Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 18, Issue 4, 2018
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SORGHUM - AN IMPORTANT CEREAL IN THE WORLD, IN THE EUROPEAN UNION AND ROMANIA

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Abstract

The paper analyzed the status of Sorghum crop worldwide, in the EU and Romania regarding the cultivated area, production, yield and trade pointing out the main trends. The data provided by the Data bases of NIS and Faostat have been processed using usual methods such as fixed index and comparison. In 2017, the world Sorghum production reached 63.9 million tonnes, and the average yield 1,427 kg/ha. The main producers of Sorghum are the USA, Nigeria, Sudan, Mexico, Ethiopia and India. In 2017, the EU represented just 0.12 % of the world area cultivated with Sorghum. and produced 755 thousand tonnes of grains,i.e.1.18 % of the world output. But, the EU average yield is 5,580 kg/ha, being 3.81 times higher than the world mean. In main EU producers of Sorghum are: Italy, France, Spain, Romania, Austria, Hungary, and Bulgaria. In 2017, Romania cultivated 13,833 ha, representing 25.2 % of the EU area and produced 54,282 tonnes Sorghum grains, i.e.7.18 % to the EU output. Per surface unit, Romania carried out 3,879 kg/ha, 2.71 times more than the world mean and by 30 % less than in the EU. Romania is also an important exporter of sorghum grains and the trade balance is positive. Due to the advantages of this crop and taking into account the need to mitigate the effects of climate change, the EU policy provides a new perspective to grow the cultivated surface and production. Romanian farmers must use new technologies, paying attention to high value hybrids, fertilization and plant protection to improve yield, and production. Romania has to keep its position as an important producer and exporter of Sorghum in the EU by developing this agricultural sector.

Key words**:** *Sorghum, production, cultivated area, yield, characteristics, advantages, perspectives, worldwide, EU, Romania*

INTRODUCTION

Sorghum is a cereal belonging to "Kingdom *Plantae*, Phylum:*Magnoliophyta*, Class: *Liliopsida*, Order: *Poales*, Family*: Poaceae*, Tribe: *Andropogoneae*, Genus: *Sorghum"* [4, 45].

Sorghum has a large variety of annual and perennial species. The most important species is "*Sorghum vulgare*, *Pers. sin, Sorghum bicolor (L) Moench"*[4] which includes all the cultivated species. The cultivated Sorghum is classified into *"Sorghum var. eusorghum, Sorghum var. technicum, Sorghum var. saccharatum* and *Sorghum Sudanese"* [4, 42].

The origins of are in the tropical areas of Africa, somewhere in Sudan and Ethiopia, from where it was spread to the warm climate zones situated between 40-45^0 Nordic Latitude and 40-45^0 South Latitude, being named "the cereal of the arid areas" [4].

At present, Sorghum is cultivated in 110 countries from all the continents, mainly in Africa, Asia, but also in the North, Central and South America, in Oceania and Europe.

Sorghum crop has important characteristics and advantages. First, it is a plant resistant to drought as its root system is very well developed allowing the plant to reduce its growing intensity in the periods when water is not sufficient. This is the reason why Sorghum could perform better than maize and other crops in the areas where precipitations are less than 450 mm.

Secondly, Sorghum has a high adaptation capacity in the arid and semiarid zones on the soils with a different texture and pH (4.5-8.5). From this point of view, it could be successfully cultivated on the soils which are not suitable for other crops (sandy, salted and eroded soils) [4].

Also, Sorghum is a good plant in crop rotation, being used as previous culture for sunflower and maize and other crops [51].

It has a high grain production potential, but less than maize in similar conditions. It also could produce an important amount of green mass and dry matter. This is due to the large range of varieties and hybrids with a high production potential, but which are also highly resistant to drought, diseases and pests, have a lower tannin content and/or are lacked of "durrhina", a toxic glycoside which could produce intoxications to animals.

Sorghum requires low inputs: a low quality for agricultural land which can't be used by other crops, a low amount of seeds, fertilizers, a lower utilization of plant protection substances and water [24].

The plant has a short vegetation period ranging between 110 -150 days/year which allows farmers to obtain two harvests per year. This is possible as after moving, the plant is able to quickly regenerate its vegetative mass.

Sorghum is an environmental friendly crop as it has the capacity to absorb an amount of 50-55 t/ha C_2O from atmosphere and to release a huge amount of oxygen. The forests and cereals absorb a lower quantity of carbon dioxide, only 16 t/ha, and, respectively, 3-10 t/ha yearly.

The chemical composition of Sorghum reflects a high nutritional value quite similar to maize. As affirmed by Neucere and Sumrell (1980), the Sorghum grains contain: "10.g protein, 3.2 g fat, 73 g carbohydrates, 2.3 g crude fiber, 1.6 g ash, 329 kcal energy, minerals (27 mg Ca, 4.3 mg Fe, and also small amounts of Cu, Mg, Ni), vitamins mainly from the B group (Thiamine 0.3 mg, Niacin 2.83 mg and Riboflavin 0.138 mg), but also tannins depending on variety". [28, 34].

According to the synthesis made from literature results by Ratnavathi (2013), the variation thresholds of different chemical components are the following ones:"protein (4.4-21.1 %), water soluble protein (0.3-0.9 %), lysine (1-3.6 %), starch (55.6-75.2), amylose (21.2-30.2), soluble sugars (0.7-4.2), reducing sugars (0.05-0.53), crude fiber (1-3.4 %), fat (2.1-7.6), ash (1.3-3.3), minerals (Ca 11-586, P 167-751, Fe 0.9-20), vitamins (in mg/100 g: Thiamine 0.2-0.5, Niacin 2.9-6.4, Riboflvin 0.1-6.2), antinutritive components (tannins 0.1-7.2 5, phytic acid 8.7-2,211 mg/100 g)" [25, 34, 40, 47].

Other parts of Sorghum plant, like stalks and leaves, are rich in cellulose and hemicellulose, but also in starch [6].

Sorghum plant could be used entirely: grains, flowers, stalks, panicles, etc.

The diversity of Sorghum cultivars and hybrids has determined a large range of uses. Sorghum is on the 5th position as importance among the cereals in the world. It is a staple food in Africa, but also in Neat East and Asia (India, China, Bangladesh etc) [4, 40].

