

SOME CONSIDERATIONS ON THE PROSPECTS OF SORGHUM CROP

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Abstract

The paper purpose was to analyze the sorghum statement at world, EU and Romania level in order to establish the main trends in the future of this crop. Sorghum is an important cereal coming on the 5th position after maize, rice, wheat and barley at world level due to its importance in human nutrition, animal feed, in producing bioethanol and green energy, and due to its good impact on environment. It is cultivated on all the continents, in the tropical, subtropical and temperate areas due to its resistance to drought, production potential, low inputs and production cost. It is an alternative to maize crop being more utilized as substituent in animal diets. The world sorghum production reached 63,811 thousand metric tons in 2014, the main producers being the USA, Mexico, Nigeria, India, Argentina, Ethiopia, Sudan and China. The world consumption of sorghum reached 63,148 thousand metric tons and it is continuously increasing. The sorghum exports accounted for 7,690 thousand metric tons in 2014, of which the USA export represents 4,600 thousand metric tons. Besides the USA, other exporting countries are Argentina, Australia, Ethiopia, India, Nigeria, Uruguay, while the main importing countries are China, Japan, Chile, Colombia, Mexico, the EU, Sudan. In 2014, the EU produced 576 thousand metric tons sorghum, imported 200 thousand metric tons, and consumed 770 thousand metric tons. The main EU producers of sorghum are France, Italy, Romania, Spain and Hungary. In 2012, Romania cultivated 20,000 ha with sorghum crop, 18 times more than in 2007. Also, in 2012, Romania produced 37.5 thousand tons of sorghum grains, by 31 times more than in 2007. The sorghum yield was 1,875 kg/ha by 66% higher in 2012 compared to 2007. Therefore, these figures show the increasing importance of sorghum crop at world level. Because Romania is situated in suitable geographical area for producing sorghum, it could increase production and become a more important supplier for the EU.

Key words: bioethanol, Sorghum crop, efficiency, green energy, food, feed, perspectives

INTRODUCTION

Among cereals crops at world level, Sorghum Sp. comes of the 5th position after maize, rice, wheat and barley [15,19,20,25].

Origin: Sorghum is plant known from the old times. More than 2000 years ago, Sorghum was known in the Roman Empire during Plinius the Elder, a well known naturalist who mentioned this plant in his Naturalis Historia. The first documents regarding Sorghum as a cultivated plant are dated 800 years A.D. attesting that this plant was firstly cultivated in Asiria and India.

However, most of the authors sustain that Sorghum origins are in Africa, where it is still existing as a wild plant on large surfaces. [15]. From the tropical zones of Central Eastern Africa (Sudan, Ethiopia), Sorghum has been extended its area in the hot and

temperate regions from 40-45 degrees North Latitude to 40-45 degrees South Latitude. Nowadays, Sorghum can be found in many arid areas from numerous African countries, in the Central and Southern America and Southern Asia, and also in the Mediterranean countries. [2].

Sorghum types. Sorghum belong to Gramineae Family, Sorghum Genus, including more than 3,000 annual and perennial species of which the most important one is Sorghum bicolor(L), Moench, sin. Sorghum vulgare Pers. This species has the following varieties: (a)Sorghum bicolor var. eusorghum or grain sorghum, (b) Sorghum b.var. technicum or broom sorghum, (c)Sorghum B. VAR. saccharatum or sweet sorghum and (d)Sorghum b. var. sudanese or feed sorghum.

Scientific research has given its contribution

to practical agriculture creating a large variety of hybrids of high production potential. [15]

Sorghum economic importance is given by its large variety of uses.

Sorghum grains are successfully used for human nutrition all over the world, but mainly in the African and Asian countries. Sorghum is considered a gluten less cereal. It is transformed in flour for producing bread in Africa, Central America, Southern Europe and Southern Asia, porridges and side dishes. [3, 14]

Sorghum is used in food industry for producing malted and distilled beverages (beer, low alcohol drinks), and popped grains. Also, sorghum grains are used as animal feed for pigs and cattle fattening as well as for poultry growing. The grains need to be processed by cracking, rolling or grinding, making sorghum nutritive value to be almost similar to the one of maize [3,]

Some varieties of sweet Sorghum have a high productivity in green mass and in sugar production. [14]

Sorghum could be used as green grass during summer season for cattle, sheep and goats, for grazing, also as silage and hay. Sorghum silage is similar to maize silage being rich in sugar and minerals (calcium, phosphorus, caroten). Because when the plants are young, sorghum is dangerous for animals due to its content in a toxic substance called "durrhina", which in the stomach of the animals is transformed in prussic acid, a real poison. Only 1 mg/kg live weight in case of cattle and 0.1 mg/kg live weight in case of sheep is enough to poison these animals. Only the sweet sorghum could be used by animals without any restriction. [5,6].

