RESEARCH ON THE INFLUENCE OF THE DENSITY AND THE HYBRID USED IN DETERMINING THE YIELD OF GRAIN SORGHUM GROWN IN THE CLIMATIC CONDITIONS OF SOUTHEASTERN ROMANIA

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Abstract. *This paper aims to provide information on the experience with grain sorghum hybrids grown in the climatic and pedological conditions of the Brăila Agricultural Research and Development Station. This experience consisted of the use of eight commercial grain sorghum hybrids. They were the following: Es Alize, Es Shamal, Es Arabesk, Es Armorik, Anggy, Ggustav, Bellugga and Huggo. They were grown in two densities: Density 1- 22 germinating seeds/m² and Density 2- 250 germinating seeds/m². From a climatic point of view the year 2023 proved to be a favorable one for the sorghum culture, thus during its vegetation period it benefited from a greater amount of precipitation compared to the multiannual average and from the temperature point of view it was warmer than multiyear. The sorghum hybrids used were very productive, thus the average of the experience was 7.57 t/ha.*

Keywords*: grain sorghum, yield,adaptability,productivity,yield*

INTRODUCTION

The sorghum genus has *Sorghum bicolor* as its main representative, being the most commonly cultivated worldwide. This, in turn, presents several varieties, among which: *Sorghum bicolor* variety *Eusorghum* (grain sorghum), *Sorghum bicolor* variety *technicum* (technical sorghum) , *Sorgum bicolor* variety *saccharatum* (sugar sorghum), and *Sorgum bicolor* variety *sudanese*, which is the used for forage (Roman et al., 2011). Among the grains cultivated worldwide, sorghum is ranked fifth, being surpassed by wheat, rice, corn and barley, and from the point of view of cultivated area, it is present on approximately 40 million hectares (*World/European Market of Sorghum: Situation and Outlook*,2021). Sorghum is mainly cultivated in African countries but also in North America, moreover also in European Union countries, both in developed countries and in some developing countries. Sorghum lends itself to being cultivated in areas where the climatic and pedological conditions are not favorable for other crops (pedological drought and prolonged heat) and can bring important productions from a quantitative but also a qualitative point of view. Sorghum, due to its possibilities of adaptability and productivity, presents the nickname of "*The camel of crops*".

Sorghum has multiple uses, primarily it has the role of preventing the land from desertification according to studies carried out by Antohe in 2002. The main product exploited from the sorghum culture is represented by sorghum grains.The chemical composition of sorghum grains is represented by starch, which is present in a percentage of 65 to 90%, proteins that vary between 7 and 15% and fats in composition less than 5% (Oprea et al 2020). Sorghum grains are valuable due to the fact that gluten-free flour can be obtained from them, a product highly appreciated by people with intolerance to this compound. This flour is used in the milling and baking industry resulting in many products of this type (Antohe, 2007; Bîlteanu, 2003; Pochișcanu, 2016, 2017). Beverages can also be obtained from sorghum grains by fermenting them. 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). The sorghum can be used as wel in the production of bioethanol (Kasegn, 2023). The grains can also be used in animal feed: cattle, swine or poultry with very good results in terms of meat quality (Kornilova et al 2023). In addition to grain production, green or dry biomass is also a very good source of feed for animal consumption (Bangladesh, 2023).

The biomass resulted from stems and leaves can be used as fodder for ruminants especially and can be administrated together with corn fodder and other concentrates in feed recipes (Liman, 2023). It can be more profitable for sorghum fodder to be administered in animal feed, taking into account the fact that it is easier to produce on poor soils and in areas where other fodder plants do not show the same productive yield (Crâșmaru, 2021). Sorghum biomass can be succesfully used in energetic way, in order to reduce the dependence of fossil fuels.

MATERIAL AND METHODS

The research was conducted at the Agricultural Research Development Station Braila located in Braila County. The experiment took place in the 2023 agricultural year on a chernozem soil, characteristic of the area

with a medium humus content (2.4 – 3.1%) in the upper horizons. Total nitrogen content varies between 0.14 – 0.25% with 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.

The experiment was made by the method of subdivided plots with 2 factors. The first factor was represented by the denisty with 2 graduations: Density 1 with 22 seeds/m^2 and 70 cm distance between the rows and Density 2 with 25 seeds/m^2 and 50 cm distance between the rows. The factor B was represented by the comercial sorghum hybrids that were been used. The hybrid had 8 graduations: Es Aize, Es Shamal, Es Arabesque, Es Armorik, Anggy, Ggustav, Belluga, Huggo. These are some commercial sorghum hybrids which are classified as hybrids with less than 0.3% tannin content which is very low figure, starch content of 78% and protein content of 10-11%. Those are classified as hybrids with high production capacity especially in favorable conditions. (*Ragt Sorghum varieties catalogue*,2022). The agricultural year began with the preparation works of the field that had been cultivated with sunflower one year before in 2021-2022 agricultural year. These work carried out in the fall of 2022 was represented by harrowing. In the spring of 2023, a complex fertilizer was applied with an ammonia nitrogen (NH_4) content of 18% and phosphorus pentaoxide (P_2O_5) – 46%. It was applied 200 kg of commercial product per hectare. The next two works that were executed were the applying of a total herbcide 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 18th of May 2023 in an experimental field by the method of subdivided plots.The plots consisted of six rows of 8 meters long. Until the stage of panicle emergence, 2 manual weed control hoeing were carried out. During the period of vegetative growth but also at the time of maturity, different biometric measurements were performed to observe the development of the plants and to emphasize the elements of production..The harvest took place on 26th September 2023 at the physiological maturity stage when the umidity was at the 15 % level. The ANOVA function from Microsoft Excel was used for processing the collected data from the field..

