Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 20, Issue 3, 2020
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SORGHUM PRODUCTION IN ROMANIA IN THE PERIOD 2010-2019 - TRENDS AND DETERMINANT FACTORS

Agatha POPESCU[1,2,3]

[1]University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Marasti Boulevard, District 1, 011464, Bucharest Romania, Phone: +40213182564, Fax: +40213182888, Email: agatha_popescu@yahoo.com
[2]Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu-Sisesti", 61 Marasti Boulevard, District 1, 011464, Bucharest Romania, Email: agatha_popescu@yahoo.com
[3]Academy of the Romanian Scientists, 1 Ilfov Street, Bucharest, 030167, Romania,
Email: agatha_popescu@yahoo.com

Corresponding author: agatha_popescu@yahoo.com

Abstract

The paper analyzed the dynamics of Sorghum cultivated area, production and yield in the decade 2010-2019 pointing out the position of Romania among the EU-28 producing countries, the relationship between production and yield using ANOVA, and regression analysis in terms of linear fit. The results showed that the cultivated area increase by 52.7 % in reaching 15,712 ha in 2019. The West and South West regions cultivate 81 % of Romania's cropped area with Sorghum. Production increased 3.2 times reaching 60 thousand tons in 2019, 80% being achieved by West region (63.4 %) and South West Oltenia (10.5%). Sorghum yield was doubled in 2018 achieving 3,819 kg/ha, the highest records being in North East and West. Romania is ranked the 4th in the EU-28 after France, Italy and Hungary for Sorghum cultivated surface, production and yield. Between production and yield is a positive and strong relationship, r = 0.842 and R^2 = 0.710, reflecting that 71 % of the variation of production is caused by yield change. The regression model Y = 0.0112 x + 13.424, shows that if Sorghum yield increases by one unit, production will grow by 13.43 units. Therefore, a higher productivity per surface unit will contribute to production growth. For this reason, farmers have to use modern technologies involving high potential varieties and hybrids, optimized tillage, fertilization, sowing depth, plant density, distance between rows, correct and timing application of the agricultural works, the use of modern equipments for tillage, sowing, crop maintenance and harvesting. The technologies have to be adapted to climate change, meaning the use of earlier cultivars, looking for a new depth of sowing where soil moisture content favours seeds germination and chose the best harvesting moment.

Key words**:** *Sorghum, cultivated area, production, yield, trends, Romania*

INTRODUCTION

Sorghum is the 5th cereal in the world after maize, wheat, rice and barley which is important for nourishing millions of people and animals on our planet and also providing raw material for processing industry. This is due to Sorghum high nutritional value being rich in protein, starch, fiber, micro elements, its high starch and fiber digestibility and also a high energetic value [4, 32].
That is why it is largely spread in the world being cultivated in more than 110 countries from all the continents and especially in the regions with hot climate and low precipitations below 450 mm per year as the crop is highly resistant to drought, a reason to be named "the cereal of the arid zones" [31].
It is a plant with multiple uses: food, feed, a resource for bio energy, biofuels and other materials, it has a high productivity and lower production cost in arid area compared to maize, and it is friendly with the environment.
A large variety of food could be produced of Sorghum, such as: grains, flour, gluten-free bread, baked goods, porridge, cookies, cakes, pancakes, sweet juice, vinegar, sweeteners, sweet spices, light and alcoholic drinks. More than 50% of the global Sorghum production is used for these purposes [1, 6].
Sorghum is used in feed rations for poultry, dairy cows, steers and pigs for fattening and also for pets. Depending on the animal

species, Sorghum could be used in various forms: grazing pasture, green mass, hay, silage, fodder pellets. About 40% of Sorghum production is destined for animal feeding.

From the rest of about 10 % of production, Sorghum is used in the manufacturing industry as biomass for producing renewable energy, electricity and heat, as a resource for achieving biofuels (bioethanol, solid and gaseous fuels), as a resource for obtaining other materials: paper, textiles, building, chemical and plastic materials, brushes, brooms, floral arrangements etc. [1, 8].

Because there are differences between demand and offer among various regions and countries in the world, Sorghum is subject of international trade. The main producing and exporting countries are USA, Mexico, Nigeria, Sudan, India, China, Argentina, and the principal importing countries are China, Mexico, Japan, EU etc. [10].

Sorghum has specific characteristics which allow this crop to be successful in the competition with maize in the warm climate countries. Its special capacity to resist to high temperatures is due to its deep root which is able to penetrate the soil to find moisture and prove its high water uptake capacity, a reason why the plant is cultivated on non irrigated land and in this way Sorghum gives its contribution to water preservation, a reason to be considered environmentally friendly. Therefore, Sorghum is an alternative in the areas where maize cultivation is limited by climate conditions [33].

Research results proved that in the drought prone environments, Sorghum is able to give a higher yield and net returns than maize in the hot months. The higher and higher the temperature in August, the higher the yield difference between Sorghum and maize [35].

In biogas production, the hybrids of Sweet Sorghum and Sorghum-Sudan grass were able to produce by 27% more ADW than maize in the drought periods [33].

