THE INFLUENCE OF THE DENSITY AND HYBRID USED REGARDING THE BIOMASS AND DRY MATTER YIELD AT SOME GRAIN SORGHUM HYBRIDS AT ARDS BRAILA

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Abstract. *The purpose of this paper is to highlight the productive capacity of some grain sorghum hybrids in relation to the amount of green biomass and dry matter. In the experiment were tested eight commercial varieties with good yield characteristics in two different densities. These hybrids were cultivated in a field that benefited from the pedological and climatic conditions from Agronomical Research Development Station of Brăila. This area is recognized for its very productive soil but also for the heat that is present very often in the summer season. In addition to grain production that can be used for multiple purposes, the secondary production of sorghum is represented by the number of stalks, leaves and panicles separated from the grain. This amount can be used for animal feed or energy purposes. Sorghum, due to its ability to adapt and develop in areas with poor weather conditions, can represent a good option to supplement and complete some plants used for fodder purposes. Through this article it can be highlighted that for the production of a superior amount of green biomass, it is important to cultivate sorghum hybrids that are taller and with greater leaf mass. In this way, can be cultivated some varieties that have an important production of grains but also a high amount of biomass.*

Keywords*: grain sorghum, biomass use, dry matter*

INTRODUCTION

Sorghum is one of the most important cereals in the world. It occupies the fifth place, 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 alongside India, U.S.A. and some countries from the E.U. as well. *Sorghum*, with the nickname" The camel of crops" due to its ability to adapt and present high yields, especially in the areas where the precipitation intake is lower and the heat is very often present. 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 G.V., 2011). It was demonstrated that sorghum has an important role in preventing land desertification. (ANTOHE, 2002). Grain sorghum is a cereal with many important uses. Sorghum is successfully used in human food, especially in the developing countries (African countries) but also in the developed countries due to its flour that don't contains gluten, a very good characteristic for the people with gluten intolerance. The flour can be used in bakery and pastry as well in producing some drinks (ANTOHE, 2007; BÎLTEANU, 2003; POCHIȘCANU, 2016,2017). Some studies showed that the sorghum grains can be used with the medicinal purpose as well (FATOKI et al., 2003; HERNÁNDEZ, 2022; ISTICIOAIE,2020; KHALID, 2022).

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).

Sorghum is known to be a grass species from the Gramineae family which has the potential to be developed optimally as a fodder. It is a very good source of food for ruminants and can be administered in feed recipes together with corn fodder and concentrates (LIMAN, 2023). From an economic point of view, it is 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; DRĂGHICI, 2016).

MATERIAL AND METHODS

The research was conducted at the Agricultural Research Development Station Braila located in Braila County, 11 kilometres from the city. 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 density 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 commercial sorghum hybrids that has been used. The hybrid had 8 graduations: Es Ayze's 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 favourable conditions.
(https://ragt-semences.fr/sites/default/files/public/medias/variety/pdfs/RGT%20ANGGY.pdf).
The agricultural year began with the preparation works of the agricultural land that had been cultivated with sunflower in 2021-2022 agricultural year. This work carried out in the fall of 2022 was represented by harrowing. In the spring of 2023, 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 that was 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 herbicide 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 18$^{th\ of}$ 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. The harvest took place on 26th October 2023.For the determination of the biomass and dry matter quantity were made some operations in the experimental field and in the laboratory. At the physiological maturity stage when the humidity was at the 15 % level were harvested 5 plants in 3 samples for each hybrid and repetition. In the laboratory, the leaves and panicles were then separated and weighed, then cut into particles smaller than one centimetre and then placed in a laboratory oven at 105º C. Multiple weighing were carried out until the moment when it was reached a constant mass for each sample. The ANOVA function from Microsoft Excel was used for processing the collected data from the field.

RESULTS AND DISCUSSIONS

Table 1 presents 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 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 232 mm was recorded, 5 mm more than the multi-annual May-September in this area of Braila County. Regarding the temperature it can be observed that 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 sum of the solar radiation totalized 1242 hours and the wind speed average for the May-September was 2.1 m/s.

Table 1

The climatic conditions registered in Braila Agricultural Research and Development Station in 2023

Month	2023 Temperature (°)	Multiannual average (°)	2023 Precipitations (mm)	Multiannual average (mm)	2023 Solar radiation	2023 Wind speed
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

Table 2 shows the elements that refer to the amount of harvested biomass in 2023 depending on the sowing density and the hybrid used. Harvested green biomass is divided into three categories in the same way that were separated and calculated in the laboratory. These are the total leaf biomass production, stem biomass production and total biomass per hectare which is the sum of leaf, stem and panicle biomass without grains with the latest representing a very small percentage of the total biomass being in the aisle of 0.03-0.05 percent. For the density of 22 seeds/m² the highest amount of fresh biomass was obtained by Shamal hydride, this having the value of 17.86 t/ha. being closely followed by Anggy hybrid which produced 17.85 t/ha fresh biomass. The experience average for this density was 16.32 t/ha. Of this amount, the biomass of the leaves was 28.2% and the biomass of the stems was 71.6%. For the density of 25 grains/m² it can be seen from the table that the average of the experience was 17.83 t/ha. Of this amount, 71.2% represents the biomass of the stems/ha and 28.6% is represented by the biomass of the leaves. In the Density 2, the most productive hybrid

turned out to be the Anggy hybrid, that obtained 19.44 t/ha. The Ggustav hybrid presented a high production as well with the quantity of 19.22 t/ha.