Sorghum is used as biomass for producing bioenergy and also as raw material for producing biofuel (bioethanol). [11, 12,17]

Sorghum fibers are utilized for producing brooms, washing brushes, knittings, paper, wallboard, fences, biodegradable materials for packaging due to their peculiar resistance. Also, solvents, dried stalks are used for cooking fuel.[2,4, 26]

For the reasons mentioned above, Sorghum is

a crop more and more cultivated in the world and could be considered among the main crops of the future agriculture.

In this context, the paper goal was to point out some considerations on the future of Sorghum crop in the world, in the European Union and in Romania, identifying the main trends regarding the cultivated surface, yield and production.

MATERIALS AND METHODS

The paper is based on a large documentation including the updated publications on Sorghum, also on the main data bases regarding cultivated surface, yield and production at world level in the period 2010-2014, and in the USA, as the main producer and exporting country at world level in the period 2011-2013.

Also, it was analyzed the statement of production, import, domestic consumption and stocks in the EU in the period 201-2014, identifying the main producing and exporting countries.

The main data sources have been USDA Crop Production, 2013, US Grain Council Reports, 2014.

Also, in case of Romania, there were used the statistical data provided by Romania's Statistical Yearbook, 2013 for the period 2007-2012 regarding the Sorghum cultivated area, production and yield.

Taking into consideration the collected information, it was identified the main trend and future of the Sorghum crop and its importance at world level, in the EU and in for Romania as a country with a high potential for cultivating this plant and becoming an important exporter for the EU.

The indices with fixed basis were used to determine the increase/decrease of the cultivated surface, production, consumption, export, import.

RESULTS AND DISCUSSIONS

Advantages of Sorghum crop.

(a) Sorghum has a similar chemical composition to the one of maize, being rich

in starch (73.8 %) and high value protein (12.3%), fats (3.9 %) and ash (1.65 %).

However, its use imposes as the diet to be supplemented with vitamins and minerals.

Table 1. Sorghum chemical composition versus Maize (%)

Sorghum				Maize			
Starch	Protein	Fat	Ash	Starch	Protein	Fat	Ash
73.8	12.3	3.9	1.65	71.5	10.3	4.8	1.44

Source: [2]

Sorghum seeds or caryopsis are rich in calories and protein, a reason to be an important food mainly for the African and Asian people. being an important food. [24]

(b) Sorghum can partially replace maize in the recipes for animal feed. Being a nourishing plant, containing high nutritive constituents, Sorghum could be successful used as a partial substituent in various diets for poultry, sheep, goats, cattle, pigs. This could be very important decision as long as maize price on international markets has substantially increased during the last decades. Because Sorghum has a low content of tannin, it could used just partially in the proportion 50 % maize and 50 % sorghum. This was proved by various experiments like the one carried out in Brasil at Sao Paulo University where a sample of 600 poultry, Cobb 500 Hybrid was divided into three experimental groups as follows: V1(control) fed with a daily diet consisting of 100% maize; V2 (Experimental variant 1) fed with 50% maize and 50% sorghum and V3 (Experimental variant 2) fed with 100 % sorghum poor in tannin. Based on the results regarding live weight, food consumption and carcass weight, it was drawn the conclusion that the poultry fed with 50% sorghum and 50 % maize registered almost a similar performance with the control variant, and the group V3 fed only with sorghum recorded the lowest performance. [16]

Other authors mention that sorghum could be included 20 % in hens diet and 40 % in pigs diet. [9,]

Some other authors mentioned that grain sorghum silage could be used as a supplement for growing steers grazing high quality pastures [1,]

