below the imposed threshold imposed by the EU regulations or replace it with bio-products with similar effects [19, 52];

-To apply conservative agriculture which could assure carbon sequestration, less polluted soils, biodiversity preservation, labor savings, lower production costs, a healthier

environment and a sustainable development [21, 22, 23].
-To practice organic farming on larger areas [42];
-To implement the measures provided by the EU Green Deal which aims to achieve food security and safety from farm to fork and a healthier environmentally friendly food system and a better life [7, 53].

CONCLUSIONS

In the analyzed decade 2012-2021, cereals production in Romania increased by +116.27% accounting for 27.79 million tonnes in the year 2021.
Maize is the main cereal crop with the highest contribution to cereals output 53.3% in the year 2021, when its production reached 14.82 million tonnes by 149.07% higher than in 2012.
Wheat comes on the 2nd position with an output of 10.43 million tonnes, the maximum level attained in the studied interval, being by +96.79% higher than in 2012. As a result, the contribution of wheat to cereals production was 39.5% in the year 2021.
Therefore, maize and wheat represent 92.8% of Romania's cereals production.
These high performances are explained by the large areas cultivated with cereals, which in the year 2021 accounted for 5.351 thousand ha, being by 1.6% smaller than in the year 2012. In the cultivated surface with cereals, maize accounts for 47.6% and wheat for 40.6%, all together summing 88.2%.
Regarding the yield level, Romania is far away from the performances achieved by France, Germany, Poland, Italy and Spain, which are its main competitors in producing cereals in the EU.
However, during the last decade, Romanian farmers made substantial efforts to increase cereals yield whose level reached 5,188 kg/ha in the year 2021, being by 120% higher than 2,357 kg/ha in 2012.
In case of maize yield, the growth rate was +166.16%, this crop producing 5,802 kg grains/ha in 2021 compared to only 2.180 kg/ha in the year 2012.
Wheat yield increased in the analyzed interval by +78.85%, attaining 4,797 kg/ha in 2021 compared to only 2,682 kg in the year 2012.
Despite of these performances, production level was much affected by severe meteorological phenomena which during the last decade have been more intense: high air temperatures, heat waves, long droughts, low precipitations.
In addition, irrigation systems operates only on small surfaces and in many farms production depends of the precipitations level.
During the last decade, farmers were facing a huge stress caused not only the impact of climate
change, which obliged them to adapt the applied technologies ever year to the new situations, but also due to the higher and higher prices for farm inputs which have deeply increased production costs making their business a high risk activity.
The prices of Diesel, seeds, fertilizers mainly Nitrogen-based fertilizers, chemical products for plant protection (herbicides, fungicides, insecticides, pesticides) registered an unpredictable volatility in the whole analyzed period, culminating with the price boom emerged by the conflict between Russia and Ukraine which started since February 2022, which produced an unbalanced cereals production and trade.
As a results, production costs increased and cereals price at the farm gate as well, being also influenced both by the unbalance demand/supply ratio in the international market but also by cereals quotations at the international stock exchange.
This critical situation puts cereals production in an uncertain future, as farmers are not able to predict climate and price evolution for the 2022/2023 agricultural year and also in the coming ones.
It is clear that they have to establish new technological alternatives adapted to their local conditions regarding crop structure, cultivated areas, crop rotation, to be more oriented to conservative agriculture, with lower farms inputs and environmentally friendly, to sustain soil fertility and extend biodiversity, to keep production costs under

strict control, to assure a lower risk for their business.

Cereals culture has to become a high performance and sustainable activity, protecting environment, preserving biodiversity and assuring food safety and security.

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