In the USA, Sorghum cropping is subject of business depending on price volatility, farmers being attracted to produce more Sorghum when its grain price is at least 1.1 times higher than maize price [37].

Besides its tolerance to drought, water efficiency, high nutritive and energetic value, environmentally friendly, Sorghum proved that its production cost is lower than in case of maize. For this reason Sorghum is used in animal rations replacing maize, for instance in silage production for dairy cows [16].

Global warming whose effects are more and more visible in all the fields, including agriculture, has determined scientists and practitioners to innovate agricultural technologies adapting them to the new climate conditions [12, 34].

The EU is also facing with increased temperatures and long severe droughts in its Southern and Eastern countries. Not being an important producer of Sorghum, but an important importer, the EU Commission considered that Sorghum could be promoted in the countries where their geographical position, soil and climate conditions allow to extend the cultivated surface and increase production [1, 8].

Besides other countries like France, Italy, Spain, Hungary, Romania is also included in the EU Program destined to Sorghum promotion.

Romania is an important cereal producer and exporter in the EU with a long tradition in cropping maize, wheat, barley, oats, rice, Sorghum, millets etc. [11, 22, 24, 30]. However, maize and wheat are the top cereals produces and exported by Romania [17, 20, 21, 25, 26, 27, 28, 29].

In this context, the extend of the cultivated surface in Romania imposed new experiments to test more local and foreign Sorghum cultivars and hybrids for assessing the impact of various technological factors (seeding density, distance between rows, sowing period, seeds germination, fertilization degree, harvesting moment etc) on yield and production performance. The results proved that Sorghum has a better behaviour on non irrigated land and during the severe drought period giving high production and profit to farmers [6, 7].

Recent research results showed that in South East Muntenia region, if Sorghum is sown at a distance of 70 cm between rows and receive N120P60K60 fertilization level, it could produce 9.22 tons/ha. If only the distance between rows it is extended from 50 cm to 70 cm, the yield surplus varies between 0.21 and 0.48 tons/ha [19].

In Central Moldavia, for a N120P120 fertilization level, it resulted an yield varying between 7,043 kg and 10,279 kg/ha depending on the used hybrids [23].

In Dobrogea region, where drought reached the highest level and rainfalls are scarced for years, Sorghum looks to be the best crop compared to maize on non irrigated surfaces. Taking into consideration the climate change, crop technologies have been adapted by farmers as follows: the sowing period was moved one month in advance compared to the traditional technology as the crop to benefit of the moisture accumulated in the soil during winter season and help seed germination, earlier hybrids with a shorter vegetation period were chosen to avoid the hot and droughty season in June, the treatments for crop protection involved herbicides and pesticides of the last generation [13, 14]. In Amzacea area, a surplus of 1,331 kg/ha was obtained using Alize hybrid sown on March 23 compared to April 15, 2019 [15].

In this context, taking into account the increased interest of farmers to extend the cultivated surface and produce more Sorghum in Romania, the purpose of the paper was to analyze the trends in Sorghum production in the period 2010-2019 in order to identify the changes that have occurred and the position of Romania among the EU producing countries. Also, a statistical approach was applied to evaluate the existing link between cultivated area, production and yield and to establish the best fitted regression model.

MATERIALS AND METHODS

Data collection

This research is based on empirical data provided by National Institute of Statistics Tempo Online, and Eurostat for the decade 2010-2019.

Sorghum crop performance in Romania was analyzed using the following indicators: (i) cultivated area, (ii) production, and (iii) yield.

Methodological aspects

The empirical date were processed using the following methodology:

Fixed Index, with its formula: $I_{t/t0} = (X_t/X_0)100$, for studying the dynamics of each indicator in the last year 2019 compared to the first one, 2010 and establishing the growth rate in the last decade;

The average annual growth rate, $\bar{\Delta} = (y_n - y_0)/(n - 1)$;

The graphical illustration of the dynamics of the three studied.

The structural index (SI%) to analyze the dispersion of the cultivated area, production and yield by region of development.

Descriptive statistics including mean, standard error, standard deviation, minimum and maximum value and coefficient of variation for the three indicators mentioned above in the period 2010-2018.

The comparison method in order to assess the position of Romania among the EU-28 top Sorghum producing countries and also to estimate the contribution of various regions of development to the cultivated area, production and yield.

The correlation coefficient, R square, Adjusted R square, and Standard Error were used to assess in what measure Sorghum production is influenced by cultivate area and productivity per ha.

ANOVA and linear regression fit Y = bx +a were used to establish the influence of the independent variable X, Sorghum yield, on the dependent variable Y, Sorghum production.

The results were presented in tables and graphics, and specific comments and interpretations accompanied them. Finally, conclusions included the main ideas resulting from this research and also issued a few recommendations for farmers in order to improve Sorghum production.

RESULTS AND DISCUSSIONS

Sorghum types cultivated in Romania

Four groups of Sorghum are cropped in Romania: grain Sorghum, sweet Sorghum, broom Sorghum and forage Sorghum. Each of them are produced for various purposes as shown in Table 1.