(c) Sorghum is a plant with a well developed root system, with its leaves and its roots

and stalk covered by a wax layer. Growing longer than 1 m, the root explains the increased resistance of this plant to draft and thermic stress, compared to maize. Sorghum roots are disposed in 8 storeys and are covered by other small and thin roots. Also, the wax thin layer covering the leaves and stalk helps the plant to diminish perspiration and better resist to drought. [16]

(d) Sorghum is a highly resistant crop to drought and for this reason it may be cultivated in all the arid zones of the world, being named as the "vegetal camel".[16]. Compared to maize, sorghum can normally grow with just 100 mm rainfalls during the vegetation cycle. Also, its pollen is resistant to temperatures higher than 45-50 degrees, while maize pollen is resistant just up to 35-40 degrees.[9]

(e) Sorghum requirement for soil is very modest. For this reason, Sorghum could be cultivated on low quality and fertility soils where other crops don't. Sorghum can use sandy and salted soils very well, soils with a large pH (4.5-8.5). [16]

(f) Sorghum requires low fertilizer compared to maize or other crops. While maize needs more units of fertilizer, sorghum requires just: 20-60 units phosphorus, 20-60 units of Kalium, but 50-80 units of Nitrogen. [9]

(g) Sorghum requirement for water is less than in case of maize.

Sorghum requirement for water is very low compared to maize or oats. Its water needs for producing 1 g of dray matter is ranging between 158-274 compared to 597 in case of oats. [9]

Other authors mentioned that sorghum requires less than 23 inches of water, compared to maize which needs more water, 30 inches. [20]

Other authors mentioned that sorghum need

200 cubic meters water per ton, that is 50 % less water compared to maize requirement [8]

(h) Sorghum is highly resistant to pests and diseases. Sorghum is not affected by Diabrotica like maize, just a few insects could attack this crop. [9]

(i) Sorghum could be cultivated on all the continents, both in the tropical, subtropical and temperate areas. [8]

(j) Sorghum is a low production cost crop compared to maize. One hectare cultivated with sorghum requires Euro 500, while to cultivate 1 ha of maize a farmer must spend Euro 670. Therefore, sorghum assures Euro 170 savings per ha compared to maize, according to the results obtained within an experiment in France reported by Agricultural Chamber. [9]

(k) Sorghum has an ecological impact on environment. Sorghum, mainly the saccharatum type is able to absorb CO₂. While forests absorb 16t/ha/year and cereals 3-10 t/ha/year, 1 ha of sorghum is able to absorb 50-55 t CO₂. At the same time, it is able to produce huge amounts of oxygen [14]

(l) Sorghum could be used as a green fertilizer or as crop cover due to the positive action its roots able to release some biological active substances. [14]

(m) Sorghum has a high production potential. The average sorghum yield is 15.26 q/ha, but for hybrid sorghum this could exceed 100 q/ha. Normally, sorghum production varies between 50-80 q/ha. In case of broom sorghum, the production is 15-20 q/ha bushels, but also it could reach 40 q/ha. In case of saccharatum sorghum, the production is 40-80 t/ha fresh stalks. From one ton of stalks it could be produced 50-60 l syrup and from the production achieved from 1 ha it could result 3,000 l alcohol. [2, 10]

Sorghum could produce a good amount of biomass and sugar from its succulent stalks. Some varieties could produce in average 20 t/ha, however there are other varieties producing much more: 80 t green mass and 7 t sugar. In the USA, sugar performance could range between 4-17 t/ha. [14]

Large amounts of compost could be obtained from sorghum, the residues being estimated at

15 dt/ha/year. [8]

(j) Sorghum is a raw material for producing bioethanol and green power. Sweet sorghum is suitable and has a high productivity in ethanol production. It has a high productivity, 4,200-6,000 Etoh l/ha. One liter of bioethanol could save 2.2 kg CO₂.

Because of the continuous growth in ethanol at world level, it is expected as sorghum crop to be extended. This assumption is also supported by the fact that sorghum has many advantages compared to sugar cane (lower inputs, lower quality soils, resistant to hot climate) and could produce a similar bioethanol yield/ha like sugar cane. [8]

Sorghum situation at world level: production, consumption and trade.

