THE INFLUENCE OF CLIMATIC FACTORS IN BIOMASS PRODUCTION IN SOME GRAIN SORGHUM HYBRIDS GROWN IN THE SOUTH-EASTERN AREA OF ROMANIA

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Abstract

Grain sorghum is a cereal whose cultivation is increasingly common both in Romania and worldwide. Grain sorghum is recognized for having very good yields relative to unit area and crop establishment costs. In addition to the production of raw material represented by grains, grain sorghum offers the possibility of harvesting an important amount of biomass which can be used both for the purpose of feeding animals and for the purpose of energy production.Biomass production is closely dependent on the climatic conditions but also on the type of hybrid. Thus, the higher the phreatic intake, the higher the biomass production. This study was carried out in the 2020-2021 and 2021-2022 agricultural years in the South-East of Romania, in Brăila County, an area that has faced in recent years with climatic difficulties that force the efficient utilization of the crops used. For the most efficient utilization of the grain sorghum crop, it is very important that the biomass production is superior to be used for energy purposes or as animal feed.

Key words*: Biomass yield, dry matter, green mass, grain sorghum*

INTRODUCTION

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-PierreGuillaumin.pdf). Grain sorghum lends itself to being grown in areas where water and nutrient supply can be low, and it has a very good tolerance to high temperatures. Grain sorghum is grown primarily for its grain. They can be used for food purposes because sorghum flour can be used to make gluten-free pastries and bread, breakfast cereals or certain drinks. (Antohe, 2007; Pochișcanu et al. 2016, 2017) 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). 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 secondary biomass is also a very good source of feed for animal consumption.

It can be observed that in recent years the existing climatic elements characterized by low amounts of precipitation and prolonged heat are not favorable for some fodder crops. In this case, it is necessary to find new solutions to replace these deficient productions. An important solution for farmers is the use of sorghum due to its

drought tolerance and moderate demands on climate and soil, and due to the potential to use sorghum secondary biomass.(Crâșmaru 2021)

MATERIALS AND METHODS

The research took place in in Braila County the 2020-2021 and 2021-2022 agricultural years 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: 22 seeds/m^2 with 70 cm between the rows and 25 seeds/m^2 with 50 cm between the rows. The factor B was represented by the hybrid that has been used. The hybrid had 8 graduations: Es Aize;Es Shamal; Es Arabesque; Es Foehn; Anggy; Ggustav; Belluga; 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 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 a 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 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, until the moment when it was reached a constant mass.The ANOVA function from corresponding to sowing. The hybrids were sown on 26th of May 2021 in an experimental field by the method of subdivided plots.The plots consisted of six rows of 8 meters long. The harvest took place on 1st October 2021.

In the 2021-2022 agricultural year, the sorghum experiences were positioned on another land, an area that had corn as its predecessor plant that was harvested at the end of October 2021. After this the soil scarification and harrowing work took place. In 2022, at the end of March, complex fertilizers were administered to increase the content of N, P_2O_5 and K_2O of the soil.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 using glyphosate as the active substance, respectively S-metolachlor to combat both monocotyle and dicotyle weeds. A second fertilization work was carried out at the end of May, applying granular urea with a N content of 46%. Another herbicide was also applied in June, with the active substances prosulfuron 5% and dicamba 50% to combat dicotyle 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. Certain operations were carried out to determine the amount of green mass and the determination of the dry matter content. At the moment of physiological maturity and when the humidity of 15% of the sorghum grains was recorded, plants were harvested on a sample specific to each variant of the hybrids used. In the laboratory, the leaves, stems and panicles were then separated and weighed, then chopped into particles smaller than one centimeter and then placed in an oven at 105º C. Multiple weighings were carried out Microsoft Excel was used for processing the collected data from the field.