In the Table 1 are presented the climatic elements of the 2023 year, from January to September.The climatic elements are represented by the temperature, precipitation, solar radiation and wind speed. The following data shows that the 2023 year was characterized as a year with a higher precipitation rate, compared to the multiyear. In the adjacent table, the May-September period is highlighted being a reference period for sorghum culture. The total amount of precipitation for the May-September period was also higher compared to the multiyear period corresponding to these months. During this period, the value of 232 mm was recorded, 5 mm more than the multiyear May-September in this area of Braila County. Regarding the temperature it can be observed that the year 2023 registered higher values than the multiannual average, thus, the average of the sorghum vegetation period recorded values higher than the multiyear average by 1.4º C. The sum of the solar radiation totallized 1242 hours and the wind speed average for the May-September was 2.1 m/s. Observing these data, it can be said that from a climatic point of view, the year 2023 was a favorable one for sorghum plants that presented superior morphological and productive characteristics.

Table 1. The climatic conditions registered in 2023 at Agricultural Research and Development Station of Braila

Month	2023 Temperature (°C)	Multiannual average (°C)	2023 Precipitations (mm)	Multiannual average (mm)	2023 Solar radiation (hours)	2023 Wind speed (m/s)
January	4.4	-2.1	64	28	72.3	3.7
February	1.4	-0.2	7	27	120.0	2.8
March	7.9	4.7	13	26	183.9	3.2
April	10.4	11.2	66	35	129.5	2.9
May	16.6	16.7	40	48	216.5	2.3
June	21.6	20.9	26	62	257.0	2.0
July	24.7	22.9	106	46	251.3	2.1
August	24.7	22.1	55	39	269.1	1.8
September	20.9	17.3	5	32	247.6	2.2
May-September	22	20.6	232	227	1242	2.1

RESULTS AND DISCUSSIONS

Table 2 shows the results of the morphological determinations made in the experience with sorghum hybrids. These were the height of the plant, the length of the panicle, the number of leaves. The first parameter, the height of the plant is within the limits of 88.6 and 117.5 cm. The lowest value corresponds to the Belugga hydrid at a density of 25 seeds/m², and the highest value was recorded for the Ggustav hydrid, sown at a density of 22 seeds/m². The average experience was 107.9 cm. For panicle height, the lowest value was obtained for the Huggo hybrid, sown at Density 2, and the highest value was recorded for the Ggustav hybrid, which showed 27.6 cm in the case of Density 1. From the point of view of the number of leaves, the average obtained for experience it was 7.6 leaves/plant. The most leaves were found in the case of the Anggy hydrid: 8.1 for Density 1 and the fewest were found in the variety Belugga which presented 7.0 leaves in the case of Density 2.

Sowing density (Seeds/m²)	Hybrid	Plant Height (cm)	Panicle lenght (cm)	Leaf number/plant
Density 1-22	Es Alize	104.7	23.6	7.6
	Es Shamal	109.7	24.1	8.0
	Es Arabesk	108.0	24.5	7.5
	Es Armorik	111.5	25.0	8.0
	Anggy	115.8	24.2	8.1
	Ggustav	117.5	27.6	7.5
	Belugga	89.0	24.0	7.2
	Huggo	111.1	23.1	7.5
Density 1 Average		**108.4**	**24.5**	**7.7**
Density 2-25	Es Alize	102.8	22.6	7.3
	Es Shamal	109.0	23.8	7.7
	Es Arabesk	107.8	23.8	7.3
	Es Armorik	110.7	23.6	7.9
	Anggy	115.3	23.0	7.8
	Ggustav	116.1	26.9	7.1
	Belugga	88.6	22.2	7.0
	Huggo	109.1	21.9	7.2
Density 2 Average		**107.4**	**23.5**	**7.4**
Experience Average		**107.9**	**24.0**	**7.6**