First, grains are used as human food, either as such, or boiled or in warm salads, or as flakes [42]. In food industry, grains are used to produce "floor, bread, biscuits, vermicelli, noodles, flakes, extruded products, weaning and supplementary food and bakery"[40], "tortillas, a sort of polenta, pizza, pastas and cakes" [42]. In some countries from grains are prepared "traditional meals such as: idli, dosa, chakli, papad"[40], and also vinegar [3]. In beer industry, Sorghum is utilized for malt extraction [13, 51]. From stalks, it is obtained a syrup which is an important sweetener in cakes and drinks, as this juice contains different sugars such as: sucrose 9.4 %, glucose 3.4 %, fructose 3 %, and other sugars 23.3 % [1, 3].

Sorghum is an important plant for animal feeding where it could substitute maize. Grains are a stock feed for poultry, pigs and cattle, and pets, mainly dogs [13, 38, 51]. Sorghum green mass, silage, hay, and pellets are good forages in dairy farming, steers and pig fattening [2, 31, 36].

However, the consumption of Sorghum leaves and stalks by animals could produce intoxications due to the existence of the tannin and glycosides. But, at present, the scientific research offered new hybrids with low tannin content and without glycosides.

Sorghum has many technical uses. First, grace to its capacity to develop 120-150 t phytomass, the plant it is used to produce energy: fuels (bioethanol, synthetic gases etc),

electricity, and thermal energy [2, 4, 31, 36, 51].

As bio material, Sorghum flowers and stalks are used in the cellulose and textile industry, for producing cellulose, paper and textiles, and also are used as a good construction material [2, 51].

In the handicraft industry, Sorghum is used to produce "brooms, washing brushes, braidings (knittings), paper, wallboard, fences and also biodegradable materials" as mentioned by [2, 36, 51].

Sorghum could be used green manure and fertilizer, and also to eliminate weeds from other crops as happens mainly in the USA [3, 45].

In various African and Asian countries, from Sorghum flowers, leaves pods, and even stalks are extracted colorful substances which are later utilized to paint the fabrics, wool and skins [51].

The climate change affects more intensively our Planet during the last decades. In 2016, the temperature at the earth's surface was by 0.94 Celsius degrees higher than the average of the 20th century. In the last years, global temperatures exceeded all the records so far. The increased sea level due to the decrease of the melting glaciers, the strong rainfalls, storms, droughts, floods have affected agriculture, environment, economy and people's life causing material damages and financial losses [17, 21].

Due to the climate change and the demographic evolution of the globe population, agriculture is facing many difficulties in assuring a corresponding food from a quantitative and qualitative point of view, food security and the livelihoods for the rural population being threatened [8].

In Europe, the climate change produces the decline of agricultural production, an increased incidence of forest fires, losses in biodiversity and ecosystems disruptions, and also affects the population's health. The main countries affected by high temperatures, droughts, forest fires, floods and extreme weather events are situated in the South and South Eastern Europe such as: Bulgaria, Hungary, Portugal, Republic of Moldova, Romania, Ukraine, and the Southern part of the Russian Federation [12].

For this reason, important efforts are focused to set up new strategies and measures destined to mitigate the impacts of climate change on agriculture and environment.

Regarding agriculture, we could expect important changes in crop mapping and structure, and cropping technologies to keep the production at a level able to cover the consumption needs.

For this reason, Sorghum crop is reconsidered during the last decade in many countries due to its benefits and advantages and a new orientation to a larger cultivated surface and a higher production is more and more sustain.

In this context, the paper aimed to present Sorghum crop as an alternative cereal both at the world and Europe level, mainly in the EU and Romania. The study emphasizes the characteristics of Sorghum crop, and its advantages, and also the dynamics of production in the world, in the EU and Romania, and the main producers in order to point out the trends regarding cultivated surface, production and yield in the period 2007-2017.

MATERIALS AND METHODS

The research was carried out based on the study of a large range of published reports, articles and other materials, and on the data provided by the National Institute of Statistics and Faostat and for the period 2007-2017, for the following indicators: cultivated area, production, yield, export, import, trade balance, export and import price. Comparisons between Sorghum and maize were made in order to point out the similarities and differences between the two crops [18, 33].

The main trends have been identified using the graphical method and also the fixed method index allowed to determine the growth rate for the chosen interval.

The results were tabled and graphically illustrated, the interpreted and commented and also compared and finally the corresponding conclusions were drawn.

RESULTS AND DISCUSSIONS

World Sorghum harvested area and production. In 2016, the world Sorghum production accounted for 63,930,558 tonnes grace to the contribution of the 110 countries where this crop is cultivated [5].

The harvested area of *Sorghum bicolor (L.) Moench* at the world level registered a decreasing trend from 48 million ha in 1970 to in about 42 million ha in the year 2009. In the period 1970-2009, it was noticed an increased area cultivated with Sorghum in Australia, Brazil, Burkina Faso, Ethiopia, Mexico, Nigeria, and Sudan, but a decreasing trend in China and India [39].

In the year 2000, the cultivated area with *Sorghum bicolor* was 40.9 million ha worldwide [44]. In 2016, Sorghum occupied the 3rd position in the world for 44.77 million harvested ha after corn (187.96 million ha) and barley (46.92 million ha) [22].

The main countries cultivating Sorghum in the world are: USA, India, Nigeria, Mexico, Sudan, China, Argentina, Ethiopia and Australia [48].

The top 10 producers of Sorghum in the world and their market share are the following ones: USA (19%), Nigeria (10.8%), Sudan (10.1 %), Mexico (7.8%), Ethiopia (7.4 %), India (6.9 %), Argentina (4.7 %), China (3.7%), Niger (2.8%0 and Australia (2.8 %) (Fig.1.) [44].

By continent, Africa is on the top as Sorghum is produced in 43 African countries, the main important producers being Nigeria, Sudan, Ethiopia, Niger and Burkina Faso. In 2016, Africa produced 29,773,508 tonnes Sorghum grains, representing 46.5 % of the world production.