Table 1. Sorghum types cultivated in Romania

Sorghum type	Purposes for cultivation
Broom Sorghum	-Genetic resource for sweet and grain Sorghum breeding
Sweet Sorghum	-Biomass for renewable energy and raw materials for processing industry
Forage Sorghum	-Animal feeding (green mass, silage and hay)
Grain Sorghum	-Food, grace to its high protein content, gluten-free and lower fat than maize

Source: Adapted by author based on literature [2, 3, 5].

Cultivated area

In the period 2010-2019, the cultivated area with Sorghum registered a general ascending trend. In 2019, 15,712 ha were cultivated compared to 10,283 ha in 2010, reflecting an increase by 52.79 %, which means by +5.27% average annual growth rate. However, across this decade, the cultivated surface registered an ascending slope from the year 2010 to the peak of 21.7 thousand ha in the year 2013. After that, Sorghum was cultivated on smaller and smaller areas, which in the year 2016 recorder the lowest level of 9.2 thousand ha. But, since 2016 until 2019, Sorghum was again cultivated in larger and larger surfaces, unfortunately, they never reached the peak recorded in 2013 (Fig. 1).

In 2019, the cultivated area with Sorghum in Romania represented 9.6% of the EU-28 cultivated surface with this crop. From this point of view, Romania is ranked the 4th in the EU, after France (42.4%), Italy (23.7%) and Hungary (13.1) (Fig. 2).

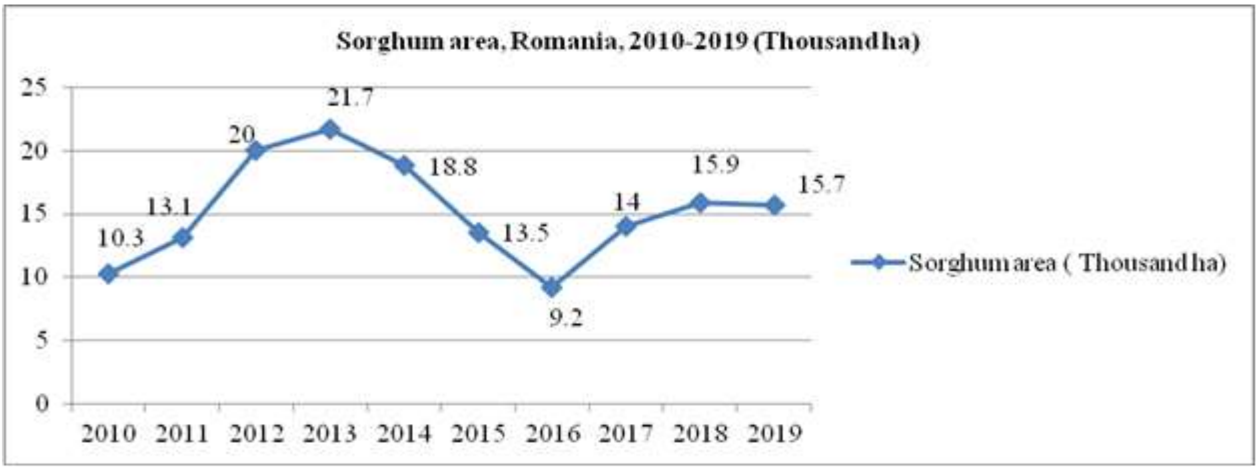

Fig. 1. Dynamics of Sorghum cultivated area, Romania, 2010-2019 (ha)
Source: Own design based on the data from [18].

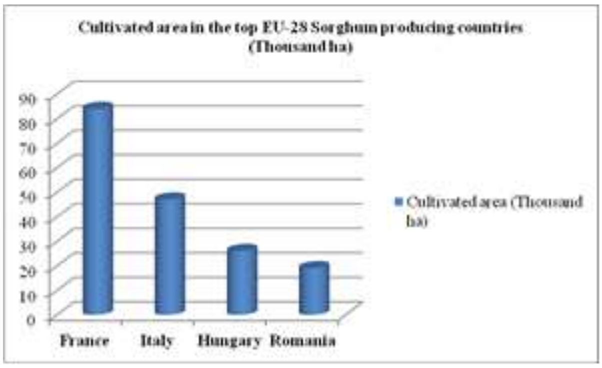

Fig. 2. Romania's position for Sorghum cultivated area among the EU-28 top producing countries in 2019
Source: Own design based on the data from [9].

In Romania, Sorghum is mainly cultivated in the West, South West Oltenia, South East, South Muntenia and North West, these five regions together accounting for 94% of the whole cultivated area with this crop.

The top position is occupied by the West area whose surface with Sorghum represents 57.5% of Romania's Sorghum area. On the 2nd position is South West Oltenia keeping 13.7%.

In the studied period, the sown area with Sorghum increased by 7,309 ha, meaning +426.6% in the West part of the country, in North West by 792 ha, meaning +249.8%, and in North East by 431 ha, i.e. + 111.3%. Smaller increases were also noticed in South Muntenia and Center, but in two regions the cultivated surface was diminished: in South East by -67.2% and in South West Oltenia by -41.3% (Table 2).

