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THE BIOLOGICAL AND AGRICULTURAL POTENTIAL OF SORGHUM CROP IN ROMANIA

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Abstract

Sorghum is the fifth most cultivated cereal in the whole world, after wheat, rice, corn and barley. It is a cereal with a chemical composition, similar to cereals grown in our country, especially corn. This crop must be reconsidered, as a cereal with great potential, to be used for human consumption, not only for animal feed. The sorghum crop is a crop that does not require large production costs, compared to other cereals grown in our country, especially in the context of climate change, in recent times. This research work aimed to present the biological and agricultural potential of Sorghum crop based on statistical data provide online by FAOSTAT, European Union Sorghum Area, Sorghum-id.com și The ARVALIS Technical Institute, France. The analyzed data refer to the period 2010-2022, so to a period of 12 years. The methods used to set up this study have been the comparison and index methods. The main results obtained based on this analysis reflect that, in Romania, where water availability may become a challenge in the future, sorghum can be a valuable crop option. Sorghum is a versatile crop that can adapt to a wide range of soil and climatic conditions. In conclusion, information about the sorghum crop is important for farmers to make the right decisions, because the sorghum crop has a high yield, which could be used in crop rotations or as a complementary crop for maize, being a crop of the future.

Key words**:** *sorghum, climate change, drought tolerance***,** *acceptabile chemical composition*

INTRODUCTION

Based on the characteristics and production potential of different areas agricultural, taking into account the objectives of diversification a energy production, farms face conversion to annual and perennial herbaceous crops: sunflower, canola, sorghum and common cane and with tree crops. Among the different forms of biomass, the energy crops grown able to ensure the production of thermal or electrical energy: stand out: sunflower, rapeseed, artichoke, sorghum, cane, poplar, willow [33, 43, 55].

Biodiesel and bioethanol are obtained from most important agricultural species (wheat, barley, corn, rapeseed, soybean, sunflower, sorghum, sugar beet, etc.) and attract favorable economic implications. Biodiesel, in particular, is considered an excellent contributor to motor vehicles and fuels. It is obtained from vegetable crops to animal fats used in oilseed crops. Biofuels are generally in diester form, a transesterification process [52, 23, 26].

Sorghum (*Sorghum bicolor*) is a monocotyledon belonging to the family Poaceae or Graminaceae, tribe Anthropogoneae. It is believed to have originated in East Central Africa (Sudan, Ethiopia) and then spread to Asia and Europe and later to America and Australia. It was a from the first cultivated species and today it is the fourth most important cereal in the world agricultural economy after wheat, rice and corn [4, 1, 41]. Based on the degree of chromosome pairing, the genus Sorghum would include 6 subgenera that can be classified based on intended use into:

1) broom sorghum or sorghum (*S. bicolor*, var. technicum). It is noted for the very short axis of the panicle, on which long branches are inserted elastic stems that form an umbelous inflorescence. The latter is used in the manufacture of brooms;

2) fiber sorghum (S. bicolor, var. technicum or its hybrids), characterized by a very tall plant, 2-5 m;

3) sugar sorghum (var. saccharatum), a very tall plant, 2-5 m, with a juicy pith, rich in

sucrose (15-20%), is not suitable for sugar production, because in addition to sucrose it has significant amounts of invert sugar that inhibits crystallization. It can be used for the production of syrups and bioethanol;
4) fodder sorghum (varr. sudangrass and saccharatum), with cultivation capacity;
5) cereal sorghum (various hybrids), characterized by low plants (1-1.5 m) with empty grains without tannins, used for human consumption in developing countries and for animal feed in advanced countries [12, 22, 7].
In 2020, the area cultivated with sorghum increased by 18% in the European Union [44]. This increase applies to both grain sorghum (+20%) and forage sorghum (+12%). Of African origin, sorghum is the 5th cereal in the world (with a production of 49 million hectares), after corn, wheat, rice and barley. Globally, 50% of the area under sorghum is in Africa, but it is also grown in the United States, where areas have increased sharply, in Argentina, India, China and Australia. In short, on five continents [12], [22].

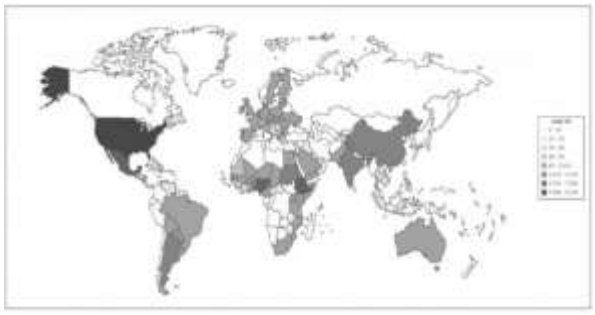

Fig. 1. Global sorghum production
Source: FAOSTAT [19].