World sorghum production increased by 4.32 % from 61,167 thousand MT in 2011 to 63,811 thousand MT in 2013. World sorghum consumption registered a higher increase than production, 5.31 %, from 59,660 thousand MT in 2011 to 63,148 thousand MT in 2013. Consumption is a little under production level, the difference reflecting the stocks, however the consumption growth rate is higher than production growth, an incentive for producers to intensify production. (Table 2).

The top ten Sorghum producers in the world are: the USA (9,144 thousand MT), Mexico (7,000 thousand MT), Nigeria (6,500 thousand MT), India (6,000 thousand MT), Argentina (4,800 thousand MT), Ethiopia (4,000 thousand MT), Sudan (3,800 thousand MT), China (2,800 thousand MT), Australia (2,050 thousand MT). [21]

The main countries consuming sorghum are: China, Mexico, Sudan, Ethiopia, Nigeria. [21]

The world sorghum trade increased by 15.83 % from 6,639 thousand MT in 2010/2011 to 7,690 thousand MT in 2014/2013.

The USA is the main exporting country of sorghum in the world with a share of 57.58 % in 2010/2011 and 59.81 % in 2014/2015. Other exporting countries are: Argentina, Australia, Ethiopia, India, Nigeria, Uruguay. (Table 3)

The main importing countries of sorghum are: China, Japan, Chile, Colombia, Mexico, the EU, Sudan. [7]

Table 2. World Sorghum production and consumption (Thousand metric tons)

Specification	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2014/2015 2010/2011 %
World production	61,167	57,245	57,933	59,168	63,811	104.32
World consumption	59,960	58,488	57,804	59,144	63,148	105.31

Source: [7] Own calculations.

Table 3. World Sorghum Trade, Oct/Sept, Thousand Metric Tons

Specification	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2014/2015 2010/2011 %
World Ty Export	6,639	5,456	7,277	7,635	7,690	115.83
Of which, the USA	3,823	1,549	2,136	5,600	4,600	120.32
The share of the USA in the world export (%)	57.58	28.39	29.35	73.34	59.81	-
World Ty Import	6,639	6,456	7,277	7,635	7,690	115.83
Of which, the USA	1	3	243	2	0	-

Source: [7] Own calculations.

Sorghum situation in the USA- the main sorghum producer in the world: cultivated surface, yield, production and trade.

The surface cultivated with sorghum for all purposes increased by 47.07 % in the period 2011-2013, from 5,481 thousand acres in 2011 to 8,061 thousand acres in 2013.

The surface cultivated with sorghum for grains increased by 66.20 % from 3,929 thousand acres in 2011 to 6,530 thousand acres in 2013, taking into account the importance of grain sorghum.

The share of the cultivated area with grain sorghum increased from 71.68 % in 2011 to 81 % in 2013.

Sorghum yield increased by 9.15 % from 54.6 bushels per acre in 2011 to 59.6 bushels in 2013. this growth is below the surface growth rate, meaning that the extent of the surface is the key factor for increasing production.

The production of sorghum grains increased by 81.42 % from 214,443 thousand bushels in 2011 to 389,046 thousand bushels in 2013.

Therefore, it is expected as the cultivated surface to continue to increase and the production as well. The surface cultivated with sorghum for silage destined to feed the

ruminants increased by 69.64 % from 224 thousand acres in 2011. to 380 thousand acres in 2013.

The silage yield per acre increased by 38.83 % from 10.3 Tons in 2011 to 14.3 Tons in 2013.

The Sorghum silage production increased by 2.35 times in the analyzed period from 2,298 thousand tons in 2011 to 5,420 thousand tons in 2013. (Table 4).

The USA sorghum production increased by 24.21 % from 8,779 thousand MT in 2011 to 10,905 thousand MT in 2013.

The USA production has registered an increased of its share in the world production from 14.35 % in 2011 to 17.08 % in 2013.

The USA sorghum consumption increased by 10.64% from 5,281 thousand MT in 2011 to 5,843 thousand MT in 2013.

The share of the USA sorghum consumption in the world consumption has increased from 8.8 % in 2011 to 9.25 % in 2013. (Table 5).

Sorghum situation in the European Union, EU-28: import, production, domestic consumption, ending stocks.

The EU is a producing but also an importing country of sorghum. The main trend in the EU is to decrease import, production, and

domestic consumption. In the analyzed period, the EU-28 diminished its import of sorghum by 78.31 % from 922 1,000 MT in 2010/2011 to 200 1,000 MT in 2014/2015.