In Africa, Sorghum is used as food, feed and fuel. For the cultivated area, Sorgum comes on the 2nd position after maize and for its production it is ranked the 4th after maize, rice and wheat. However, Sorghum productivity is low in Africa, just one tonne/ha as it couldn't keep pace with the demand growth, the variation of the climate in dry land environments and the delay in developing new technologies like in case of other crops [29].

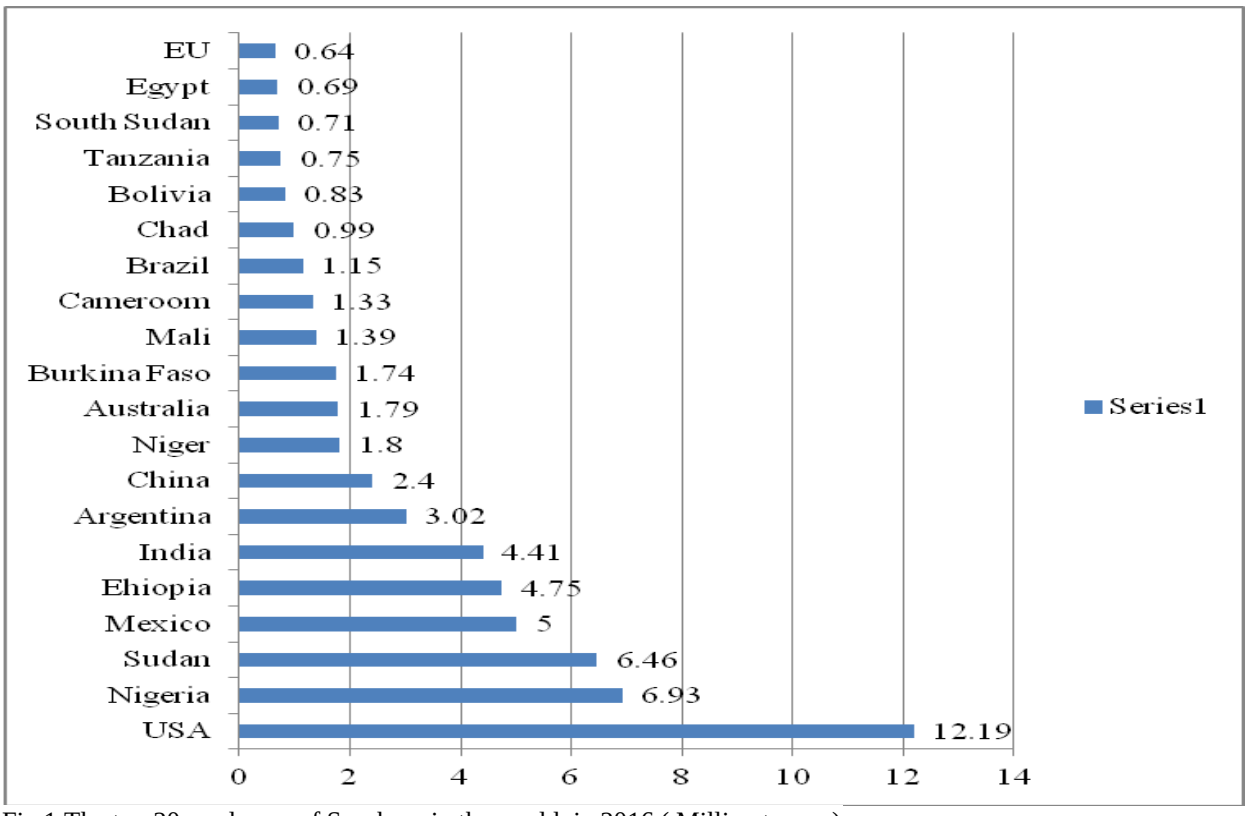

Fig.1.The top 20 producers of Sorghum in the world, in 2016 (Million tonnes)
Source: Own design based on [44].

In the Americas, the top producers are: the USA, the world leader, followed by Mexico, Argentina, Brazil and Bolivia. In Asia, the main producers are India, China, Burma (Myanmar), Pakistan, and Thailand.
In 2016, the USA produced 12.1 million tonnes Sorghum grains, of which 72 % were achieved by two states, Kansas and Texas. In the USA, Sorghum is used primarily for animal feed and for producing ethanol. In addition, taking into account as Sorghum is a gluten-free grain it is reconsidered at present as food for the people with celiac disease [44, 49].
The world Sorghum trade reflects an increase of export (+15 %), import (+15 %), production (+3.7 %), and consumption (+6.5 %). Consumption has exceeded production in the years 2011/2012, 2015/2016 and 2016/2017 which justify the intensification of the international trade (Table 1).

Table 1. World Sorghum balance, 2014-2018 (TY Million Metric Tonnes)

	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	Growth rate 2017/2011 %
Export	6.6	6.4	7.2	7.6	7.7	9.8	7.6	115.1
Import	6.6	6.4	7.2	7.6	7.7	9.8	7.6	115.1
Production	61.1	57.2	57.9	59.1	63.8	63.3	63.4	103.7
Consumption	59.9	58.4	57.8	59.1	63.1	63.8	63.8	106.5

Source: Own calculation based on [23].

Therefore, about 6-7 million tonnes are exported annually in the world, the main exporting countries being: USA, Argentina and Australia. The main importing countries are China, Japan and Mexico, but also Europe. The EU annual import of Sorghum is about 160 thousand tonnes a year, but it will increase for sure in the future to diminish the dependence on other markets [43].
Europe cultivated area and production. In the year 2000, in Europe, the cultivated area with Sorghum accounted for 216.9 thousand ha representing 0.53 % of the world surface with this crop. The largest surface was in Russian Federation, France, Italy, Albania, Ukraine, Spain, Hungary, Serbia and Montenegro and Romania [5].
In 2016, in Europe, there were 14 countries producing Sorghum, whose production totalized 1,256,541 tonnes, representing 1.96 % of the world production. In the decreasing order of their contribution to production, these countries are: Italy, Russian Federation, Ukraine, France, Spain, Romania, Austria, Hungary, Bulgaria, Slovakia, Greece, Croatia, Macedonia and Turkey [44].
The EU-28 Sorghum cultivated area and production. The EU cultivated area with Sorghum has registered a slight decline in the period 2007-2017. In 2017, it accounted for 55,233 ha representing 95.85 % of the 2007 level [16]. Therefore, the share of the EU surface cultivated with Sorghum in the world area is very small, only 0.12 %.
In 2016, the EU came on the 20th position in the world for 669,887 tonnes of Sorghum grains representing 1.01 % market share of the world level. The EU countries producing Sorghum are: Italy, France, Spain, Romania, Austria, Hungary, Bulgaria, Slovakia, Greece, and Croatia, whose production ranged between 313,788 tonnes in Italy and 206 tonnes in Croatia (Fig.2.)

