Scientific Papers. Series A. Agronomy, Vol. LXVI, No. 2, 2023
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE RESEARCH METHODOLOGY USED REGARDING THE BEHAVIOUR OF SOME SORGHUM HYBRIDS IN TERMS OF PRODUCTIVITY AND ADAPTABILITY UNDER THE CONDITIONS AT BRAILA AGRICULTURAL RESEARCH AND DEVELOPMENT STATION

Florin MOCANU, Costică CIONTU

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
Marasti Blvd 59, District 1, Bucharest, Romania

Corresponding author email: mocanuflorinn24@gmail.com

Abstract

The plant that was the object of the research was represented by the sorghum plant (Sorghum bicolor var. eusorghum) and the aim of the work was to be able to observe the behaviour of some hybrids in the pedo-climatic conditions of the Braila Agricultural Research and Development Station. It is known about grain sorghum that it presents some physiological characteristics that allow it to be cultivated in restrictive pedo-climatic conditions. These conditions refer to the presence of poor soils and areas where temperatures are higher than average and water supplies are poor. Under such conditions it is more difficult for the maize crop to provide economically profitable production. In this situation, growers can use sorghum as a safe option for obtaining profitable productions. In this paper it will be discussed the adaptability and productivity, two important elements for this crop.

Key words*: sorghum, productivity, adaptability.*

INTRODUCTION

The main representative of the *Sorgum* genus is *Sorghum bicolor*, which presents several varieties as well, the most well-known and used in culture being: *Sorghum bicolor* variety *eusorghum* (grain sorghum), *Sorghum bicolor* variety *technicum* (technical sorghum or broom sorghum), *Sorgum bicolor* variety *saccharatum* (sugar sorghum), and *Sorgum bicolor* variety *sudanese*, which is the forage sorghum (Roman Gh. V., 2011)

Sorghum is the cereal that occupies the fifth place in the world among the cultivated cereals, being surpassed only by wheat, rice, corn and barley, worldwide the area occupied by sorghum is 40 million ha., with the main cultivation areas on the African continent (Nigeria Sudan, Ethiopia), India but also important areas of the USA. From Europe, Russia, France, Spain and Italy stand out as countries with high areas cultivated with this plant. (https://www.sorghum-id.com/content/uploads/2022/02/2.bis-Arthur-Boy-Pierre Guillaumin.pdf)

What these areas have in common is the constant presence of high temperatures and low rainfall, giving sorghum plants an important place in the culture, being able to obtain very good yields where corn is limited by adverse pedological and atmospheric factors. This adaptability has given sorghum the nickname "The camel of crops". Also, through the research carried out in 2002 by Antohe , it was demonstrated that sorghum has a beneficial role in preventing land desertification.

Sorghum is a cereal with many uses, being successfully used in human food (African countries being an example in this sense) through the suitability of using flour in baking and pastry, the use of sweet syrup as a substitute for sugar and even obtaining drinks from sorghum grains. (Antohe, 2007; Bâlteanu, 2003; Pochișcanu et al., 2016; 2017). In the conducted researches, the role of sorghum in the medical field was highlighted due to the compounds the grains contain: ferulic acid, p-coumaric acid, p-hydroxybenzoic acid, and vanillic acid (Fatoki et al., 2023)

In animal nutrition, sorghum also has an important place considering that the use of sorghum grains mixed with corn grains, in a 50-50 percentage, has a special contribution, but also sorghum hay has a high value.

Correlating the fact that *Sorghum bicolor* presents good productions, varied uses in multiple branches of industry with the fact that areas in Romania, as well as worldwide, no longer benefit from the usual rainfall, sorghum can be a solution that can be counted on in the years that will follow.

MATERIALS AND METHODS

The research took place in the 2020-2021 and 2021-2022 agricultural years in Braila County on a chernozem soil, characteristic of the area moderately calcium-supplied in the upper part of the profile and strongly carbonated in the lower part (19.3%), with a medium humus content (2.4-3.1%) in the upper horizons and only 1.6 % in the transition horizon.