Table 4. Sorghum cultivated area, yield, production at world level in the USA, 2011-2013

Specification	MU	2011	2012	2013	2013/2011 %
Sorghum cultivated surface for all purposes	1,000 acres	5,481	6,244	8,061	147.07
Of which, Grain Sorghum	1,000 acres	3,929	4,955	6,530	166.20
The share of surface cultivated for grains in the total cultivated area	%	71.68	79.35	81.00	-
Yield	Bushels per acre	54.6	49.8	59.6	109.15
Production	1,000 bushels	214,443	246,932	389,046	181.42
Sorghum for silage	1,000 acres	224	363	380	169.64
Silage yield per acre	Tons	10.3	11.4	14.3	138.83
Silage production	1,000 Tons	2,298	4,135	5,420	235.85

4. Source: [18]. Own calculations.

Table 5. The USA Sorghum production and consumption (Thousand metric tons)

Specification	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2014/2015 2010/2011 %
The USA production	8,779	5,447	6,272	9,882	10,905	124.21
The share of the USA production in the world production	14.35	9.51	10.82	16.55	17.08	-
The USA consumption	5,281	3,953	4,775	4,293	5,843	110.64
The share of the USA consumption in the world consumption	8.80	6.75	8.26	7.25	9.25	-

Source: [7] Own calculations.

Production also declined, but by only 8.43 % from 629 1,000 MT in 2010/2011 to 576 1,000 MT in 2014/2015.

Domestic consumption of sorghum has been diminished by 50% from 1,535 1,000 MT in 2010/2011 to 770 1,000 MT in 2014/2015.

The main producing countries of sorghum in the EU-28 are: France, which cultivates 50,000 ha and has a sorghum yield of 6.5 tons/ha, Italy comes on the 2nd position with 35,000 ha cultivated area, Romania on the

3rd position, followed by Spain and Hungary.[9]

The new orientation of the EU to biofuels imposed to look for solutions to produce them in an efficient manner. The best crop for coproduction of bioethanol and power is the sweet sorghum. In this respect, researchers from EUBIA, European Biomass Industry Association, provided the following solutions for the EU:

(a) A small Sorghum plantation of minimum 1,000 ha, bioethanol capacity 6,000 m³/year in

microdistillery;

(b) A large Sorghum plantation, on 10,000-50,000 ha, bioethanol capacity 60,000-300,000 m³/year.

These solutions could assure a low production cost of bioethanol, Euro 200/Ton, compared

to the production cost registered in 2005 in the EU, Euro 600/Ton and in other countries: USD 420/Ton in the USA, except Brazil where the ethanol production cost is the lowest one, USD 160/Ton [8]

Table 6. The EU-28 Sorghum import, production, consumption and stocks, Thousand Metric Tons)

Specification	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2014/2015 2010/2011 %
Import	922	126	291	200	200	21.69
Production	629	671	495	596	576	91.57
Domestic Consumption	1,535	760	795	795	770	50.16
Ending Stocks	21	14	27	23	24	114.28

Source: [7] Own calculations.

Sorghum situation in Romania: cultivated surface, yield, production.

In Romania, the cultivated area with Sorghum is very small. However, during the period 2007-2012, the cultivated area with this crop increased by 18.18 times from 1.1 thousand ha in 2007 to 20 thousand ha in 2012. This fact

reflects the interest of farmers to cultivate sorghum because the market needs in a continuous increase. The share of Sorghum in the cultivated area with cereals has increased from 0.02 % in 2007 to 0.37 % in 2012.(Table 7).

Table 7. Sorghum cultivated area in Romania, 2007-2012 (Thousand ha)

	2007	2008	2009	2010	2011	2012	2012/2007 %
Cereals cultivated area	5,129.2	5,210.7	5,284.4	5,040.6	5,224.7	5,440.3	106.06
Sorghum cultivated surface	1.1	8.0	6.1	10.3	13.1	20	1,818.18
Maize cultivated area	2,524.7	2,441.5	2,338.8	2,098.4	2,589.7	2,730.2	108.13
Share of sorghum in cereals cultivated area(%)	0.02	0.15	0.12	0.20	0.25	0.37	-

Source: [13] Own calculations.