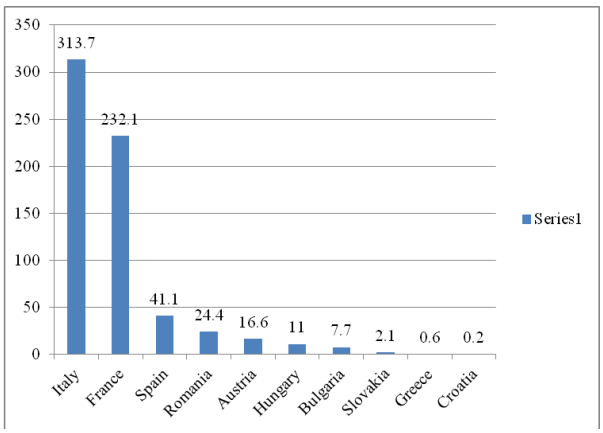

Fig.2.The top 10 producers of Sorghum in the EU, in 2016 (Million tonnes)
Source: Own design based on [44].

The EU Sorghum producers' position in the world and market shares are presented in Table 2.

Table 2.Position in the world and market share for the top EU member states producing Sorghum grains in 2016

	Rank in the world Sorghum production	Market share in the world Sorghum production (%)
Italy	22	48.29
France	28	35.73
Spain	51	6.34
Romania	61	3.76
Austria	63	2.55
Hungary	68	1.70
Bulgaria	77	1.18
Slovakia	89	0.32
Greece	92	0.09
Croatia	08	0.03

Source: [44].

Analyzing the dynamics of Sorghum production in the period 2007-2017, one may notice a 44.3 % growth rate, as in 2017, the production reached 755 thousand tonnes compared to 523 thousand tonnes in 2007 (Fig.3.)

The EU Sorghum yield increased, despite that the surface cultivated with this crop declined, and this was because of the high crop technologies including first of all varieties and hybrids with high production potential, and resistant to droughts and diseases.

The yield level increased by 1.3 % from 5.37 thousand tonnes/ha in 2007 to 5.44 thousand tonnes/ha in 2017. Therefore, in the EU, the average yield is more than 3.8 times higher than the world average yield.

The evolution of Sorghum yield is comparatively shown with the dynamics of maize yield in Fig.4 to reflect the good production potential of this alternative crop to maize. Its performance is lower compared to maize yield, but higher compared to average cereal yield in the EU.

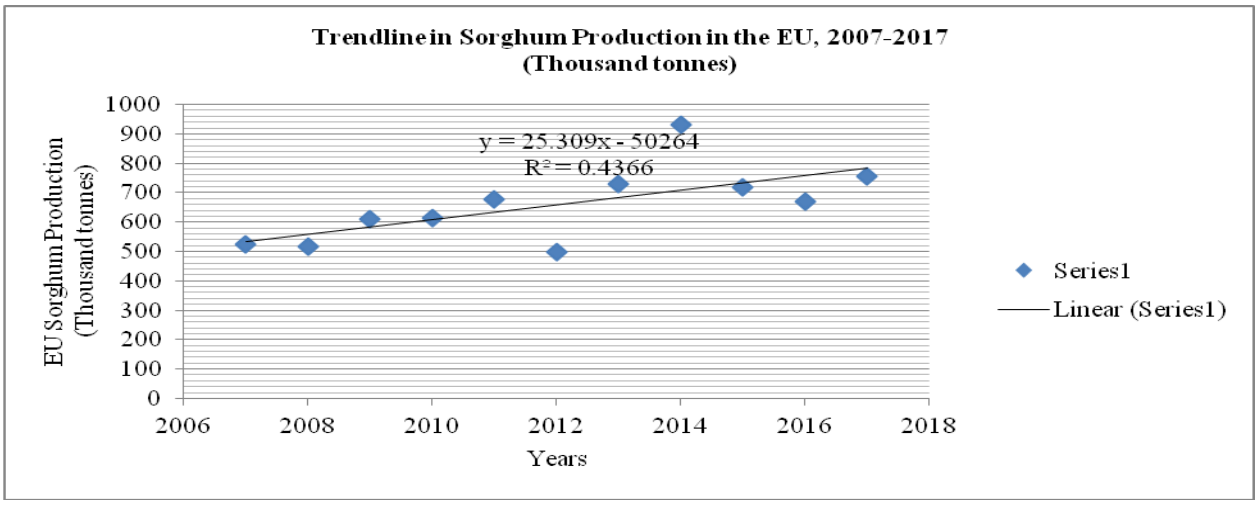

Fig.3. The dynamics and trend line in the EU Sorghum production, 2007-2017 (Thousand tonnes)
Source: own design based on [16].

France, Italy, Romania and Spain are the main producers of Sorghum in the EU.

In the EU, Sorghum is used as animal feed, a gluten free source, and also as a source of renewable energy (methanol, synthesis gases etc).

In France, Sorghum is used as feed either as silage or grain. As silage it is used in dairy cows and beef cattle feeding. The research results proved that the mixture of silage maize and Sorghum in the proportion 1:1, used in dairy cows feeding, could reduce the starch content in the diet, increase milk fat and feed efficiency. In case of the use of Sorghum grains, it was noticed an increased intake, but if the dry matter in the harvest is over 35 %, milk production will go down by 10 % and feed efficiency as well. In steers fattening, if the dry matter in Sorghum silage is over 25 %, the intake could higher depending on the breed, like in case of Limousine compared to Charolaise breed. The combination 50 %

grain Sorghum and 50 % maize silage could increase the dry matter and also the daily gain. The mix of Sorghum and maize silage could diminish the feed ingesta and increase daily gain [19].