Total nitrogen content varies between 0.14-0.25% mobile phosphorus content 174-225 ppm and mobile potassium 24.0-26.0 mg/100 g soil in the arable layer and with a pH of 7.9-8.4. As physical and hydrophysical indices, the soil has an apparent density of 1.10-1.31 g/cm^3 with a field capacity of 22.9-25.2%, a wilting coefficient of 6.7-10.2%, a hygroscopicity coefficient of 3.7-6.4% and a minimum ceiling of active humidity of 13.8-17.4%.

The experiment was made by the method of subdivided plots and having 4 repetitions (in 2020-2021) and 3 repetitions for the 2021-2022 agricultural year.

In the experience, factor A was tested with 8 graduations a1 - Es Aize; a2 - Es Shamal; a3 - Es Arabesque; a4 - Es Foehn; a5 - Anggy; a6 - Ggustav; a7 - Belluga; a8 - Huggo.

All these hybrids are classified as hybrids with very low tannin content, less than 0.3%, starch content of 78% and protein content of 10-11%, being hybrids with high production capacity, especially in favorable conditions. (https://ragt-semences.fr/sites/default/files/public/medias/variety/pdfs/RGT%20ANGGY.pdf).

The factor B was represented by the sown density wich had 2 graduations: the density of 220.000 seeds/ha, and 250.000 seeds/ha with 70 cm between the rows for the firts density respectievly 50 cm between the rows for the second one.

The 2020-2021 agricultural year began with the preparation works of the agricultural land that had been cultivated with autumn wheat . These works carried out in the fall of 2020 were represented by harrowing.In the spring of 2021, starter fertilization was carried out with the DAP 18-46-0 complex fertilizer with an ammonia nitrogen content of (NH_4) - 18% and phosphorus pentaoxide (P_2O_5) - 46%. The dose applied was 200 kg per hectare of commercial product.

The next two works that were executed were the pre-emergent herbicide applying with the total herbcide Leo Green 360 with the active substance content of 360 g/l glyphosate in a dose of 4 l/ha and then the preparing of the germinal bed, corresponding to sowing.

The hybrids were sown on 26th of May 2021 in an experimental field that was made up of 8 variants (corresponding to each hybrid), with 4 repetitions each.

The plots consisted of six rows of sorghum 8 meters long, with a sowing distance of 70 cm between rows, at a density of 220.000 plants/ha and and the distance of 50 cm with the density of 250.000 plants/ha.

The harvest took place on 1st October 2021, being executed manually.

In the 2021-2022 agricultural year, the experiences with sorghum hybrids for grains were positioned on another land, an area that had corn as its predecessor plant.

It was harvested at the end of October 2021, after which the soil scarification work was carried out and then harrowing to break up the large soil formations.

In 2022, at the end of March, complex fertilizers 15-15-15 were administered to increase the content of N, P_2O_5 and K_2O.

Sowing was carried out on 8th of May 2022, being preceded by the preparation of the germinal bed.

After sowing, herbicide application was carried out with Barbarian Super and Dual Gold with the active substance glyphosate, respectively S-metolachlor to combat both monocotyledonous and dicotyledonous weeds.

A second fertilization work was carried out at the end of May, applying granular urea with a N content of 46%. In the case of treatments, Casper herbicide was also applied in June, with the active substances prosulfuron 5% and dicamba 50% to combat dicotyledonous weeds.

The harvesting took place on 15th of September 2021 when the sorghum hybrids reached the

optimal moisture of 15 %. The 2021-2022 agricultural year was characterized by the fact that precipitation was reduced compared to the previous year and compared to the multi-year average, so from the date of sowing to the date of harvest, the value of 125.5 mm/m² was recorded.
The collected data from the field were analysed using ANOVA function from Microsoft Word.

RESULTS AND DISCUSSIONS

In the therm of climatic conditions the data shown in the Table 1 highlighted the fact that the 2020-2021 agricultural year was characterized as a year with a high precipitation rate comapred to the multiannual. The temperature recorded was also increased than the multiannual.