RESULTS AND DISCUSSIONS

Table 1 shows the climatic elements of the years 2021 and 2022. The following data demonstrates that the 2021 year was characterized as a year with a high precipitation rate,compared to the multi-annual. aspects can be observed: The 2021 was characterized as high precipitation year , thus from January to September the precipitation rate was higher than the multi-annual. The total amount of precipitation for the May-September period was also higher compared to the multi-annual 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. Regarding the temperature it can be observed that the year 2021 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 0.6º C.The year 2021 2022 is characterized by the fact that it recorded a lower amount of precipitation compared to both the multi-annual and the year 2021. The year 2022 stood out for the fact that had a pronounced atmospheric drought. In the Table 1 it can be seen that the precipitation rate is lower for every mounth compared to the multi-annual and for vegetation period of sorghum (May-September period) it can be observed that the precipitation totals 125.5 mm, being 101.5 mm less than the multi-annual specific for this period. Regarding the recorded temperature, for each month of 2022 the value compared to the multi-annual is higher, with the exception of March.

Table 1-The climatic conditions of 2021 and 2022 years registered at the experimental field in Braila County

Month	2021 Temperature (°)	2022 Temperature (°)	Multiannual average (°)	2021 Precipitations (mm)	2022 Precipitations (mm)	Multiannual average (mm)
January	2.2	1.3	-2.1	41.2	6.5	28
February	2.4	4.1	-0.2	7.4	11.1	27
March	4.7	3.8	4.7	31.4	13.8	26
April	9.4	11.9	11.2	53.3	25.1	35
May	16.7	18.0	16.7	75.8	24.3	48
June	20.2	22.7	20.9	173.8	33.3	62
July	24.8.	24.8	22.9	40.4	8.9	46
August	23.4	24.9	22.1	36.7	26.9	39
September	16.9	17.9	17.3	10.4	32.1	32
May-September	21.2	21.6	20.6	337.1	125.5	227

Table 2 shows the elements that refer to the amount of harvested biomass in 2021 depending on the sowing density and the hybrid used. Harvested green biomass is divided into three categories: Total leaf biomass production, stem biomass production and total biomass per hectare which is the sum of leaf, stem and panicle biomass without grains. However, the panicle without grains represent a very small percentage of the total biomass of 0.03-0.05 percent. For the density of 22 seeds/m^2 the highest amount of fresh

biomass was obtained by Foehn hydrid, this having the value of 21.75 t/ha. The experience average for total biomass for this density was 18.87 t/ha. Of this amount, the biomass of the leaves was 28.4% and the biomass of the stems was 71.6%. For the density of 25 grains/m^2 it can be seen from the table that the average of the experience was 19.9 t/ha. Of this amount, 73.4% represents the biomass of the stems/ha and 26.6% is represented by the biomass of the leaves. Foehn hydrid was found to be the most productive, in terms of biomass, at second density, as well as at first density.

Sowing density (Seeds/m^2)	Hybrid	Leaves biomass yield t/ha	% of total biomass yield	Stems biomass yield t/ha	% of total biomass yield	Total (Leaves, stems and panicles) biomass yield t/ha
Density 1-22	Alize	5.60	30.7	12.65	69.3	18.26
	Shamal	5.64	29.5	13.45	70.4	19.10
	Arabesk	5.42	28.3	13.70	71.6	19.13
	Foehn	5.79	26.6	15.95	73.3	21.75
	Anggy	5.72	26.4	15.94	73.5	21.68
	Ggustav	4.93	24.7	15.01	75.2	19.96
	Belugga	4.49	35.0	8.32	64.8	12.83
	Huggo	5.22	28.5	13.07	71.4	18.30
Average		**5.35**	**28.4**	**13.51**	**71.6**	**18.87**
Density 2-25	Alize	5.55	30.3	12.78	69.7	18.34
	Shamal	5.08	24.9	15.33	75.1	20.42
	Arabesk	5.39	26.4	15.04	73.6	20.44
	Foehn	5.64	24.6	17.32	75.4	22.97
	Anggy	5.85	26.0	16.61	73.9	22.47
	Ggustav	5.02	24.2	15.75	75.8	20.78
	Belugga	4.65	33.6	9.19	66.4	13.85
	Huggo	5.14	25.9	14.72	74.1	19.87
Average		**5.29**	**26.6**	**14.60**	**73.4**	**19.90**