Table 2. Cultivated area with Sorghum in 2019 versus 2010 by micro region in Romania

	2019		2010		2019 versus 2010	
	ha	%	ha	%	Δ ha	Δ%
Romania	15,712	100.0	10,283	100.0	+5,429	+52.7
North West	1,109	7.0	317	3.1	+792	+249.8
Center	90	0.6	29	0.3	+61	+210.3
North East	818	5.2	387	3.8	+431	+111.3
South East	1,317	8.4	3,070	29.8	-1,753	-67.2
South Muntenia	1,185	7.5	1,048	10.2	+137	+13.1
Bucharest-Ilfov	22	0.1	63	0.6	-41	-65.1
South West Oltenia	2,149	13.7	3,656	35.5	-1,507	-41.3
West	9,022	57.5	1,713	16.7	+7,309	+426.6

Source: Own calculation based on the data from [18].

Sorghum production

During the last decade, Sorghum production increased 3.21 times or by +221.3% with an average annual growth rate of +22.135. In 2019, Romania produced 60,010 tons Sorghum compared to 18,677 tons in 2010 (Fig. 3).

Fig. 3. Romania's Sorghum production, 2010-2019 (Thousand tons)
Source: Own design based on the data from [18, 36].

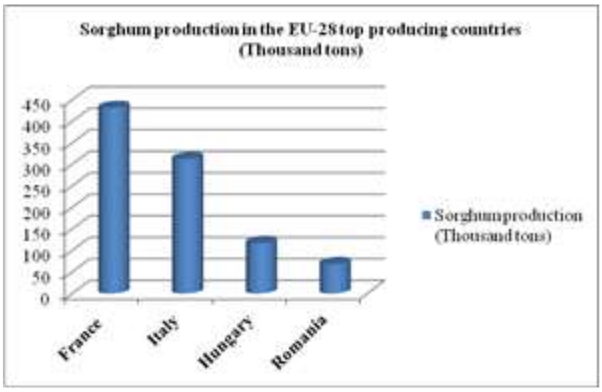

Fig. 4. Romania's position for Sorghum production among the EU-28 top producing countries in 2019
Source: Own design based on the data from [9].

According to Eurostat, Romania comes also on the 4th position for Sorghum output after France, Italy and Hungary. The contribution of these four countries to the EU-28 Sorghum production (1,019 thousand tons) accounted for 42.3%, 30.6%,11.5% and 6.7%, summing 91.1% (Fig. 4).

Sorghum production is not equally achieved in the territory of Romania, and more than this important changes from a region to another have been noticed in the analyzed interval.

In 2010, the top position was occupied by South West Oltenia whose share in the national production was 35.1%, followed by South East with 23.9%, West with 18.1% and South Muntenia with 14.1%, these four regions producing that time 91.2% of Romania's Sorghum output.

In 2019, the West region in on the top position contributing by 63.4%, being followed by South West Oltenia with 10.5%, summing about 80%, reflecting the growth of production concentration (Table 3). It is obviously normal such a situation as long as these two regions cultivate 71.2% of Sorghum surface.

Table 3. Sorghum production 2019 versus 2010 by micro region in Romania

	2019		2010		2019 versus 2010	
	Tons	%	Tons	%	Δ Tons	Δ%
Romania	60,010	100.0	18,677	100.1	+41,333	+221.3
North West	3,799	6.3	777	4.2	+3,022	+388.9
Center	364	0.6	32	0.2	+332	+1,037.5
North East	3,830	6.4	700	3.7	+3,130	+447.1
South East	3,643	6.1	4,457	23.9	-814	-28.3
South Muntenia	3,979	6.6	2,639	14.1	+1,340	+50.8
Bucharest-Ilfov	61	0.1	128	0.7	-67	-47.6
South West Oltenia	6,286	10.5	6,563	35.1	-277	-4.3
West	38,048	63.4	3,381	18.1	+34,667	+1,025.3

Source: Own calculation based on the data from [18].

Sorghum yield

The performance in Sorghum yield has also recorded and ascending trend in the studied period. If in 2010, Romania produced 1,816 kg/ha Sorghum, in 2019, the yield was 2.1 times higher, i.e. 3,819 kg/ha. The average annual growth rate in the whole analyzed interval accounted for 11.03% (Fig. 5).