Table 1. The climatic conditions registered in Braila Agricultural Research and Development Station in 2021

Month	2021 Temperature (°)	Multiannual average (°)	2021 Precipitations (mm)	Multiannual average (mm)	2021 Solar radiation	2021 Wind speed
January	2.2	-2.1	41.2	28	90.7	3.2
February	2.4	-0.2	7.4	27	90.5	2.8
March	4.7	4.7	31.4	26	150.9	2.8
April	9.4	11.2	53.3	35	170.0	2.4
May	16.7	16.7	75.8	48	213.6	2.2
June	20.2	20.9	173.8	62	181.1	3.1
July	24.8.	22.9	40.4	46	287.7	1.6
August	23.4	22.1	36.7	39	280.4	3.8
September	16.9	17.3	10.4	32	207.5	1.6
May-September	21.2	20.6	337.1	227	1170.3	2.4

The 2021 year was characterized as a year rich in precipitation, thus from January to September in five months the precipitation rate was higher than the multiannual for the same month. The total amount of precipitation for the May-September period , was also higher compared to the multi-year period corresponding to these months. During this period, the value of 337.1 mm was recorded, 110.1 mm more than the multi-annual May-September in this area of Braila and from the date of sowing to the date of harvest, the value of 304.4 mm/m² was registered. Sorghum, a plant with low demands in terms of water consumption, benefited from a sufficient amount, especially during the period of formation and filling of the grains leading to increased production elements. From the point of view of temperature, the year 2021 stood out for the fact that were registered higher values than the multi-annual average, thus, the average of the sorghum vegetation period recorded values higher than the multi-annual average by 0.6°C. Along with the climatic elements, the hybrid factor and the density factor also had a very important influence on the growth and development of sorghum plants. The morphological determinations studied were highlighted in Table 2. Those were the plant height, panicle length and the number of leaves. The results show that both the density of the plants per hectare and the hybrid that has been used influenced these parameters. Depending on the density, the values of the plant height were in the range 117.0 cm and 120.0 cm, the panicle length were situated in 23.1 cm to 24.9 cm and the leaf number was situated between 7.8 and 8.3 leaves per plant. The lower values are correspondent for the higher plant density. From the point of view of the hybrid that has been used the lowest plant height is present at the Belugga hybrid. It registered 95.1 cm for the 220.000 seeds/ha density and 90.6 cm for the higher plant density. The biggest height recorded was observed at the Es Foehn hybrid both at the density of 220.000 and 250.000 seeds/ha. In the term of panicle length the biggest value was measured at the Es Arabesk variety and that was 26.6 cm, being present at the 220.000 density. At the 250.000 seed density the length of 25.3 cm stood out as the highest panicle length. The biggest leaf number was observed on the Es Foehn variety at the lower density.

Table 2. The influence of density and hybrid on the sorghum development in 2021

Sowing density (Seeds/ha)	Hybrid	Plant Height (cm)	Panicle lenght (cm)	Leaf number/plant
Density 1-220.000	Es Alize	117.5	22.7	8.4
	Es Shamal	122.7	24.7	8.5
	Es Arabesk	124.3	26.6	8.5
	Es Foehn	130.1	26.2	9.2
	Anggy	128.1	25.2	8.3
	Ggustav	119.7	26.4	7.9
	Belugga	95.1	22.5	7.3
	Huggo	124.9	25.0	8.4
Average		**120.3**	**24.9**	**8.3**
Density 2-250.000	Es Alize	115.1	20.0	7.3
	Es Shamal	119.3	22.9	8.0
	Es Arabesk	122.1	24.4	8.1
	Es Foehn	126.3	25.3	8.4
	Anggy	125.6	23.5	8.3
	Ggustav	116.8	24.0	7.5
	Belugga	90.6	21.5	7.1
	Huggo	120.0	23.4	7.8
Average		**117.0**	**23.1**	**7.8**

The experience sustained in 2021 confirmed the adaptability and productivity of grain sorghum. In the location of the experiment, the Brailei Plain sorghum for grains obtained important yield, without requiring an additional amount of water from irrigation, the pluviometric input ensuring the crop's needs however the fertilization regime used consisted in 35 kg N/ha and 90 kg P/ha. In the Table 3 and Figure 1 are registered the productions obtained by the eight hybrids at the two densities.