Table 2-The influence of hybrid and density used in biomass production.(2021)

From Table 3 it can be seen that the average total biomass harvested for the 8 hybrids is 19.4 t/ha, regardless of the density used. From a statistical point of view, the hybrids Anggy and Foehn stand out, which at the density of 25 seeds/m² have distinctly significant positive productions, being higher by 18.5% and 15.9% respectively compared to the average. The Bellugga hybrid stands out as very significantly negative for the density of 22 seeds/m², the production being 33.8 lower than the average and the same for the density of 25 seeds/m², the production being 28.5% lower than the average. This is because this hybrid is a small one. Its height was on average 92.8 cm.

From the point of view of the resulting dry matter, it can be observed that the average for the 8 hybrids is 5.07 t/ha according to Table 4. The statistical significances presented are as follows: For the Foehn and Anggy hybrids, the significance is distinctly positive both for the density of 22 seeds / m² as well as for 25 seeds/m². In the case of the first density, they present higher productions by 0.54 t/ha and respectively by 0.64 higher than the average.

Table 3- The influence of hybrid and density used in biomass production and the significance (2021)

Sowing density (Seeds/ha)	Hybrid	Total biomass yield			Signification
		t/ha	%	Differences (t/ha)	
Density 1-220	Alize	18.26	94.2	-1.12	-
	Shamal	19.10	98.6	-0.28	-
	Arabesk	19.13	98.7	-0.25	-

	Foehn	21.75	112.2	2.37	*
	Anggy	21.68	111.9	2.30	*
	Ggustav	19.96	103.0	0.58	-
	Belugga	12..83	66.2	-6.55	ooo
	Huggo	18.30	94.4	-1.08	-
Density 2-250	Alize	18.34	94.6	-1.04	-
	Shamal	20.42	105.4	1.04	-
	Arabesk	20.44	105.5	1.06	-
	Foehn	22.97	118.5	3.59	**
	Anggy	22.47	115.9	3.09	**
	Ggustav	20.78	107.2	1.40	-
	Belugga	13.85	71.5	-5.53	ooo
	Huggo	19.87	102.5	0.49	-
Experience average-Control		19.4	100	Control	Control

Dl 5 %= 1.91 t /ha; Dl 1%= 2.82 t/ha; Dl 0.1 %= 4.37 t/ha

Table 4 - The influence of hybrid and density used in dry matter yield and the significance (2021)

Sowing density (Seeds/ha)	Hybrid	Dry matter yield			Signification
		t/ha	%	Differences (t/ha)	
Density 1-220	Alize	4.78	94.2	-0.29	-
	Shamal	5.08	100.2	0.01	-
	Arabesk	4.90	96.6	-0.17	-
	Foehn	5.61	110.6	0.54	**
	Anggy	5.71	112.6	0.64	**
	Ggustav	5.36	105.7	0.29	-
	Belugga	3.63	71.6	-1.44	ooo
	Huggo	4.76	93.8	-0.31	-
Density 2-250	Alize	4.75	93.6	-0.32	-
	Shamal	5.25	103.5	0.18	-
	Arabesk	5.20	102.5	0.13	-
	Foehn	5.81	114.6	0.74	**
	Anggy	5.83	114.9	0.76	**
	Ggustav	5.53	109.1	0.46	*
	Belugga	3.84	75.7	-1.23	ooo
	Huggo	5.11	100.7	0.04	-
Experience average-Control		5.07	100	Control	Control