Table 2. Sorghum morphological measurements 2023

Figure 1. The biometrical measurements realised in the field

Table 3. Sorghum grain yield and signification

Sowing density (Seeds/m²)	Hybrid	Grain yield t/ha	Grain yield %	Differences (t/ha)	Signification
Density 1-22	Es Alize	7.26	95.9	-0.31	-
	Es Shamal	8.89	117.4	1.32	*
	Es Arabesk	6.37	84.1	-1.2	O
	Es Armorik	7.40	97.8	-0.17	-
	Anggy	8.81	116.4	1.24	*
	Ggustav	9.26	122.3	1.69	**
	Belugga	7.40	97.8	-0.17	-
	Huggo	7.18	94.8	-0.39	-
Density 2-25	Es Alize	7.22	95.4	-0.35	-
	Es Shamal	8.38	110.7	0.81	-
	Es Arabesk	5.50	72.7	-2.07	OO
	Es Armorik	7.25	95.8	-0.32	-
	Anggy	8.26	109.1	0.69	-
	Ggustav	8.18	108.1	0.61	-
	Belugga	6.92	91.4	-0.65	-
	Huggo	6.93	91.5	-0.64	-
Experience average-Control		**7.57**	**100**	**Control**	**Control**

Dl 5 %= 0.99; Dl 1%=1.46 ; Dl 0.1%= 2.26

From the data in Table 3, it can be seen that the average productions of the experience with sorghum hybrids is 7.57 t/ha. At Density 1 the average production was 7.82 t/ha and for Density 2 the average production was 7.31 t/ha The highest production was obtained by the hybrid Ggustav which was 9.26 t/ha in the case of the density of 22 seeds/ m^2 (Figure 2). This brings a production increase of 1.69 t/ha compared to the control which is represented by the average of the experience. The second hybrid in terms of production is the Anggy hybrid, which obtained 8.81 t/ha, being 1.24 t/ha higher than the experience control. The hybrid Es Arabesk obtained a production of 6.37 t/ha for Density 1, being 1.2 t/ha lower than the experience average. At Density 2, the hybrid with the lowest production was the same Es Arabesk, which obtained 5.50 t/ha, this being a lower production than the control with 2.07 t/ha. The listed variants also stand out from a statistical point of view as follows: The most productive hybrid, Ggustav, was distinctly significantly positive, the Es Shamal and Anggy hybrids were significantly positive, the Es Arabesk hybrid was significantly negative, all of them being grown at a density of 22 seeds /m². For Density 2, Es Arabesk hydride stood out as distinctly negative.

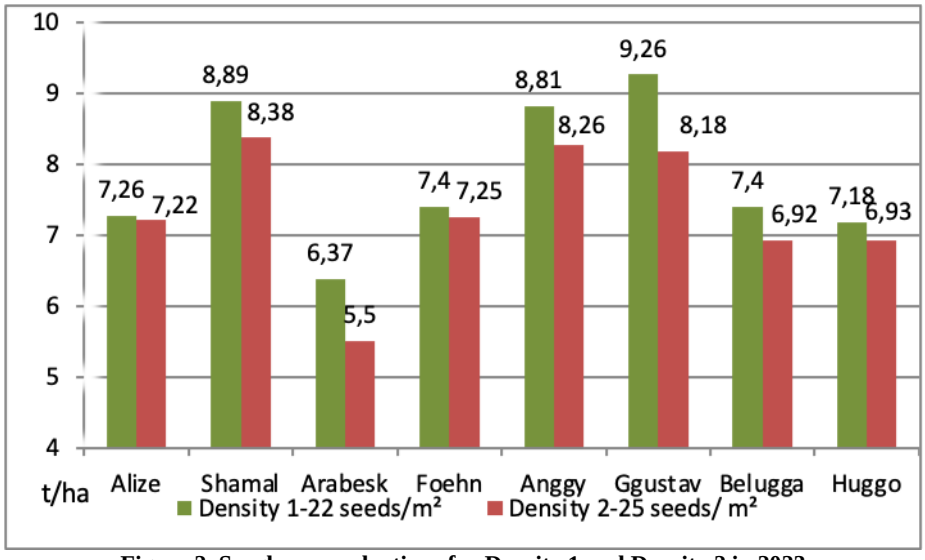

Figure 2. Sorghum productions for Density 1 and Density 2 in 2023

CONCLUSIONS

According to this study it can be said that the year 2023 was favorable for the sorghum crop from the climatic point of view, thus the 2023 year was characterized as a year with a higher precipitation rate, compared to the multiyear. The total amount of precipitation for the May-September period (sorghum vegetative period) was higher compared to the multiyear period corresponding to these months being recorded 232 mm which is 5 mm more than the multiyear May-September for this area. Regarding the temperature the year 2023 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 1.4º C. The sorghum hybrids were sown at two different densities: Density 1-22 seeds/m^2 and Density 2- 25 seeds/m^2. Regarding of the obtained production, it can be concluded that the obtained yields were very good. The experience average was 7.57 t/ha. For Density 1 the production values situated between 6.37 t/ha and 9.26 t/ha. For Density 2, the lowest production value was obtained for the Arabesk hybrid, which was 5.5 t/ha and the highest production was 8.38 t/ha. for the Es Shamal hybrid.
From a statistical point of view the Ggustav hybrid was distinctly significantly positive, the Es Shamal and Anggy hybrids were significantly positive, the Es Arabesk hybrid was significantly negative, all of them being grown at a density of 22 seeds /m². For Density 2, Es Arabesk hydride stood out as distinctly negative.

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