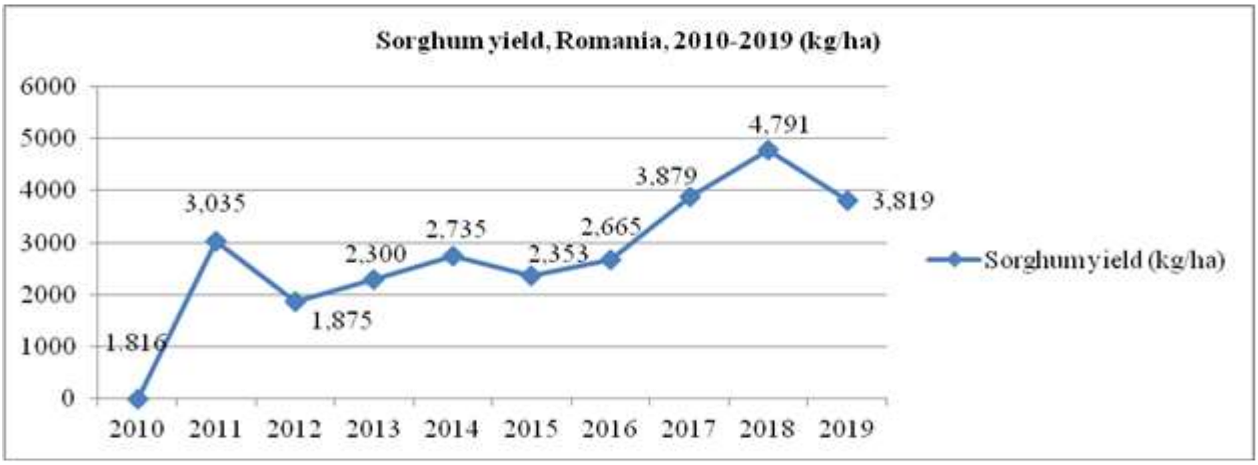

Fig. 5. Romania's Sorghum yield, 2010-2019 (kg/ha)
Source: Own design based on the data from [18].

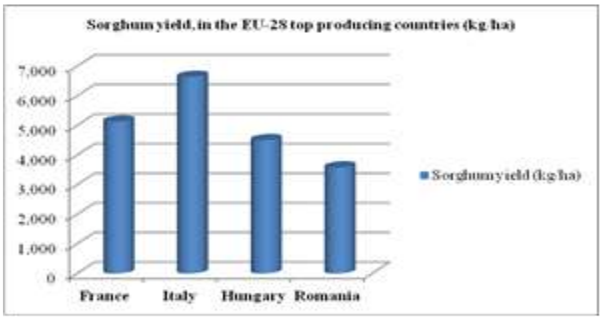

Fig. 6. Romania's position for Sorghum yield among the EU-28 top producing countries in 2019
Source: Own design based on the data from [9].

Compared to the other three top Sorghum producing countries in the EU-28, Romania comes on the 4th position for its yield level after Italy (6,638 kg/ha), France (5,130 kg/ha) and Hungary (4,500 kg/ha) (Fig. 6).

The change in the national average yield of Sorghum was deeply influenced by the different records carried out at the level of each region in the analyzed interval.

South Muntenia (2,518 kg/ha) and North West (2,451 kg/ha), followed by West, Bucharest-

Ilfov, South West Oltenia and North East and South East.

In 2019, the highest yield was achieved in North East accounting for 4,683 kg/ha and West, 4,217 kg/ha. In South West Oltenia, which is on the 2nd position for the cultivated area and production, the yield was only 2,925 kg/ha, by 31% less than in the West region.

The results presented in Table 4 reflect a higher yield performance in all the regions in the analyzed decade, ranging between +33.35 in South Muntenia to +264.7% in the Central area.

Table 4. Sorghum yield 2019 versus 2010 by micro region in Romania

	2019	2010	2019-2010	
	kg/ha	kg/ha	Δ kg/ha	Δ%
Romania	3,819	1,816	+2,003	+110.2
North West	3,424	2,451	+973	+39.6
Center	4,023	1,103	+2,920	+254.7
North East	4,683	1,809	+2,874	+158.8
South East	2,767	1,452	+1,315	+90.5
South Muntenia	3,357	2,518	+839	+33.3
Bucharest-Ilfov	2,773	2,032	+741	+36.5
South West Oltenia	2,925	1,795	+1,130	+62.9
West	4,217	1,974	+2,243	+113.6

Source: Own calculation based on the data from [18].

Descriptive statistics

The results regarding the main statistical parameters for Sorghum cultivated area, production and yield are presented in Table 5.

The variation coefficients have high values which reflect the followings:

- in case of cultivated area with Sorghum, CV = 26.6% tells us that the values of this variable are relatively heterogeneous and the mean is less representative;
- in case of production, CV = 39.3% shows that the series of data has heterogeneous values and the mean is not representative;
- in case of yield, CV = 47.56% also reflects a high heterogeneity among data and in consequence the main is not representative.

Table 5. Descriptive statistics for Sorghum studied indicators in the period 2010-2019

	Cultivated area (ha)	Production (Thousand tons)	Yield (kg/ha)
Mean	15.22	44.37	2,745.38
Std.Error	1.28	5.51	412.98
Std. Deviation	4.05	17.43	1,305.96
Min	9.2	18.6	1,816
Max	21.7	76.3	4,791
Variation coefficient (%)	26.6	39.3	47.56

Source: Own calculations.

The relationships between Sorghum cultivated area, production and yield

For studying the three pairs of possible relationship between these three indicators, the correlation coefficients, r, the determination coefficients, R^2, adjusted R square and Standard Error were calculated and their results are presented in Table 6.

A strong positive correlation coefficient was found between production and yield, r = 0.842, much higher than in case of the connection between production and cultivated area, r = 0.509 and r = 0.157, the weakest value between yield and cultivated area.