Dl 5%=0.36; Dl 1 %=0.53; Dl 0.1 %= 0.82

For Density 2 Foehn has a higher production compared to the average by 0.74 t/ha and Anggy a higher production by 0.76t/ha. The Bellugga hybrid stands out as shows the elements that refer to the amount of harvested biomass in 2022 depending on the sowing density and the hybrid used. The harvested biomass is divided into three categories that had been studied, as well as for the 2021 year and those are the total leaf biomass production, stem biomass very significantly negative through it's production. Dry matter for this hybrid is 1.44 t/ha lower than average for Density 1 and 1.23 t/ha lower for Density 2.Table 5 production and total biomass per hectare which is the sum of leaf, stem and panicle biomass without grains. For the density of 22 seeds/m^2 the highest amount of fresh biomass was obtained by Foehn hydrid, this having the

value of 15.75 t/ha. The experience average for total biomass for this density was 14.00 t/ha. Of this amount, the biomass of the leaves was 28.2% and the biomass of the stems was 71.7 % .For the density of 25 grains/m² it can be seen from the table that the average of the experience was 15.5 t/ha

Table 5- The density and hybrid used in biomass production (2022)

Sowing density (Seeds/m^2)	Hybrid	Leaves biomass yield t/ha	% of total biomass yield	Stems biomass yield t/ha	% of total biomass yield	Total (Leaves, stems and panicles) biomass yield t/ha
Density 1-22	Alize	4.14	27.2	11.08	72.8	15.23
	Shamal	3.91	27.4	10.36	72.5	14.28
	Arabesk	3.79	28.1	96.97	718.8	13.49
	Foehn	4.40	27.9	11.34	72.0	15.75
	Anggy	4.40	29.4	10.54	70.5	14.95
	Ggustav	3.85	27.2	10.30	72.7	14.16
	Belugga	3.39	31.2	7.46	68.6	10.87
	Huggo	3.72	28.0	9.55	71.9	13.28
Average		**3.95**	**28.2**	**10.04**	**71.7**	**14.00**
Density 2-25	Alize	4.14	24.3	12.91	75.7	17.06
	Shamal	4.02	25.2	11.95	74.8	15.98
	Arabesk	4.22	28.1	10.79	71.8	15.02
	Foehn	4.70	26.8	12.83	73.1	17.54
	Anggy	4.32	27.2	11.54	72.7	15.87
	Ggustav	4.25	26.6	11.70	73.3	15.96
	Belugga	3.63	30.2	83.70	696.9	12.01
	Huggo	3.90	26.8	10.63	73.2	14.53
Average		**4.14**	**26.7**	**11.34**	**73.2**	**15.50**

Of this amount, 73.2% represents the biomass of the stems/ha and 26.7% is represented by the biomass of the leaves. Foehn hydrid was found to be the most productive, in terms of biomass, at Density 2, as well as at the Density 1, due to the fact that is one of the highest hybrids of the experience and had the heaviest stems. From Table 6 it can be seen that the average total biomass harvested for the 8 hybrids is 14.7 t/ha, regardless of the density used. From a statistical point of view, the hybrids Foehn and Alize stand out, which at the density of 25 seeds/m² have significant positive productions, being higher by 19.0% and 15.7% respectively compared to the average. The Bellugga hybrid stands out as distinctly negative for the density of 22 seeds/m², the production being 26.3 % lower than the average and the same for the density of 25 seeds/m², the production being 18.5% lower than the average. This is because this hybrid is the smallest from the experience. It's height was on average 86.2 cm and the stem was 40.1 g/plant at the average.

From the point of view of the resulting dry matter, it can be observed that the average for the 8 hybrids is 5.07 t/ha according to Table 7. The statistical significances presented are as follows: The Foehn hybrid is the only one with the positive significance for the 25 seeds/m² density. The Foehn has a higher production compared to the average by 0.67 t/ha.The Bellugga hybrid stands out as distinctly negative through its production at the Density 1. The dry matter for this hybrid is 0.85 t/ha lower than average for Density 1 and 0.6 t/ha lower for Density 2. The production of dry matter/ha was influenced, as in the case of biomass, by the height of the hybrids, thus in the larger hybrids, the production was superior.