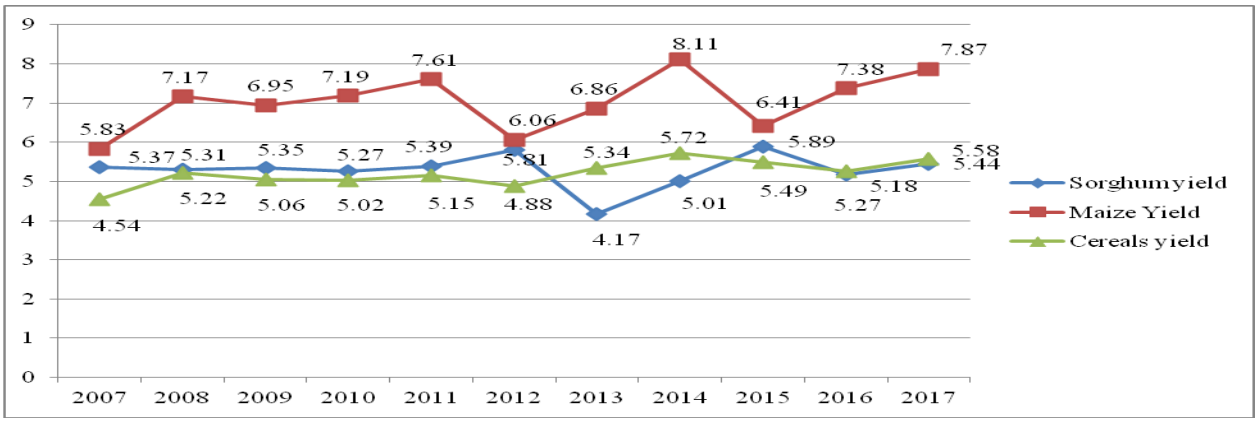

Fig.4. The comparative dynamics of Sorghum and maize yields in the EU-28, 2007-2017(Tonnes per ha)
Source: own design based on [16].

The absence of gluten in Sorghum grains in connection with the people who suffer of celiac disease has led to the reconsideration of this crop and new varieties were created to produce high-quality food and beverage products (flour, bread, noodles, cookies, waffles, and beer) [15].

In Italy, Sorghum is used for animal feeding as silage being produced in the areas where maize is not able to perform. The vegetation length is about 110 days, yield could reach 7-8 tonnes per year and the production cost per ha is by Euro 200-300 lower than in case of maize. Also, Sorghum is used as biomass for producing ethanol and biogas [10].

In Germany, Sorghum biomass is utilized to produce biogas and methanol, whose production is satisfactory [20].

In the EU, a special attention is paid to Sorghum seed quality which has to meet the standards regarding minimum germination (80%) and analytical purity (98%) and zero impurities. At present, in France for instance, there are many high potential cultivars which are registered in national and EU catalogues [41].

Romania's Sorghum cultivated area, production and yield.

In Romania, Sorghum is cultivated in the areas with a warm climate, mainly in the plain regions from South Muntenia, Oltenia, Banat, Crisana and the Central Moldova, but also in the Bucharest-Ilfov area and Dobrudja, therefore in the same areas where maize is cultivated. In these parts of the country, the hybrids have records by 40 % higher than the pure cultivars [51].

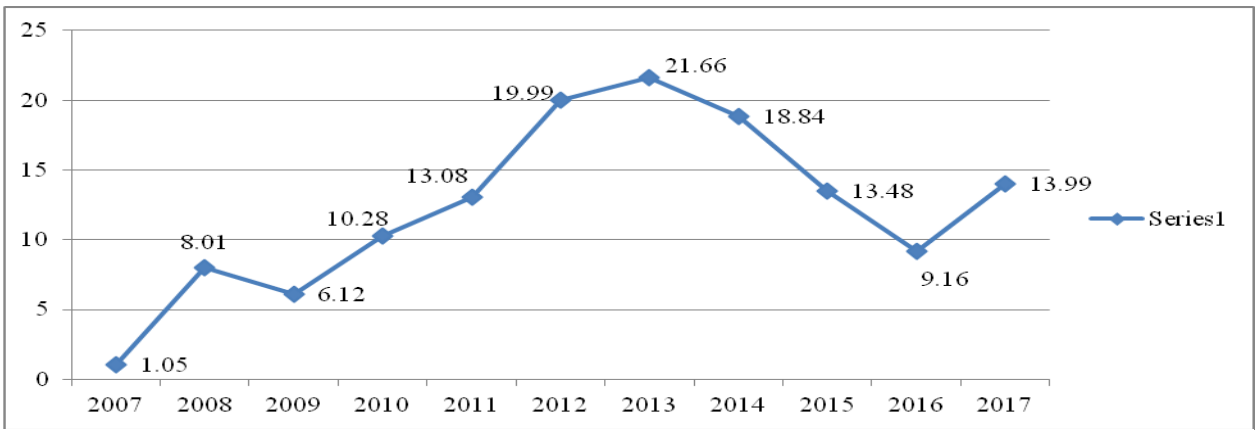

Fig.5.The evolution of Sorghum cultivated area in Romania, 2007-2017 (thousand ha)
Source: Own design based on the data from [33].

Romania has substantially increased the cultivated area with Sorghum in the interval 2007-2017 as this crop is important in agriculture and industry, it is a source of jobs and incomes, an alternative to maize crop, due to its advantages: good adaptability to various soil types, resistance to high temperatures and low rainfalls, resistance to diseases and pests, low inputs and production cost. This is a proof of the interest of the farmers to adapt to climate change and increase their income.

In 2017, Sorghum grain cultivated area was 13,933 ha being 13.2 times higher than in 2007 (Fig.5).

Therefore, the cultivated area with Sorghum in Romania represents 25.2 % of the EU cultivated area with this crop.

Sorghum production increased 45.5 times from 1,193 tonnes in 2007 to 54,282 tonnes in 2017 (Fig.6.)