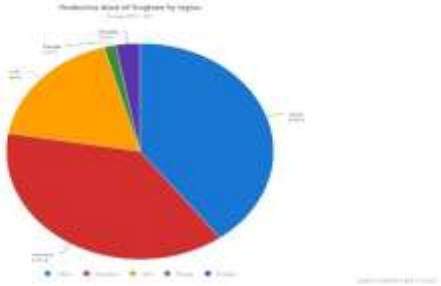

Fig. 2. Production share of Sorghum by region
Source: FAOSTAT [19].

It is mainly used in traditional dishes from Africa, Southern Europe, but also in Central America and Asia. Cultivated grain sorghum, also known by the scientific name Sorghum bicolor, belongs to the family Poaceae (grasses) and the panicoid subfamily. It is a herbaceous plant, widespread in the wild in tropical and subtropical climates. For centuries, the peoples of Africa and Asia have used its seeds for food, its straw for fodder. Sorghum was later introduced to Europe and the United States, but is mainly used for animal feed [7, 56, 28].
In Europe, the sorghum culture was brought in the fifteenth century, but did not know a wide spread.
Sorghum cultivation in Romania is classified in the specialized literature as a technical and fodder crop.
There are over 30 different species of sorghum originating from regions with a tropical and subtropical climate. Most are used as animal feed or are processed to produce alcohol or sorghum syrup. Few varieties are grown for human consumption [41], [25].
For a sustainable production and consumption it is necessary to have a continuous increase of resource productivity, to avoid stagnation and syncope at the macroeconomic level. Should not be lost sight of that increase of resource efficiency in Europe is a means by which the objectives of economic policy, social and environmental development can achieve easier, safer and with lower costs.
Information about the sorghum crop is important for farmers to make the right decisions, because the sorghum crop has a high yield, so it crop rotations, being a crop of the future.
In this context, the aim of this study was to present the biological and agronomical characteristics of sorghum crop, as well as the cultivated areas and production in Romania, EU and at the global level.

MATERIALS AND METHODS

This study was carried out based on based on statistical data provide online by FAOSTAT, European Union Sorghum Area, Sorghum-id.com și The ARVALIS Technical Institute, France.
The analyzed data refer to the period 2010-2022, so to a period of 12 years.

The comparison and index methods were used as analysis methods. Based on these methods, areas and productions were compared worldwide and at the European level.
The indicators (K- FAOSTAT source) as well as the comparative biochemical analysis of sorghum with the main cultivated cereals (data from the Arvalis Institute in France), show the evolution of phenomenon of increasing areas and productions of sorghum culture, but also a favorable chemical composition compared to wheat and especially in relation to corn. That is why the sorghum culture does not compete with that of corn, on the contrary, it contributes to increasing the global grain production, by occupying climatic regions and soils unfavorable for classical cultures [51].

RESULTS AND DISCUSSIONS

Sorghum is a perennial plant that can be harvested several times a year. But in our latitudes, grain sorghum is grown as an annual crop. The stem (stubble) is usually a meter tall, sometimes more, and 1 to 5 cm thick. The leaves, which resemble those of corn, have a flat blade, broadly rounded at the base, 30–100 cm long and 5–100 mm wide [43, 55, 52].
Sorghum is a thermophilic, versatile plant, also called a „camel "plant, because it can be grown on acidic lands and especially on salts, where other plants cannot be grown, having a wide pH range (4.5-8.5).
The plant breeding work shad several objectives: precocity, low content in tannin and hydrocyanic acid, improvement of tolerance to salinity and soil alkalinity [56, 28, 25].
It harnesses low, uneven rainfall, so a sorghum root reaches 4.8 m depth, compared to a maize root, which reaches 2.4 m depth in the soil.
It is an environmentally friendly plant, for example, one ha of sugar sorghum absorbs 50t of carbon dioxide year [41], [13], [46].
The sorghum species is primarily self-pollinated, but wind cross-pollination can occur under certain conditions. For this reason, most local sorghum breeds grown by farmers consist of mixtures of pure and semi-pure lines. Cross-pollination is higher for forage sorghum. Flowering time is extremely variable. Depending on the genotype, depending on the climate, the plant can flower 30 to 100 days after germination. Wet and cold weather causes delayed flowering [23, 26, 4, 5].
The Arvalis Institute in France carries out analyses on sorghum grains every year. The results indicate an advantageous chemical composition because it is comparable to other cereals such as wheat or corn.
The starch content of sorghum represents 74 % of the dry matter; it is equal to that of maize.

Table 1. The chemical composition of Sorghum versus wheat and maize

Dry matter (%)	Wheat	Maize	Sorghum
Starch	69	74	74
Protein	12	9	11
Fat	1.8	4.2	3.5
Sugars	2.9	1.9	1.3

Source: Own conception based on the data from The Arvalis Institute [49].