Table 3. The influence of density and hybrid on the sorghum yield in 2021

Sowing density (Seeds/ha)	Hybrid	Grain yield			Signification
		kg/ha	%	Differences (kg/ha)	
Density 1-220.000	Es Alize	6654	93.2	-485	-
	Es Shamal	7880	110.4	741	-
	Es Arabesk	6047	84.7	-1092	o
	Es Foehn	7229	101.3	90	-
	Anggy	8212	115.0	1073	*
	Ggustav	8628	120.9	1489	**
	Belugga	7378	103.3	239	-
	Huggo	6441	90.2	-698	-
Density 2-250.000	Es Alize	6318	88.5	-821	-
	Es Shamal	6640	93.0	-499	-
	Es Arabesk	5945	83.3	-1194	o
	Es Foehn	6551	91.8	-588	-
	Anggy	7892	110.5	753	-
	Ggustav	8595	120.4	1456	**
	Belugga	7242	101.4	103	-
	Huggo	6569	92.0	-570	-
Experience average-Control		7139	100	Control	Control

LSD 5% - 890.5 (kg/ha), LSD 1% - 1315.1 (kg/ha), LSD 0.1% - 2032.7 (kg/ha)

From the point of view of the hybrid factor, the average production obtained recorded the value of 7139 kg/ha, the highest being recorded by the hybrid Ggustav, namely 8628 kg/ha under the conditions of the density of 220.000 germinating seeds/ha. From the point of view of the density factor, at Density 1 the average production of hybrids was 7309 kg/ha and for Density 2 it was 6969 kg/ha.The Arabesk hybrid recorded a value of 6047 kg/ha at the lower density and 5945 kg/ha at the higher density. These two values show negative statistical significance. The hybrid Anggy with the production of 8212 kg/ha at Density 1 is significantly positive and the hybrid Ggustav with productions of 8628 kg/ha at the density of 220.000 plants per hectare and 8595 kg/ha at 250.000 plants per hectare is classified as distinctly significant positive.

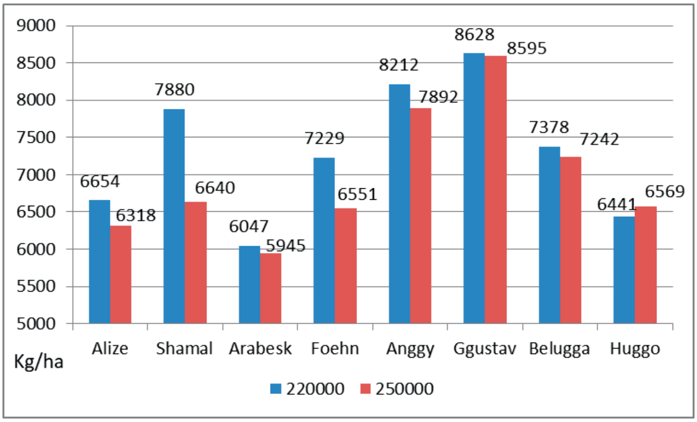

Figure 1. Influence of the density and hybrid on sorghum yield in 2021

The year 2022 stood out from the point of view of the pronounced atmospheric drought, so in Table 4 it can be seen that in each month of the year, the recorded precipitation is lower compared to the multi-annual specific for the same month. For the period May-September, the vegetation period of sorghum, it can be observed that the precipitation totals 125.5 mm, being 101.5 mm less than the multi-annual specific for this period. From the point of view of the recorded temperature, for each month of 2022 the value compared to the multi-annual is higher, with the exception of March. For the May-September period, a higher value was recorded by 1.0°C higher than the multi-annual average of the same period.

Table 4. The climatic conditions registered in Braila Agricultural Research and Development Station in 2022

Month	2022 Temperature (°)	Multiannual average (°)	2022 Precipitations (mm)	Multiannual average (mm)	2022 Solar radiation	2022 Wind speed
January	1.3	-2.1	6.5	28	114.3	2.5
February	4.1	-0.2	11.1	27	126.5	3.0
March	3.8	4.7	13.8	26	171.8	3.0
April	11.9	11.2	25.1	35	193.0	3.0
May	18.0	16.7	24.3	48	269.0	2.1
June	22.7	20.9	33.3	62	229.7	2.0
July	24.8	22.9	8.9	46	281.9	2.1
August	24.9	22.1	26.9	39	246.1	2.1
September	17.9	17.3	32.1	32	215.2	2.4
May-September	21.6	20.6	125.5	227	1241.9	2.1

It can be observed in Table 5 the morphological determinations made during the experience with sorghum in the year 2022. For the density factor, the lower values are recorded for Density 1, thus the height of the plant is 106.8 cm, higher than the 105.2 cm specific to Density 2. The height of the panicle records higher values in the case of the density of 220,000 seeds/ha. Also the number of leaves is slightly higher in the case of Density 1, namely 7.6, compared to 7.5 for the higher density. From the point of view of the hybrid factor, Ggustav has the highest height: 114.6 and the longest panicle: 25.9 cm. The Foehn hybrid has a superior value for the number of leaves: 8.1.