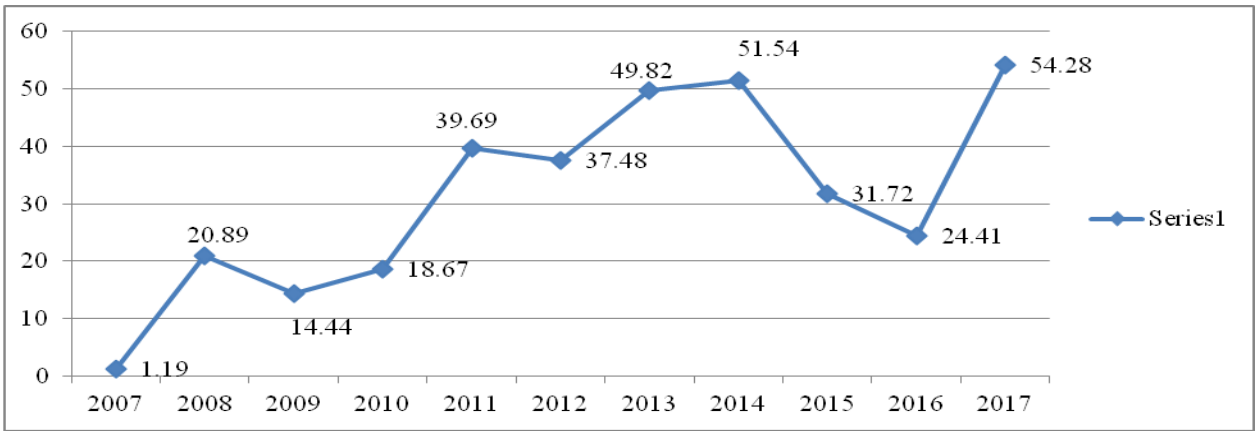

Fig.6.The evolution of Sorghum grain production in Romania, 2007-2017 (thousand tonnes)
Source: Own design based on the data [18].

The contribution of Romania to the EU Sorghum production is 7.18 %.

Sorghum yield followed a positive evolution both due to the growth in the cultivated surface and production of grains. In 2017, the yield was 3,879 ka/ha, being 3.43 times higher than in 2007 (1,128 kg/ha). But, comparatively with maize, Sorghum yield has a lower performance (Fig.7).

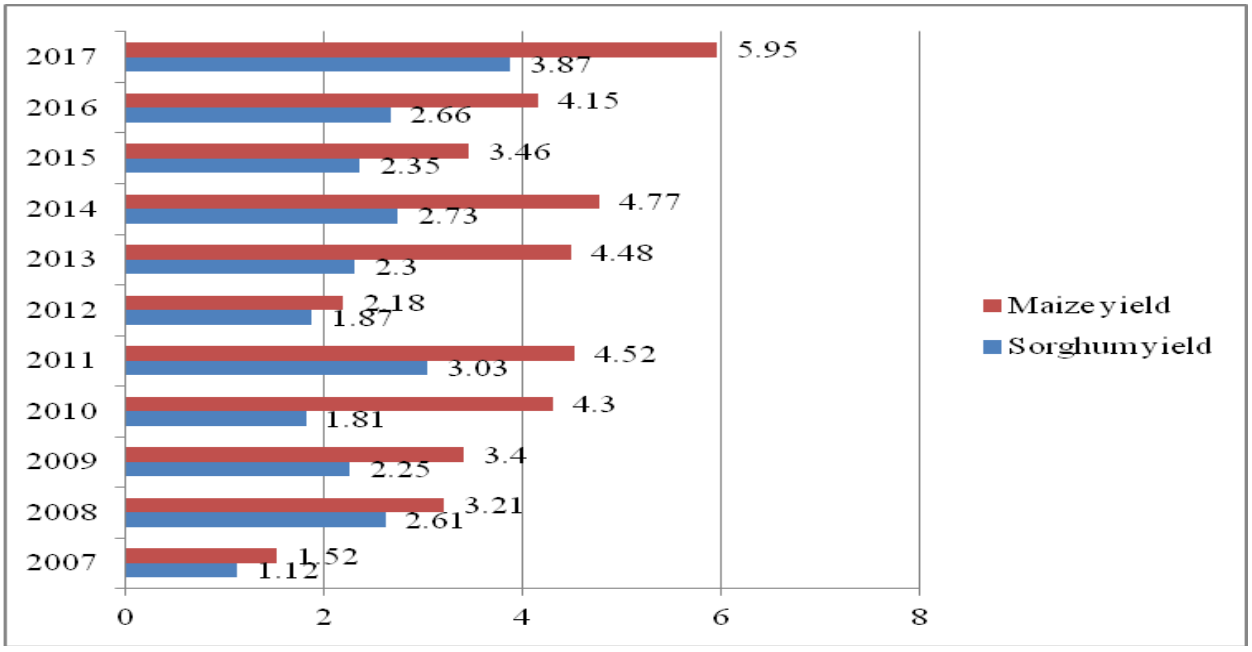

Fig.7.The comparative levels of Sorghum and maize grain yields in Romania, 2007-2017 (tonnes/ ha)
Source: Own design based on [33].

Romania's yield of 3,879 kg/ha is by 30 % lower than the EU average.

In Romania, there are used many varieties and hybrids of Sorghum as resulted from the scientific research works carried out by Fundulea Research and Development. The most important hybrids are the following ones: "Roza, Doina, Prut, Fundulea and Cernea for *Sorghum saccharatum*, Tutova, Tereza and Catinca for Sorghum Sudanese, Siret, Denisa and Donaris for Sorghum technicum" as mentioned by Antohe (2007) [2].

Hybrids like Fundulea 21, 30 and 32 are resistant to drought and diseases and have a short period of vegetation of about 108-128 days. The plants could reach 90-130 height and the agricultural works are mechanized [4].

The Romanian hybrids have a high production potential, are adapted to soil salinity and alkalinity, to diseases and pests, have an increased protein and starch content, and low tannin and hydrocyanic acid [2].

Sorghum saccharatum is a good cultivar in Romania as it is able to produce not only a high grain production, but also sugar yields. From 1 ha cultivated with this variety, it could be obtained a production of stalks ranging between 40 and 80 tonnes. From one tonne of stalks, it could be obtained 50-60 liters of sweet juice (syrup), and from the total production per ha it could be achieved 3 thousand liters alcohol [2].