Also, in case of the link between production and yield, the coefficient of determination recorded the highest value, R^2 = 0.710, reflecting that 71% of the production variation is caused by the change in Sorghum yield.

The adjusted R square had the highest value also in case of the relationship between production and yield, Adj. R Square = 0.674, and the standard error had the smallest value, Std. Err. = 9.95 compared to the other two pairs of indicators.

The relationship between production and cultivated area was characterized by a positive and medium correlation, r = 0.509, by the fact that only 25.9% of the variation in production is determined by the cultivated surface, as proved by R^2 = 0.259.

The correlation coefficient r = 0.157 reflected that between yield and cultivated surface with Sorghum it is a positive but very weak relationship, R^2 showed that practically the variation of the cultivate area has no impact on average production and in addition Standard error had a very high value (Table 6).

Table 6. The values of r, R^2, Adjusted R square and Standard Error for the three pairs of studied indicators

Pairs of indicators	r	R^2	Adj. R square	Std. Error
Production and Yield	0.842	0.710	0.674	9.95
Production and cultivated area	0.509	0.259	0.166	15.91
Yield and cultivated area	0.157	0.024	- 0.097	1,367.97

Source: Own calculation.

The variance and regression analysis

Based on these results mentioned above, it was taken the decision to analyze the dependence of production, considered the variable Y on yield level, considered the variable X, using the variance and regression analysis, whose results are shown in Table 7.

ANOVA presents the regression between production on yield, the residual variance caused by other nonregistered factors, residual and total variance determined by all the factors.

Fisher test, F, reflected the ratio between the two dispersions connected by the degrees of freedom.

The regression parameters, a and b, allowed us to establish the regression model under the form of a linear fit, Y = 0.0112 X + 13.474.

The availability of the regression fit was attested by F stat whose value was higher than the table critical value, as well as by the significance level which is almost zero, Sign. F = 0.0021 (Table 7).

Table 6, Variance and regression analysis between Sorghum production and yield

ANOVA						
		df	SS	MS	F	Sign. F
Regression		1	1,943.89	1,943.89	19.65	0.0021
Residual		8	792.22	99.02		
Total		9	2,736.12			
Regression parameters						
	Coefficients	Std. Error	t stat	P - Value	Lower 95%	Upper 95%
Intercept	13.474	7.650	1.761	0.116	- 4.166	31.11
X var 1	0.0112	0.0025	4.430	0.0021	0.0053	0.0171

Source: Own calculation.

The confidence intervals for each regression parameter, a and b, of the linear fit model were the following ones: - 4.166 < a < 31.11 and 0.0053 < b < 0.0171 for 0.05 threshold (95% lower and upper) (Table 7).

Replacing the X values in the linear fit, Y_x = 0.0112 X + 13.474, there were determined the values of the predicted Y**.** As long as the sum of the adjusted Y depending on X is equal with the sum of the empirical values, the parameters a and b of the regression model are correctly calculated.

Also, the residuals reflect the prediction error calculated as difference between the observed and forecasted value, and finally the standard error in terms of standard residuals is also presented in Table 8.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 20, Issue 3, 2020
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 7. Predicted Y and residuals

Observation	Predicted Y	Residuals	Standard residuals
1	13.49543557	5.104564426	0.544071897
2	47.62920472	-8.029204719	-0.85579577
3	34.57520859	2.924791415	0.31173998
4	39.35792269	10.44207731	1.112972693
5	44.25317124	7.246828764	0.772405938
6	39.95435527	-8.254355268	-0.879793525
7	43.46543009	-19.06543009	-2.032095954
8	57.12711225	-2.82711225	-0.30132881
9	67.39025404	8.909745962	0.949648586
10	56.45190555	3.548094446	0.378174966

Source: Own calculation.

The quality of the linear regression model is also confirmed by the residual plot for Sorghum yield which tells us that between the yield, the independent variable and the residuals, there is no any relationship (Fig. 7).

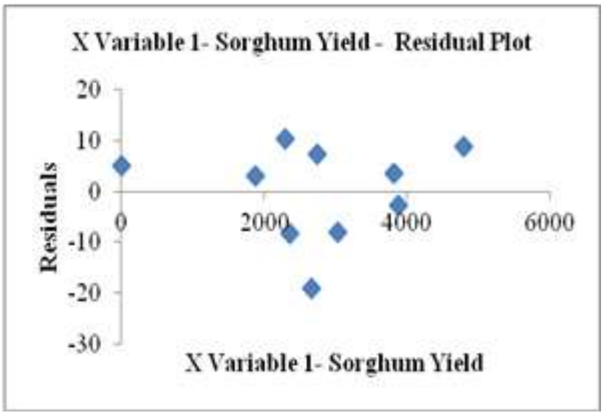

Fig. 7. Sorghum yield and residuals diagram
Source: Own result.

Therefore, the linear fit availability is confirmed and the model could be used now to forecast Sorghum production based on yield.

The model Y = 0.0112 X + 13.474 shows that if X, Sorghum yield will vary by one unit, then, Y, production will grow by 13.43 units. The increased of yield by 2 units will determine the growth of production by 13.4964 units.