Table 5. The influence of density and hybrid on the sorghum development in 2022

Sowing density (Seeds/ha)	Hybrid	Plant Height (cm)	Panicle lenght (cm)	Leaf number/plant
Density 1-220.000	Es Alize	101.3	22.3	7.5
	Es Shamal	108.4	22.5	7.6
	Es Arabesk	105.5	24.7	7.5
	Es Foehn	111.8	24.4	8.1
	Anggy	115.1	24.0	7.9
	Ggustav	115.5	26.7	7.2
	Belugga	87.0	21.8	7.0
	Huggo	109.8	22.4	7.8
Average		**106.8**	**23.6**	**7.6**
Density 2-250.000	Es Alize	99.6	21.1	7.3
	Es Shamal	106.5	21.9	7.4
	Es Arabesk	104.1	23.9	7.4
	Es Foehn	109.9	23.6	8.2
	Anggy	114.0	23.8	7.7
	Ggustav	113.7	25.2	7.0
	Belugga	85.8	21.6	6.9
	Huggo	108.1	22.7	7.7
Average		**105.2**	**23.0**	**7.5**

Table 6. The influence of density and hybrid on the sorghum yield in 2022

Sowing density (Seeds/ha)	Hybrid	Grain yield			Signification
		kg/ha	%	Differences (kg/ha)	
Density 1-220.000	Alize	5059	89.8	-573	o
	Shamal	5624	99.9	-8	-
	Arabesk	4977	88.4	-655	oo
	Foehn	5807	103.1	175	-
	Anggy	6088	108.1	456	*
	Ggustav	6544	116.2	912	**
	Belugga	5717	101.5	85	-
	Huggo	5804	103.1	172	-
Density 2-250.000	Alize	4630	82.2	-1002	ooo
	Shamal	5109	90.7	-523	o
	Arabesk	4988	88.6	-644	oo
	Foehn	6017	106.9	385	-
	Anggy	5955	105.8	323	-
	Ggustav	6251	111.0	619	*
	Belugga	5720	101.6	88	-
	Huggo	5817	103.3	185	-
Experience average-Control		5631	100	Control	Control

LSD 5% - 423.9 (kg/ha), LSD 1% - 626.1 (kg/ha), LSD 0.1% - 967.6 (kg/ha)

In 2022, a year in which there was no favorable rainfall regime, the sorghum hybrids obtained an average production of 5649 kg/ha. The productions obtained fell within the limits of

4630 kg/ha and 6544 kg/ha as can be seen in Table 6 and in Figure 2. Depending on the hybrid factor the highest value was obtained by the Ggustav hydride, which obtained a average of 6533 kg/ha. Taking into account the density factor, it is deduced that Density 1 brings a higher production compared to Density 2, thus at 220,000 seeds/ha an average production of 5703 kg/ha is obtained, and for 250,000 seeds/ha the average production is 5595 kg/ha. From a statistical point of view, it can be observed the Ggustav hybrid, which at Density 1 obtains a distinctly significant positive production and the Es Alize hybrid, at a density of 250,000 seeds/ha obtains a very significant negative value. Most of the variants are statistically insignificant.