Sorghum production has recorded a significant growth in Romania, from 1.2 1,000 T in 2007 to 37.5 1,000 T in 2012. This means that it was 31.25 times higher in 2012 compared to the level from 2007. The growth rate was higher compared to the cereals production, which increased by 64%. As a result, the share of sorghum in cereals production increased from 0.01 % in 2007 to 0.29 % in 2012. It is a very small share, but its continuous increasing trend shows that

sorghum has become an important crop among the other cereals in Romania.(Table 8).

The average Sorghum production increased by 66.22 % from 1,128 kg/ha in 2007 to 1,875 kg/ha in 2012. Compared to maize yield, it is a higher growth rate. Looking at the yield level, it is obviously that sorghum performance is lower in comparison with the one of maize.(Table 9).

The increased yield and production is a

consequence of the extended cultivated surface but also of the use of high productive potential hybrids produced by the Research Institute from Fundulea (Fundulea 21,

Fundulea 30, Fundulea 32, hybrids between sorghum and Sudan grass named Sweetleaf and Tudora, with a low content of durrhina and high production.

Table 8. Sorghum production in Romania, 2007-2012 (Thousand tons)

	2007	2008	2009	2010	2011	2012	2012/2007 %
Cereals grains	7,814.8	16,826.4	14,873.0	16,712.9	20,842.2	12,824.1	164.10
Sorghum grains	1.2	20.9	14.4	18.7	39.7	37.5	3125.0
Maize grains	3,853.9	7,849.1	7,973.3	9,042	11,717.6	5,953.4	154.47
Share of sorghum in cereals production(%)	0.01	0.12	0.10	0.11	0.19	0.29	

Source: [13] Own calculations.

Table 9. Sorghum yield in Romania, 2007-2012 (kg/ha)

	2007	2008	2009	2010	2011	2012	2012/2007 %
Maize grains	1,526	3,215	3,409	4,309	4,525	2,180	142.85
Sorghum grains	1,128	2,608	2,359	1,816	3,035	1,875	166.22

Source: [13] Own calculations.

Also, in Romania, there are companies like as Euralis which offers hybrids such as: Arkanciel, Armida, ES Alize, Tramontane and Caussade Semences, which offers other hybrids such as: Balto CS, CSS 29, Fuego CS, Brise CS for grains and Super Sile 20 CS sweet sorghum for silage. [9,14]

The most cultivated areas with sorghum in Romania are the ones suitable for this crop: the plains of South Muntenia, Oltenia, The Banat Plain, the Central Plain of Moldova, in general, the areas where maize is raised.

Sorghum is a profitable crop because of its lower production cost per ha compared to maize. Maize crop need to produce by 10 % more per ha than sorghum to bring the farmer a similar profit like sorghum.

Table 10. Production performance of Sorghum ES Alize Variety compared to maize, 2011-2012 (kg/ha)

Hybrid	2011	2012	Differences 2012-2011
Sorghum ES Alize hybrid	8,280	6,200	-2,080
Maize hybrid	10,441	5,323.6	-5,117.4

Source: [9]

In the areas where the rainfalls are over 250

mm/year, maize is suitable for cropping, leading to yield of 7-8 tons/ha, therefore in these regions maize is more profitable than sorghum.

But, in the areas with 150-250 mm rainfalls, the ES Alize sorghum variety produced by Euralis is more efficient, producing 6 tons/ha while maize is able to produce just 5 tons/ha. Also, in the droughty areas with less than 150 mm rainfalls, sorghum is the most suitable crop producing 5 tons/ha while maize is able to produce only 3 tons/ha. Therefore, sorghum is more efficient to be cultivated in the droughty areas like South, South West and West Romania also for Dobrudja region, where irrigation systems are missing. [9]

The Research and Development Station from Tirgu Mures organized some experiments in order to compare production of ES Alize sorghum hybrid with maize in the period 2011-2012. The chemical composition of the grains of this hybrid is: 11.4 % protein, 4.1 % fat, 66.3 % starch and fibers. [9]

Important experiments were achieved by National Institute for Biology and Animal Nutrition Balotesti (NIBANB) in order to partially replace maize in animal diets. The

obtained results encourages researchers to recommend farmers various recipes based on sorghum. A selection of these recipes is presented in Table 10.[22,23]

These recipes are suitable to the farms where ruminants are grown. They include Sorghum in various forms such as green grass, and silage, but also there are recipes based on Sorghum hay.