CONCLUSIONS

The research results proved that in Romania farmers are interested to extend the cultivated surface with Sorghum and increase production.

The analysis showed that the cultivated area increase by 52.7 % in the last decade reaching 15,712 ha in 2019. About 81 % of the are cultivated with Sorghum is situated in the West and South West regions where soil and climate conditions are the most favorable.

Sorghum production increased 3.2 times reaching 60 thousand tons in 2019. The highest contribution to Sorghum output is given by West region 63.4 % and South West Oltenia 10.5%, representing together 80% of Romania's production.

Sorghum yield had a general increasing trend achieving 3,819 kg/ha in 2019, when it was recorded a double level compared to the year 2010.

The highest average production was recorded in North East and West, accounting for over 4,200 kg/ha.

Romania is ranked the 4th in the EU-28 after France, Italy and Hungary for Sorghum cultivated surface, production and yield.

The statistical analysis showed that between production and yield is a positive and string relationship, attested by the correlation coefficient, r = 0.842 and the determination coefficient R^2 = 0.710, which reflected that 71 % of the variation of production is caused by the deviations in Sorghum yield.

As a consequence of ANOVA and regression analysis, it was found that the regression model Y = 0.0112 x + 13.424, which shows that an increase by one unit of Sorghum yield could increase production by 13.43 units.

Therefore, this research proved that in case of Sorghum, a higher productivity per surface unit will contribute to the improvement of production.

In consequence, farmers interested in Sorghum cultivation have to be aware that their business will be a successful one if they will use modern technologies involving high potential varieties and hybrids, optimized tillage, fertilization, sowing depth, plant density, distance between rows, correct and timing application of the agricultural works, the use of modern equipments for tillage, sowing, crop maintenance and protection and harvesting.

Technological factors have to be adapted to climate change. The long periods of drought during the last years obliged many farmers to adapt technologies to the new conditions using earlier cultivars, changing the depth of sowing in relations with the soil moisture content to allow seeds germination and to offset the moment of harvesting in a more suitable period.

REFERENCES

[1]AgronoMag, 2017, European program to promote sorghum launches in the summer of 2017, https://agronomag.com/european-program-promote-sorghum/, Accessed on July 25, 2020.

[2]Antohe, I., 2007, Results regarding grain Sorghum breeding for quality, https://www.incda-fundulea.ro/anale/74/74.11.html, Annals of ICDA Fundulea, 74.

[3]Antohe, I., 2007, Achievements on Sorghum breeding at Fundulea (Realizari in ameliorarea sorgului la Fundulea), Annals of I.N.C.D.A. Fundulea, Vol., LXXV, 137-157.

[4]Balteanu, G., Birnaure, V., 1989, Phytotechnics (Fitotehnie), Ceres Publishing, Bucharest, 256-268.

[5]Chilba, C., Brejea, R. P., Jula, I., 2018, Sorghum-Evolution and cultivation in Romania, Annals of the University of Oradea, Fascicle: Environmental Protection, Vol. XXX, 13-16.

[6]Coclea, D., Nita, S., Mateas, I.M., Albai, A., Popa, D., Borta, L., 2014, Sorghum grain yield under the influence of fertilization, Research Journal of Agricultural Science, 46 (3): 14-16.

[7]Euralis, 2018, Sorghum in the feed of laying hens, meeting with a Romanian producer, 2018, https://euralis-seeds.com/?news=sorghum-in-the-feed-of-laying-hens-meeting-with-a-romanian-producer, Accessed on July 25, 2020.

[8]Europa, EU, Promotion of sorghum and sorghum seeds on the internal market, https://ec.europa.eu/chafea/agri/en/campaigns/promotion-sorghum-and-sorghum-seeds-internal-market, Accessed on July 25, 2020.

[9]Eurostat, 2020, Main tables, https://ec.europa.eu/eurostat/web/europe-2020-indicators/europe-2020-strategy/main-tables, Accessed on July 25, 2020.

[10]Faith, C., 2017, Top Sorghum Producing Countries in the World, Economics, https://www.worldatlas.com/articles/top-sorghum-producing-countries-in-the-world.html, Accessed on July 25, 2020.

[11]Gimbasanu, G., Micu, R.A., Petre, I.D., 2017, Comparative analysis of the import and export of Sorghum and barley made in the light of pre-accession and post-accession to the European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.17(2):121-127.

[12]Grigoras, M.A., Popescu Agatha, Holeab, C., Chedea, V., Merce, E., 2007, Bridging the innovation gap and the management of interdisciplinary project for sustainable development, XXXVII Annual Meeting of European Society for New Methods in Agricultural Research, ESNA, pp.10-14.

[13]Jinga, V., Vlăduț, V., Marin, E., Manole, D., 2018, Sorghum culture a solution for Dobrogean agriculture. International Symposium, ISB-INMA TEH' 2018, Agricultural and mechanical engineering, Bucharest, Romania, 1-3 November 2018 , pp. 951-954. ref.7.