Table 2

Table 2-The influence of hybrid and density used in biomass production

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	4.74	27.4	12.53	72.5	17.28
	Shamal	4.89	27.3	12.96	72.6	17.86
	Arabesk	5.13	31.3	11.20	68.5	16.34
	Armorik	4.86	29.4	11.62	70.4	16.49
	Anggy	4.63	25.9	13.21	73.9	17.85
	Ggustav	4.58	25.9	13.08	73.5	17.68
	Belugga	3.98	32.4	8.28	67.5	12.26
	Huggo	4.08	27.5	10.70	72.2	14.80
Average		**4.61**	**28.2**	**11.70**	**71.6**	**16.32**
Density 2-25	Alize	5.16	27.5	13.72	72.2	18.72
	Shamal	4.96	25.9	14.31	73.8	19.11
	Armorik	5.39	30.8	12.24	69..1	17.48
	Armorik	5.87	31.2	13.07	68.6	18.77
	Anggy	5.09	26.1	14.53	73.7	19.44
	Ggustav	5.18	26.9	14.21	72.9	19.22
	Belugga	4.49	33.4	9.03	66.4	13.41
	Huggo	4.62	28.1	11.97	71.7	16.45
Average		**5.10**	**28.6**	**12.88**	**71.2**	**17.83**

From Table 3 it can be seen that the average total biomass harvested for the 8 hybrids is 17.01 t/ha, regardless of the Density factor. This is an important amount that can be used practically. Compared to the average value, hybrids Shamal, Anggy, Gustav, Alize obtained higher yields. The increases compared to the average were between 1.6 and 5.0 %. The lowest value was obtained by the Bellugga hybrid. It obtained the production of 12.26 t/ha, at Density 1 and the production of 13.41 t/ha at Density 2, being 4.75 t/ha and 3.6 t/ha lower compared to the average. From a statistical point of view the hybrids were insignificant, except for the Bellugga hybrid which obtained a significantly negative value for the density of 25 seeds/ha and a distinctly significant negative value for the density of 22 seeds/ha. From table 4 it can be observed that the average for the dry matter production was 5.07 t/ha. As the same like the biomass production, the Shamal, Anggy, Alize and Gustav managed to obtain higher yields compared to the average of the experience. Gustav was the most productive hybrid in term of dry matter being able to obtain with 0.65 t/ha more than the control. From a statistical point of view the was obtained the same results as for the biomass production thereby all the hybrids were statistically insignificant, except for the Bellugga hybrid which obtained a significantly negative value for the density of 25 seeds/ha and a distinctly significant negative value for the density of 22 seeds/ha. This was possible do to the fact that the Bellugga hybrid was the smallest from the experience in term of the height being only 88 cm tall.

The density of 25 seeds/m² provided the bigger amount of dry matter for each hybrid compared to the other density used.

Table 3

The influence of hybrid and density used in biomass production and the significance

Sowing density (Seeds/ha)	Hybrid	Total biomass yield			Signification
		t/ha	%	Differences (t/ha)	
Density 1-22	Alize	17.28	101.6	0.27	-
	Shamal	17.86	105.0	0.85	-
	Arabesk	16.34	96.1	-0.67	-
	Foehn	16.49	96.9	-0.52	-
	Anggy	17.85	104.9	0.84	-
	Ggustav	17.68	103.9	0.67	-
	Belugga	12.26	72.1	-4.75	OO
	Huggo	14.80	87.0	-2.21	-
Density 2-25	Alize	18.72	110.1	1.71	-
	Shamal	19.11	112.3	2.1	-
	Arabesk	17.48	102.8	0.47	-
	Foehn	18.77	110.3	1.76	-
	Anggy	19.44	114.3	2.43	-
	Ggustav	19.22	113.0	2.21	-
	Belugga	13.41	78.8	-3.6	O
	Huggo	16.45	96.7	-0.56	-
Experience average-Control		17.01	100	Control	Control

Dl 5%=2.58; Dl 1 %=3.82; Dl 0.1%=5.90

Table 4

The influence of hybrid and density used in dry matter yield and the significance

Sowing density (Seeds/ha)	Hybrid	Dry matter yield			Signification
		t/ha	%	Differences (t/ha)	
Density 1-220	Alize	4.56	99.6	-0.02	-
	Shamal	4.84	105.7	0.26	-
	Arabesk	4.26	93.0	-0.32	-
	Foehn	4.40	96.1	-0.18	-
	Anggy	4.82	105.2	0.24	-
	Ggustav	4.83	105.5	0.25	-
	Belugga	3.45	75.3	-1.13	OO
	Huggo	3.98	86.9	-0.60	-
Density 2-250	Alize	4.93	107.6	0.35	-
	Shamal	5.17	112.9	0.59	-
	Arabesk	4.49	98.0	-0.09	-
	Foehn	4.97	108.5	0.39	-
	Anggy	5.22	114.0	0.64	-
	Ggustav	5.23	114.2	0.65	-
	Belugga	3.73	81.4	-0.85	O
	Huggo	4.41	96.3	-0.17	-
Experience average-Control		5.07	100	Control	Control