The protein content of sorghum grains can vary between 10 and 12%, these are values that make sorghum a crop with a favourable chemical composition with a high agricultural potential. It has a wide range of uses.
Sorghum grains do not contain gluten.
Sorghum grains can be included in human food, not only for feeding animals.
Sorghum has an amazing 22 grams of protein in one cup (192 grams) of cooked whole grain. The recommended daily dose of protein for women is 46 grams, and for men, 56 grams. On average, sorghum contains 43% of the daily protein requirement [27, 21, 16].
One portion contains 47% of the required iron and 55% of the recommended value of phosphorus. It is also a good source of magnesium, copper, calcium, zinc and potassium [9, 3, 39].
A portion of sorghum also contains approximately 30% of the recommended amount of niacin and thiamine. These two types of vitamin B are necessary for the correct metabolism of carbohydrates and nutrients.

Sorghum contains a varied range of phytochemicals that act as antioxidants in the body, such as tannins, phenolic acids, anthocyanins, phytosterols and policosanols. In fact, the shell of the sorghum grain has a higher amount of antioxidants than blueberries, strawberries and plums. Antioxidants contribute to slowing down the aging process, and foods rich in antioxidants are associated with a reduced risk of heart disease, diabetes, cancer, type 2 diabetes and some neurological diseases [23, 26, 4].

Many studies confirm that a consumption of whole grains reduces the rate of deaths caused by cardiovascular disease, phytochemicals being considered to be largely responsible for this. It has been proven that they reduce cholesterol and prevent thickening of the arteries. Sorghum is one of the best sources of dietary fiber. One portion contains 48% of the recommended daily dose of fiber [45, 15, 35].

Fibers are vital for the optimal functioning of the digestive system.

Compared to maize, sorghum has a greater number of stomata, but they are smaller in size. This feature, along with the properties of the epidermis and the presence of a waxy layer, offers a strong capacity to save water, thus resisting drought [31, 32, 8]. Practically, the plant is able to reduce transpiration to a minimum until growth is arrested during the driest periods, to then resume vegetation when conditions return to normal humidity [30,11, 29].

Sorghum has a high biological and agricultural potential, which is why it is grown by many farmers, especially in Europe.

Sorghum has a C_4 photosynthetic cycle, meaning high interception efficiency and conversion of light radiation: a quality that is particularly enhanced in environments characterized by high light intensity and high temperature [57, 47, 18].

In Europe, about 80% of agricultural area is not irrigated; this has led to a visibility of sorghum cultivation.

Sorghum is among the most demanding species from a thermal point of view: it requires at least 12- 14°C for germination (2°C more than corn) and 16°C for plant development, while the optimal growth temperatures are 27-28°C. The species has a good adaptation to a wide range of terrains, but the salty ones do not tolerate soils subject to water stagnation. In addition, di- the size of the seed and the lack of vigor of the shoots make the culture very sensitive to the superficial crust in muddy soils [17, 42, 10].

In this sense, as already mentioned, it must be taken into account that biomass production is strongly dependent on the duration of the biological cycle. of the plant which, in a temperate environment, is conditioned by the moment in which it can be found seeding is carried out, which in turn depends on the control of genetic factors germination and development below 16°C. Availability of low grade resistant genotypes if temperatures would allow require early seeding in first two weeks. March of late and more productive types [36, 37, 38 , 40, 2, 20].

At European level, the genetics of sorghum hybrids are constantly being improved as the plant of the future - EUROSORGHO - is the European program for the creation of new sorghum hybrids,

The first European Sorghum Congress was held in Romania in 2016, 3-4 November, in Bucharest, with the theme: Sorghum – the culture of the future. The new varieties, the result of European research, are well adapted to our climate and prove to be much more productive than the first varieties introduced [48, 14, 24, 38].

According to the statistics, the area cultivated with grain sorghum in Europe reached 375.000 ha in 2020 and in 2022, in EU they decreased to 183.000 ha cultivated with sorghum [1, 41]

In the EU in 2022, there were 183,000 ha cultivated with sorghum. From the total EU production, 41% is achieved in France, 34% in Italy, 8% in Hungary and 7% in Romania [44]. In Romania, 5,702 ha were cutivated with sorghum in 2022 [34].

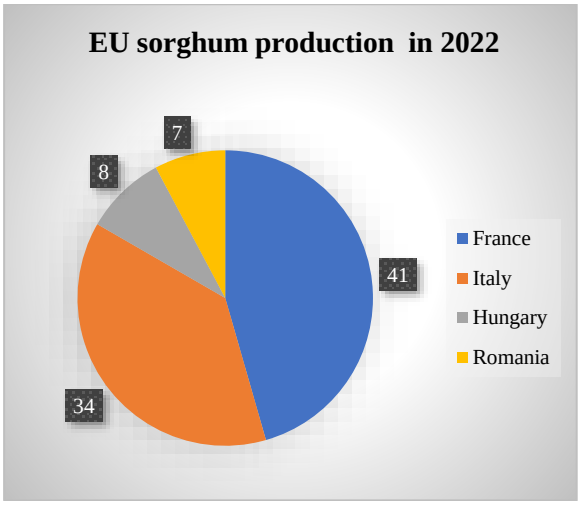

Fig. 3. EU sorghum production 2022
Sou rce: Own conception based on the data from European Union Sorghum Area [44].