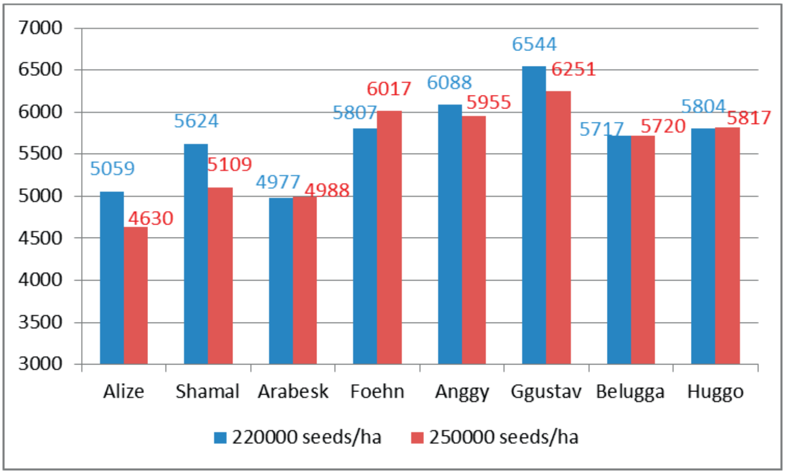

Figure 2. Influence of the density and hybrid on sorghum yield in 2022

CONCLUSIONS

Taking into account what is presented in this paper, the following aspects can be highlighted: The experience with sorghum hybrids took place over the period of two years, namely 2021 and 2022. Among them, the year 2021 was a year that ensured a significant rainfall regime, thus during the sorghum vegetation period, namely May-September, a amount of 337 mm precipitation. In these atmospheric conditions the average production of the experiment was 7139 kg/ha. The Ggustav hybrid was the one that ensured the maximum value of 8628 kg/ha at the density of 220.000 seeds/ha. The fertilization regime that was used was represented by the application of 35 kg N/ha and 90 kg P/ha. The year 2022 was dry and warmer than the multi-year average. This year the production average was 5631 kg/ha, with the maximum production obtained of 6544 kg/ha, of the same Ggustav hydrid, also at the density of 220.000 seeds/ha. For the year 2022, 130 kg N/ha and 40 kg P/ha were applied for fertilization. The climatic differences between the two years had an important impact, thus the productions recorded in 2022 were much lower compared to the previous year. From the productions obtained, the density factor had an important role, thus the lower density ensured higher values. All eight commercial hybrids showed superior yields.

REFERENCES

Antohe, I., Drăghici, I., Naidin, C. (2002). Sorghum an alternative crop for south of Romania. In: *Drought mitigation and prevention of land desertification*, 22-24 April, Bled, Slovenia, p. 112.

Antohe, I. (2007). Achievements in sorghum improvement in Fundulea. N.A.R.D.I. Fundulea, Vol. LXXV, Jubilee Volume, 137 -157.

Bâlteanu, Gh. (2003). *Phytotechnics.* Ceres Publishing House, Bucharest.

Fatoki, Toluwase & Oluwafisayomi, Oluwadare & Famusiwa, Courage & Oyebiyi, Ridwan & Ejimadu, Blessing & Lawal, Olaolu & Amosun, Busayo & Adeyeye, Toheeb & Falode, John. (2023). In Silico Evaluation of Nutri-Pharmacological Potentials of Phytochemicals in Sorghum (*Sorghum bicolor*) Grains. *Journal of Food Bioactives. 23.* 10.31665/JFB.2023.18354.

Kasegn, Melaku & Simachew, Addis & Redda, Yisehak & Mehari, Hailay. (2023). Production of bioethanol from sweet sorghum [*Sorghum bicolor* L.] juice using yeast isolated from fermented sweet sorghum juice. *International Microbiology*. 1-14. 10.1007/s10123-023-00403-8.

Pochișcanu, S., Druțu, A. (2016). *Sorghum "The camel of crops"*. "Ion Ionescu de la Brad" Publishing House, Iași, 106.

Pochișcanu, S., Buburuz, A., Popa, L. (2017). Influence of some crop management sequences on the grain yield and quality at Sorghum bicolor L. under the center of Moldavia conditions. *Romanian Agricultural Research, 34*. 287–291.

Roman, Gh.V. (2011). *Phytotechnics*. University Publishing House, Bucharest.

World/European Market of Sorghum: Situation and Outlook,2021.-https://www.sorghum-id.com/content/uploads/2022/02/2.bis-Arthur-Boy-PierreGuillaumin.pdf

(https://ragtsemences.fr/sites/default/files/public/medias/variety/pdfs/RGT%20ANGGY.pdf). Sorghum catalogue