Dl 5%=0.65 ; Dl 1 %=0.96; Dl 0.1%=1.48

CONCLUSIONS

It can be stated that sorghum, in the addition of the main production of grains may present a biomass production resulting from leaves, stems and panicles without the seeds. It is important to harvest the biomass too, because it can be used in different ways. It can be a good fodder for some animal species, especially the ruminants presenting good results in a development and milk producing for the cattle. It can present a good yield in some unfavourable climates regarding the soil and the precipitation regime, better than other fodder species.

The study revealed that the sorghum was more productive at the density of 25 seeds/m². The average obtained for this density was 17.83 t/ha, comparing to the other density. At the density of 22 seeds/m² it was obtained a 16.32 t/ha average. The most productive hybrid was the Anggy variety which obtained 19.44 tons of biomass per hectare at the higher density. The least productive hybrid in the term of biomass yield was the Belluga variety that obtained 12.26 t/ha at the lower density and 13.41 at the Density 2. It has been observed that there are some tall hybrids that in addition to grain production can also show superior biomass. The average for the dry matter obtained had the value of 5.07 t/ha.

BIBLIOGRAPHY

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-Realizări în ameliorarea sorgului la Fundulea. I.N.C.D.A. Fundulea, Vol. LXXV, Volum jubiliar, 137 –157.

BANGLADESH, J. & BOT, & MORE, AMBIKA., 2023- Development of dual-purpose sorghum [sorghum bicolor (l.) Moench] hybrid for kharif season having higher grain and fodder yield of SPH 1641. 2021.

BÂLTEANU GH., 2003- Phytotechnology, Ceres Publishing House, Bucharest.

CRÂȘMARU, 2021-Sorgul-O alternative a porumbului pentru siloz în condiții de secetă în regiunea de dezvoltare Conferința "Știința în Nordul Republicii Moldova: realizări, probleme, perspective"

DRĂGHICI I., 2016 - *Evaluarea potenţialului bioenergetic al producţiei primare şi secundare la cultura sorgului pentru boabe.* Analele SCCCPN Dăbuleni, vol 20, pp 82-89.

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.

HERNÁNDEZ, ESPITIA & GONZÁLEZ, CHÁVEZ & DAVILA MEDINA, MIRIAM & FLORES-NAVEDA, ANTONIO & SILVA, T & CHACÓN, RUELAS & SEPÚLVEDA, LEONARDO & ESPITIA, PILAR, 2022. Sorghum (Sorghum bicolor L. Moench): chemical composition and its health benefits.

ISTICIOAIE S., LEONTE A., POPA D., TROTUȘ E., APOSTOL L., VOICEA I., MATEI GH., 2020-*Sorghum bicolor (L.) Moench. - Plant for the future in Moldavia agriculture (Romania) and for the human nutrition*. E3S Web of Conferences. 180. 03004. 10.1051/e3sconf/202018003004

KHALID W., ANWAR A., ARSHAD M.S., AFZAL F., AKRAM R., SIDDEEG A., KOUSAR S., RAHIM M., AZIZ A., MAQBOOL Z., SAEED A., 2022. Nutrients and bioactive compounds of **Sorghum bicolor** L. used to prepare functional foods: a review on the efficacy against different chronic disorders. International Journal of Food Properties. 25. 1045-1062. 10.1080/10942912.2022.2071293.

KORNILOVA, E. & NIKOLAEV, S. & KARAPETYAN, A. & CHEKHRANOVA, S. & DANILENKO, I. & SAMOFALOVA, O. & VUEVSKY, N., 2023- The effectiveness of the use of sorghum grain in feeding of farm animals and poultry. Kormlenie sel'skohozjajstvennyh zhivotnyh i kormoproizvodstvo (Feeding of agricultural animals and feed production). 3-12. 10.33920/sel-05-2303-01.

LIMAN, L.,2023 - Effect of Substitution of Corn (Zea mays) Fodder with Sorghum (Sorghum bicolor var. Numbu) Fodder on Nutrient Digestibility and Daily Weight Gain of Beef Cattle. Journal of Agricultural Sciences – Sri Lanka.

POCHIȘCANU, S., DRUȚU, A., 2016- Sorgul "Cămila vegetală. Iași, Editura Ion Ionescu de la Brad, 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 G.V., 2011. Phytotechnics, University Publishing House, Bucharest

https://ragt-semences.fr/sites/default/files/public/medias/variety/pdfs/RGT%20ANGGY.pdf.

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

SIDLAUSSKAS, G., BERNOTAS, S., 2003 – Some factors affecting seed yield of spring oilseed rape (Brassica napus L.). Agronomy Research, 1 (2): 229-243, Lituania.