This variety has also a good production of biomass, whose content in dry matter could reach 30 t/ha/year in low quality soils. From one ha cultivated with this variety, it could be produced as much as biomass to achieve five cubic meters bioethanol. Also, this cultivar has lowers inputs compared to maize. For instance, the amount of seeds necessary per ha is about 2.5 times lower, more exactly 15 kg/ha compared to maize which requires 40 kg per surface unit. Also, the requirements for fertilizers are lower and the water input it could be only 200 tonnes per tonne of dry matter. From an economic point of view, the production cost of one cubic meter ethanol is USD 250 [7].

Compared to Romania, in Portugal, from *Sorghum saccharatum*, it was achieved 90 tonnes biomass per ha, reflecting its production potential and its importance for producing energy. From one tonne of stalks, the ethanol production in Portugal could reach 55-60 and even 70 liters [32].

Sorghum production performance could be successfully increased in Romania using fertilizers as shown in case of F 32 and Arakan hybrids on a brown soil type by Coclea (2014) [9].

Also, grain production could be positively influenced by the use of herbicides. In the Central Moldova of Romania, after the application of herbicides, the grain yield reached between 3.4 and 5 tonnes per ha, depending on the herbicide and the dose [26].

In Romania, Sorghum is used in the compound feed for steers fattening replacing 20 % of barley. Also, 20 % Sorghum dietary grains could be successfully used in steers fattening based on silage leading to the reduction of the production cost [50].

A special attention started to be paid during the last years to Sorghum in Romania due to its strengths and advantages compared to other crops under the climate change conditions. The last decade brought extreme weather events, mainly droughts, high temperatures and low rainfalls which affected agricultural production, forests, water resources, environment and population. For this reason, the crop structure and mapping should be adapted to the variations of the climate conditions [11].

Romania's trade with Sorghum.

The exported quantity of Sorghum grains increased 56.1 times in the period 2008-2016 from 210 tonnes in 2008 to 11,798 tonnes in 2016.

The share of export in Sorghum production increased from 1 % in 2008 to 48 % in 2016. However, in 2009, Romania exported 81 % of production, the highest level.

In the studied period, the imported quantity increased 8 times from 63 tonnes in 2007 to 506 tonnes in 2016.

The ratio between exported and imported amounts varied from 1.1 in 2007 to 23.3 in 2016, but with a peak 0f 90.2 in the year 2009, reflecting that Romania is able to

produce and sell amounts of Sorghum grains on the external market important (Table 3).

Table 3. The dynamics of the exported and imported quantities of Sorghum grains in Romania, 2007-2017 (Thousand Tonnes)

	Exported quantity Thousand tonnes	Imported quantity Thousand tonnes	Export/Production ratio	Export/Import ratio
2007	0	0.063	0	0
2008	0.21	0.18	0.01	1.1
2009	11.73	0.13	0.81	90.2
2010	4.05	0.41	0.22	9.7
2011	6.37	0.34	0.17	18.3
2012	19.49	0.49	0.52	39.5
2013	5.97	0.42	0.11	14.2
2014	25.53	0.42	0.50	59.9
2015	21.83	0.38	0.69	56.4
2016	11.79	0.50	0.48	23.3

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

Sorghum export value increased 58.5 times from USD 38 thousand in the year 2008 to USD 2,224 thousand in 2016. The import value declined by 37 % from USD 2,043 thousand in 2007 to USD 1,290 thousand in 2016. In consequence, the trade balance was negative in the 1st year of the analysis, but positive in the last one (Fig.8.).

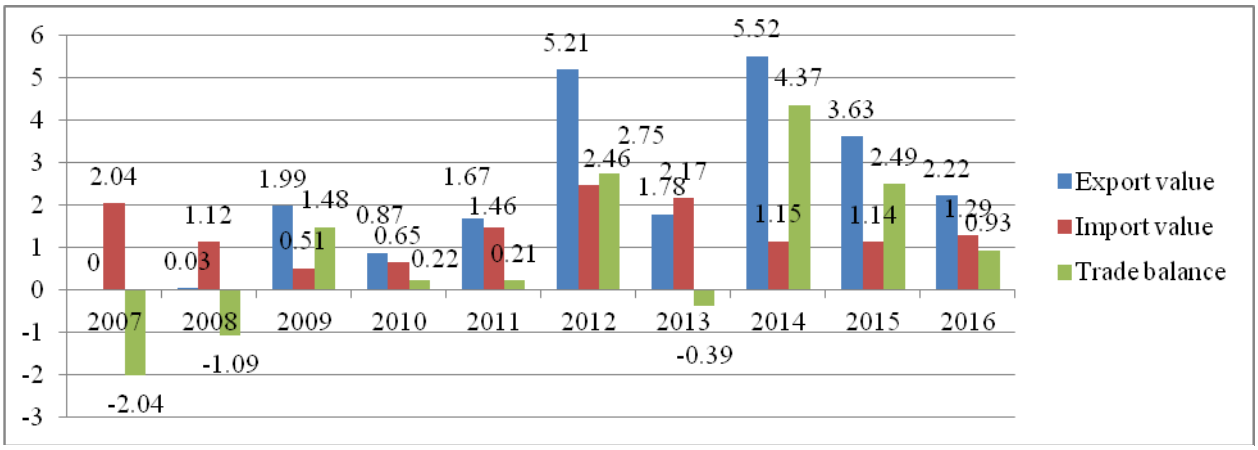

Fig.8.Sorghum export and import value, and trade balance, Romania 2007-2016 (USD Million)
Source: Own design based on [18].

However, across the period, it was noticed the highest export value, USD 5,527 thousand in the year 2014 and the lowest export value USD 38 thousand in 2008. The import value registered the peak of USD 2,460 thousand in the year 2012 and the lowest level USD 517 thousand in 2009.

Across the studied interval, the trade balance had in general a positive value, but in 2007, 2008 and 2013, it was a negative one.

The export price of Sorghum grains recorded a slight increase from USD 0.18/kg in 2008 to USD 0.19/kg in 2016 (+5.5 %).

The import price increased 7.9 times from USD 0.32/kg in 2007 to USD 2.54/kg in 2016.However, the export price varied between the minimum level USD 0.17/kg in 2009 and 2015, and the maximum level USD 0.3/kg in 2013.