Fig. 4. Yield (tones/hectare)
Source: European Union Sorghum Area [44].

In 2023, the largest cultivated areas with sorghum in the EU are in France 51,000 ha and Italy 40,000 ha. The highest production is obtained in Italy, 260,000 tons and France 219,000 tons, while the top yield was registered in Italy 6,500 kg/ha, Greece 5,200 kg/ha and France 4,300 kg/ha [44]. In recent years, sorghum culture has gained momentum in Romania due to its adaptability to semi-arid areas, to soils with low fertility, drought resistance and low production costs compared to corn culture. Sorghum production in Romania, varied as follows, according to FAOSTAT:in the period 2000-2010-25,000 t and in the period 2010-2022-75,000 t [19].
In Romania the cultivated area of sorghum, in the period 2010-2022, registered a significant increase, especially in the year 2013 (Figure 5).

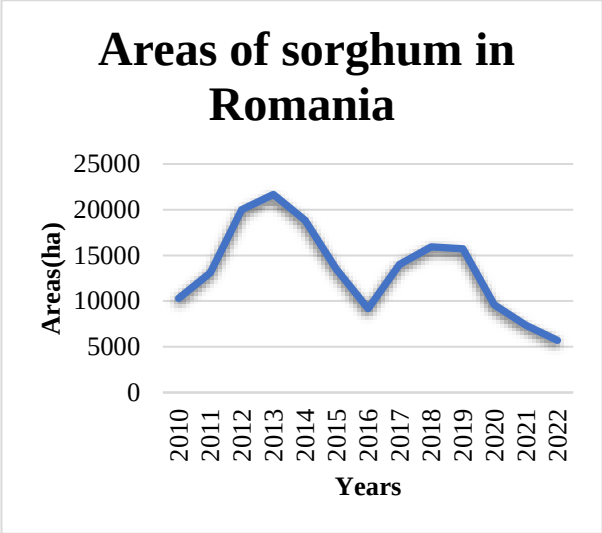

Fig. 5. Romanian sorghum production
Source: Own conception based on teh data from INS-Tempo online [34].

Research and extension services can play a crucial role in helping farmers in Romania understand how to grow and manage sorghum effectively, especially in the context of climate change. Furthermore, policymakers and agricultural organizations can encourage and support the adoption of sorghum through incentives, research funding, and the development of local markets for sorghum-based products. By leveraging the potential of sorghum, Romania can enhance its agricultural resilience in the face of climate change while contributing to food security and sustainable agriculture [33], [50 54, 53, 6].

CONCLUSIONS

The cultivation of sorghum in Europe in recent years, especially due to drought, has attracted the attention of farmers for its adaptability to low rainfall, short growing season, but also its tolerance to pests.
For many farmers, sorghum is a new crop, so information is important in Europe's sorghum development strategy.
Sorghum has a lower consumption of inputs, compared to other crops, by 30%, lower compared to maize, so low costs, but it is also a good precursor plant, it can enter rotations.
This can result in cost savings for farmers and reduce the environmental impact of agriculture.

Sorghum grown in Europe is not used locally, being exported to countries that use it, for example, Spain is the largest consumer of sorghum in Europe.

In Romania, where water availability may become a challenge in the future, sorghum can be a valuable crop option. Sorghum is a versatile crop that can adapt to a wide range of soil and climatic conditions. This adaptability can help farmers in Romania respond to changing climate conditions and shifting weather patterns. Sorghum has a relatively short growing season compared to some other crops, which allows for flexibility in planting and harvesting. Sorghum can be used for biomass production and biofuel feedstock. As the world seeks more sustainable energy sources, Romania can explore the use of sorghum for bioenergy production, which can contribute to reducing greenhouse gas emissions. Sorghum is a valuable source of livestock feed, and its cultivation can support the livestock industry in Romania. It provides an alternative feed source, especially during times of forage scarcity caused by changing weather conditions. Sorghum can be included in crop rotation systems, which can help improve soil health and reduce the risk of diseases and pests, which can become more prevalent in a changing climate.

However, it's important to note that the successful cultivation of sorghum in Romania will depend on several factors, including local climate conditions, soil types, and the availability of appropriate sorghum varieties. Additionally, farmers may need to adapt their farming practices and adopt new techniques to make the most of sorghum's potential.

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