[14]Manole D., Jinga V., Giumba Ana Maria, Dudoiu R., 2018, Sorghum crop, an alternative for Dobrogea farmers in the context of climate changes, Proceeding Book Agrobiol, International Agricultural, Biological & Life Science Conference, Edirne, Turkey, pp.415-419.

[15]Manole, D., Giumba, A.M., Ganea, L. L., 2020, Researches and contributions to plant Sorghum crop in the conditions of climate change, Annals of Academy of Romanian Scientists, Series Agriculture, Silviculture and Veterinary Medicine Sciences, Vol.9 (1): 37-48.

[16]Mc Cary, C.L., Vyas, D., Faciola, A.P., Ferraretto, L.F., 2020, Graduate Student Literature Review: Current perspectives on whole-plant sorghum silage production and utilization by lactating dairy cows, Journal of dairy Science, 103(6): 5783-5790.

[17]Medelete, D.M., Panzaru, R.L., Vladu, M., Matei, Gh., 2018, Some considerations regarding the primary wheat supply in Romania and its composition (2014 – 2016), Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18(1): 245-252.

[18]National Institute of Statistics, 2020, Tempo Online, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on July 25, 2020.

[19]Oprea, C.A., Bolohan, C., Marin, I.D. 2017, Effects of fertilization and row spacing on grain Sorghum yield frown in South-Eastern Romania, https://www.semanticscholar.org/paper/EFFECTS-OF-FERTILIZATION-AND-ROW-SPACING-ON-GRAIN-Oprea-Bolohan/7d938d2c6c2c55bce72394a5ca7ee9f87fbde004, Accessed on July 25, 2020.

[20]Panzaru, R.L., Medelete, D.M., 2014, Olt County primary offer of wheat (2010-2012), in the regional context, Scientific Papers Series Management,

Economic Engineering in Agriculture and Rural Development, Vol.14(1): 267-272.

[21]Panzaru, R.L., Medelete, D.M., 2017, Some considerations concerning the Romanian production of maize in European Context (2012 - 2014), Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.17(4): 237-242.

[22]Panzaru, R.L., Vladu, M., Medelete, D.M., Bodescu, D., 2018, Romania's cereal external trade between 2014 and 2016, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18(1): 319-324.

[23]Pochiscanu, S., Robu, T., Drutu, A. C., Pomohaci, T.-I., Naie, M., Buburuz, A., Popa, D., 2014, Partial results on the influence of fertilization on grain productions of *Sorghum bicolor* L. in the climatic conditions of Central Moldavia, Scientific Papers, Series Agronomy, Iasi, Vol.57(1).

[24]Popescu Agatha, 2012**,** Considerations on the Importance of Maize among Cereal Crops in Romania in the period 1990-2009, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.12(2):123-128.

[25]Popescu Agatha, 2015a, Research on the distribution and concentration of the farms cultivating maize for grains in Romania using the Gini Coefficient, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.15, Issue 3/2015, p. 253-260,

[26]Popescu Agatha, 2015b, Analysis of the evolution and distribution of maize cultivated area and production in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.15, Issue 3/2015, p. 261-264,

[27]Popescu Agatha, 2015c, Regression and Elasticity of Maize Price and Production in Romania, Proceedings of 26th IBIMA Conference Innovation Management and Sustainable Economic Competitive Advantage: From Regional Development to Global Growth, Madrid, Spain, November 11-2, 2015, pp.2205-2213

[28]Popescu Agatha, 2017, Maize culture- An intensive or extensive production system in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development,Vol.17(1)2017, p.351-356

[29]Popescu Agatha, 2018, Maize and Wheat - Top agricultural products produced, exported and imported by Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18, Issue 3/2018, p.339-352

[30]Popescu Agatha, Condei Reta, 2014, Some considerations on the prospects of Sorghum Crop, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.14(3): 298-307.

[31]Popescu Agatha, Dinu, T.A., Stoian, E., 2018a, The comparative efficiency in Romania's foreign trade with cereals, 2007-2016, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18(1): 371-383.

[32]Popescu Agatha, Dinu, T.A., Stoian, E., 2018b, Sorghum-An important cereal in the world, in the European Union and Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18(4): 271-284.

[33]Schittenhelm, S., Shroetter, S., 2014, Comparison of drought tolerance of maize, sweet sorghum and sorghum-Sudangrass hybrids, Journal of Agronomy and Crop Science, 55(2): 681-687.

[34]Sorghum - The Smart Choice- All about Sorghum, https://www.sorghumcheckoff.com/all-about-sorghum, Accessed on July 25, 2020.

[35]Staggenborg, S. A., Dhuyvetter K.C., Gordon, W.B., 2008, Grain Sorghum and Corn Comparisons: Yield, Economic, and Environmental Responses, Agronomy Journal, 100(6): 1600-1604.

[36]Tilasto Statistics, 2020, Romania: Sorghum, production quantity (tons), 1961-2017 https://www.tilasto.com/en/topic/geography-and-agriculture/crop/sorghum/sorghum-production-quantity/romania, Accessed on July 25, 2020.

[37]1.5 times more! This is the price difference between sorghum and maize in the USA. https://www.sorghum-id.com/en/news/, Accessed on July 25, 2020.