Table 6- The influence of hybrid and density used in biomass production and the significance (2022)

Sowing density (Seeds/ha)	Hybrid	Total biomass yield			Signification
		t/ha	%	Differences (t/ha)	
Density 1-220	Alize	15.23	103.3	0.49	-
	Shamal	14.28	96.9	-0.46	-
	Arabesk	13.49	91.5	-1.25	-
	Foehn	15.75	106.9	1.01	-
	Anggy	14.95	101.4	0.21	-
	Ggustav	14.16	96.1	-0.58	-
	Belugga	10.87	73.7	-3.87	oo
	Huggo	13.28	90.1	-1.46	-
Density 2-250	Alize	17.06	115.7	2.32	*
	Shamal	15.98	108.4	1.24	-
	Arabesk	15.02	101.9	0.28	-
	Foehn	17.54	119.0	2.80	*
	Anggy	15.87	107.7	1.13	-
	Ggustav	15.96	108.3	1.22	-
	Belugga	12.01	81.5	-2.73	oo
	Huggo	14.53	-0.21	-0.21	-
Experience average-Control		14.7	100	Control	Control

Dl 5 %= 1.91 t /ha; Dl 1%= 2.82 t/ha; Dl 0.1 %= 4.37 t/ha

Table 7 - The influence of hybrid and density used in dry matter yield and the significance (2022)

Sowing density (Seeds/ha)	Hybrid	Dry matter yield			Signification
		t/ha	%	Differences (t/ha)	
Density 1-220	Alize	3.92	101.8	0.07	-
	Shamal	3.76	97.7	-0.09	-
	Arabesk	3.54	91.9	-0.31	-
	Foehn	4.10	106.5	0.25	-
	Anggy	3.93	102.1	0.08	-
	Ggustav	3.82	99.2	-0.03	-
	Belugga	3.00	77.9	-0.85	oo
	Huggo	3.53	91.7	-0.32	-
Density 2-250	Alize	4.28	111.2	0.43	-
	Shamal	4.08	106.0	0.23	-
	Arabesk	3.87	100.5	0.02	-
	Foehn	4.52	117.4	0.67	*
	Anggy	4.13	107.3	0.28	-
	Ggustav	4.19	108.8	0.34	-
	Belugga	3.25	84.4	-0.6	o
	Huggo	3.81	99.0	-0.04	-
Experience average-Control		3.85	100	Control	Control

Dl 5 %= 0.54 t /ha; Dl 1%= 0.79 t/ha; Dl 0.1 %= 1.23 t/ha.

CONCLUSIONS

It can be stated that grain sorghum may present, in addition to the main grain production, a biomass production resulting from stems, leaves and panicles separated from the grain. This biomass can be successfully used for the creation of caloric energy but also for animal consumption. The sorghum plant can develop very well, in certain unfavorable climatic conditions where other plants do not give the same yield, thus resulting in a superior biomass production. According to the study carried out, it was demonstrated that both the climatic conditions and the characteristics of the hybrid as well as the crop density have an important role in establishing a superior production. The year 2021 was a very favorable year from the point of view of precipitation thus during the sorghum vegetation period, the value of 337.1 mm

was recorded, 110.1 mm more than the multi-annual.A This aspect led to the development of sorghum hybrids, thus, in 2021 the average production obtained per experience was 19.38 t/ha of green mass. The year 2022 stood out for the fact that had a pronounced atmospheric drought. For the sorghum vegetation period (May-September period) the precipitation totalled 125.5 mm, being 101.5 mm less than the multi-annual specific for this period. Regarding the recorded temperature, for each month of 2022 the value compared to the multi-annual is higher, with the exception of March.In the 2022 year the production was 14.7 t/ha much less than in 2021 year. It is also important for a higher biomass production to use hybrids, which, in addition to grain production, present a higher waist.

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