The new sweet sorghum varieties F-436 and F-465, created at Fundulea Research Institute, have a high production potential, have a rich sugar content and are suitable for green grass and silage. [22]

Also, it was noticed that the two Sorghum hybrids mentioned above have a nutritive and energetic potential, in terms of nutritive units, close to the one of maize, a reason to replace sorghum. The experiments based on 68/32 sorghum silage/wheat bran have lead to satisfactory results in sheep fattening. [23]

Table 11. Animal recipes where Sorghum partially replaced maize, recommended by NIBANB

Animal category and characteristics	Recipes content
Young cattle, 200 kg live weight, 800 g/day weight daily gain	Sorghum silage 5.15=3 kg, mixed hay 3.59 kg, maize 0.46 kg, soybean cake 0.27 kg, Total 9.45 kg/head/day
Dairy cow, 15 kg milk/day	Sorghum silage 25 kg, alfalafa hay 3.42 kg, alfalafa semisilage 2.64 kg, wheat straw 1.37 kg, sunflower cake 1.25 kg, barley from breweries 6.47 kg, Total 37.09 kg/day
Goat, 55 kg live weight, 3.5 kg milk/day	Green grass sorghum 6.55 kg, maize 0.72 kg, wheat bran 0.43 kg, Total 7.7 kg
Raw, 85 kg live weight	Green grass sorghum 3.79 kg, alfaalfa hay 0.71 kg, carrots 1 kg, barley 0.58 kg, peas 0.90 kg, Total 6.98 kg/day
Fattened steers, 400 kg, 1,300 g/day weight daily gain	Green grass sorghum 8.5 kg, alfaalfa hay 0.91 kg, barley 4.66 kg, sunflower cake 0.78 kg, Total 14.85 kg/day
Dairy cow, 24 kg milk/day	Green grass sorghum 25 kg, alfaalfa hay 5.49 kg, maize 5.51 kg, soybean cake 1.78, Total 37.78 kg/day

Source:[22]

CONCLUSIONS

Sorghum is an important cereal coming on the 5th position after maize, rice, wheat and barley at world level due to its importance in human nutrition, animal feed, in producing bioethanol and green energy, and due to its good impact on environment.

It can be cultivated on all the continents, in the tropical, subtropical and temperate areas due to its resistance to drought, production potential, low inputs and production cost. For this reason, it could be an alternative to maize crop being more utilized as substituent in animal diets.

The world sorghum production reached 63,811 thousand metric tons in 2014, the main producers being the USA, Mexico, Nigeria, India, Argentina, Ethiopia, Sudan and China.

The world consumption of sorghum reached 63,148 thousand metric tons and it is continuously increasing.

The sorghum exports accounted for 7,690 thousand metric tons in 2014, of which the USA export represents 4,600 thousand metric tons.

Besides the USA, other exporting countries are Argentina, Australia, Ethiopia, India, Nigeria, Uruguay, while the main importing countries are China, Japan, Chile, Colombia, Mexico, the EU, Sudan.

In 2014, the EU produced 576 thousand metric tons sorghum, imported 200 thousand metric tons, and consumed 770 thousand metric tons. The main EU producers of sorghum are France, Italy, Romania, Spain and Hungary.

In 2012, Romania cultivated 20,000 ha with sorghum crop, 18 times more than in 2007. Also, in 2012, Romania produced 37.5 thousand tons of sorghum grains, by 31 times more than in 2007. The sorghum yield was 1,875 kg/ha by 66% higher in 2012 compared to 2007. Therefore, these figures show the increasing importance of sorghum crop at world level. Because Romania is situated in suitable geographical area for producing sorghum, it could increase production and become a more important supplier for the

EU.

In Romania, Sorghum could be successfully used for animal feeding, partially replacing maize in the diets for various species and categories: poultry, pigs, sheep, cattle, increasing farmers profit due to the reduced production cost compared to maize and efficiency in animal production is similar like in case of maize.

In this respect, it required as scenarios to be established in order to develop sorghum cropping under the highest economic efficiency, the processing technology being the same.

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