The import price ranged between USD 0.32/kg in 2007, the lowest level, and USD 6.2/kg in 2008, the highest record.

This large variation was due to the demand/offer ratio, product quality, market segment etc (Fig.9).

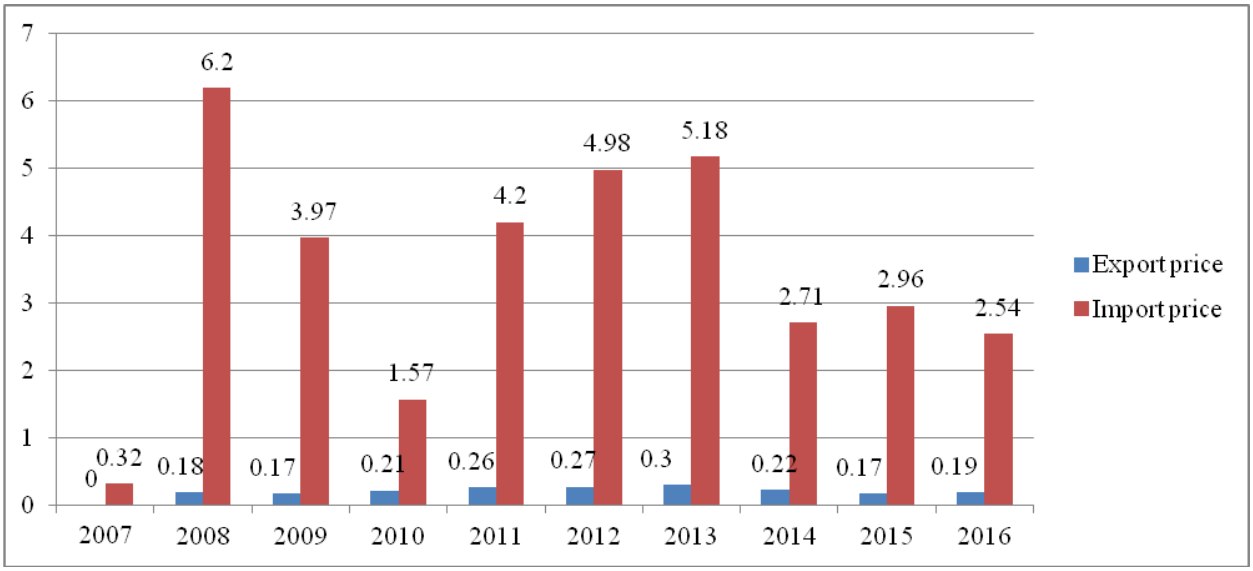

Fig.9. Sorghum grain export and import price, Romania 2007-2016 (USD per kg)
Source: Own design based on [18].

A new vision on Sorghum future in the EU.

In 2016, it took place the 1st European Congress on Sorghum crop where there were discussed the characteristics and advantages of this crop under the conditions of the climate change in Europe especially in the South and Eastern countries.

To mitigate the effects of climate change and strengthen Sorghum contribution to agricultural production and its efficiency as a source of bio raw materials, the EU established a Programme in June 2017 to promote Sorghum in the target member states: France, Spain, Italy, Bulgaria and Romania, but also in Russia and Ukraine [35].

The programme and the new EU regulations encourage the cultivation of Sorghum on larger areas, the increase of production and the producers, processors and consumers to pay more attention to this crop and its products [14].

In 2017, In Brussels, it was founded the European Sorghum Association, Sorghum-ID, an inter-professional organization including seeds producers, Sorghum farmers and processors which are aimed to increase Sorghum production for seeds, grains, silage and biofuels in Europe [27].

Also, the International INAGRA 2018 Fair has emphasized the importance of Sorghum among other agricultural crops, the fact that its production could be increased by the use of a large range of cultivars, taking into consideration the technical and economical advantages, opportunities and perspective of this crop in the EU and Romania's agriculture [37].

Also, the 2nd European Sorghum Congress held in Milan Malpensa, on November 7-8, 2018 joined the key "actors" responsible of the development of sorghum crop along its value chain such as: agricultural producers, collectors, traders, scientists, representatives of European administrations, and business people. This forum presented the actual visions and prospects on Sorghum crop development at the global and European level [46].

CONCLUSIONS

Grace to its important economic and technical role in the perspectives of agriculture development, Sorghum will continue to be a key cereal for many countries from all the continents.

The world sorghum grains achieved 63.9 million tonnes in 2017 and it is expected to continue its growth in the next years. The world average yield is 1, 427 kg/ha.

In 2017, the EU cultivated 55,233 ha, representing 0.12 % of the world area cultivated with Sorghum and produced 755 thousand tonnes, accounting for 1.18 % of the world production. However, the average yield

in the EU, 5,580 kg/ha is 3.81 times higher than the world average.

Romania is among the most important producers of Sorghum in the EU. In 2017, Romannia cultivated 13,833 ha, accounting for 25.2 % of the EU cultivated surface with Sorghum. In the same year, Romania produced 54,282 tonnes sorghum grains contributing by 7.18 % to the EU production.

Average yield in Romania is 3,879 kg/ha, 2.71 times higher than the world average, but by 30 % lower than the EU average.

Romania has intensified its exports, but also its import, and has a positive Sorghum trade balance.

In Europe and mainly in the EU, this crop is seen in a new perspective and the specific Regulation recently issued is destined to stimulate the enlargement of the cultivated surface and the creation of high potential hybrids mainly in the countries where maize crop is affected by climate change.

It unanimously recognized as Sorghum could perform in an efficient way under low inputs (seeds, fertilizers, water etc), a low product cost and could increase farmers income and profit, and delivery of raw materials for industry.

For the Romanian farmers, Sorghum is an alternative to increase agricultural production in the areas where high temperature and droughts have a high incidence and to provide higher amounts for export. A special attention must be paid to the use of high value hybrids and production technologies, to fertilization and plant protection measures in order to increase yield and production. Also, the storage, marketing, and processing should be improved in order to increase the economic efficiency along the product value chain. The development of export could be another chance to sustain Romania's position as an important producer and exporter of Sorghum in the EU.

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