RESEARCH ON THE BEHAVIOR OF *SORGHUM BICOLOR* HYBRIDS UNDER THE SOIL AND CLIMATIC CONDITIONS OF THE CENTRAL MOLDAVIAN PLATEAU

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Abstract: *Sorghum (Sorghum bicolor (L.) Moench) is a cultivated plant originating from Africa. It's presence in the Romanian area has become increasingly prominent in recent years, a fact caused by climate changes affecting several crop species, including corn. Among the advantages of sorghum cultivation are its resistance to extreme conditions, particularly drought and heat, as it is primarily grown in the arid regions of Africa. Additionally, its low fertilization requirements provide a greater economic yield compared to other crops. The purpose of this study was to observe the behavior of sorghum in order to establish which hybrids exhibit the best viability and performance under the pedo-climatic conditions of Neamt County. The experiment began in 2023 at the S.C.D.A. Secuieni, where observations were made on 6 hybrids of grain sorghum. The observations conducted during the growing season included seedling density, flowering date, plant height assessment, number of panicles, and number of tillers. The applied technology was minimal, including scarification, sowing, pesticide application, and harvesting. From the analysis of the obtained results, it is evident that under the pedo-climatic conditions of Neam County, in the year 2023, the hybrids that achieved the highest production per hectare, as well as the highest quantities of protein and starch, are in the following order: ADV – SG 2, ADV – SG 7, and ADV – SG 6.*

Key words: *sorghum, hybrids, soil, Moldavia.*

INTRODUCTION

The sorghum plant (*Sorghum bicolor* (L.) Moench) is native to Africa and has gained increasing prominence in the Romanian agricultural sector in recent years, largely as a response to climate change impacting various cultivated species, including maize. One of the primary advantages of sorghum lies in it's remarkable resilience to extreme environmental conditions, particularly drought and high temperatures, which renders it exceptionally well-suited for arid regions, such as those found in Africa. Moreover, it's reduced fertilization requirements contribute to a higher economic efficiency compared to other crops (Gh. Roman et al., 2011).

Sorghum is ranked as the fifth most significant cereal crop worldwide, with an annual production ranging between 60 and 70 million tons, maintaining it's status as an agricultural staple for decades. This crop is cultivated across all continents, with Africa contributing 40-50% of the global output. Notable producers include the United States, which recorded a production of 8.2 million tons in 2023/24, along with Argentina and Australia—key exporters alongside the USA. Conversely, countries such as China, India, and Mexico primarily focus on domestic consumption. While traditionally less prevalent in Europe, sorghum cultivation on the continent has demonstrated a steady upward trend in recent years, with annual yields varying between 500.000 and 1.1 million tons depending on seasonal conditions (H. Doggett, 1988).

In 2023, Romania cultivated approximately 9.500 hectares of sorghum, placing it behind countries such as the Republic of Moldova, Ukraine, Russia, France, and Hungary (Figure 1). Numerous countries, including China, Japan, Mexico, Spain, and Italy, import sorghum, underscoring the strategic importance of expanding sorghum production within Europe (S. Poschisanu, 2016).

A distinguishing feature of sorghum is it's classification as a C4 plant, similar to maize and sugarcane. This physiological adaptation allows the plant to achieve higher photosynthetic efficiency, particularly under elevated temperatures or heat stress conditions (E. Trotuș, 2020).

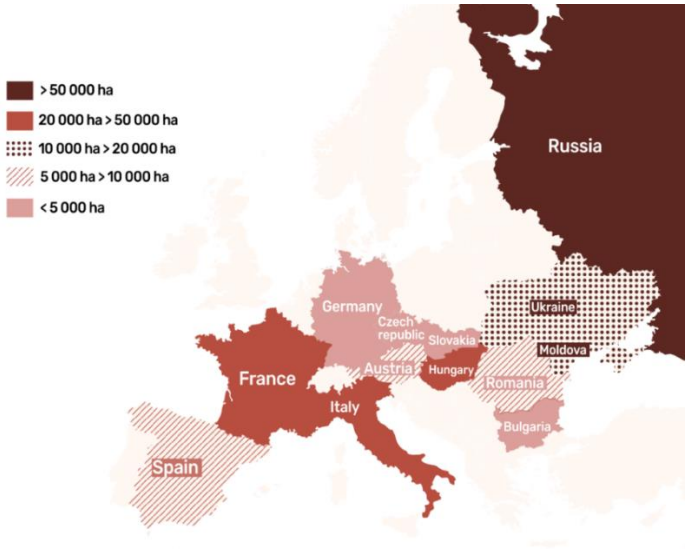

Fig. 1: *Areas Cultivated with Grain Sorghum in 2023* (source: www.sorghum-id.com)

MATERIALS AND METHOD

The aim of this study was to evaluate the behavior of sorghum in order to identify hybrids demonstrating the highest viability and performance under the specific soil and climatic conditions of the Central Moldavian Plateau. The research was initiated in 2023 at the S.C.D.A. Secuieni research station, where preliminary observations were conducted on six grain sorghum hybrids.

To fulfill the objectives of the study, the following goals were established:

- Assessing the adaptability of sorghum hybrids to the local environmental conditions,
- Comparing the agronomic and productive performance of each hybrid,
- Evaluating quality indices, including moisture content, hectoliter weight, 1.000-kernel weight (TKW), and the protein and starch content of the grain.

The experiment was structured as a single-factor trial with three replications, organized in a Latin square design. Each variant corresponded to a different hybrid, with the plot size for each variant measuring 10 square meters (2x5 m). Protective plots were established around the perimeter of the experimental layout to minimize edge effects (Fig. 2).

During the growing season, observations focused on key agronomic parameters, including emergence density, flowering date, plant height, the number of panicles, and the number of tillers.

	ADV - SG 2	ADV – SG 3	ADV - SG 4	ADV - SG 6	ADV - SG 7	ADV - SG 8	
	ADV - SG 8	ADV - SG 2	ADV - SG 3	ADV - SG 4	ADV - SG 6	ADV - SG 7	
	ADV - SG 7	ADV - SG 8	ADV - SG 2	ADV - SG 3	ADV - SG 4	ADV - SG 6	

Fig. 2: Diagram of the Experimental Layout

The experimental methodology employed minimal agricultural inputs, consisting of scarification, sowing, pesticide application, and harvesting.

In the 2023 agricultural year, a study on grain sorghum hybrids was carried out under the specific soil and climatic conditions of Secuieni, Neamț County. The trial was conducted at the S.C.D.A. Secuieni research station on a typical cambic phaeozem (chernozem) soil. This soil type is characterized by normal levels of available phosphorus (P_2O_5: 39 ppm) and potassium (K_2O: 161 ppm), moderate nitrogen availability (soil nitrogen index: 2,1), slight acidity (pH: 6,29), and low fertility, indicated by a humus content of 2,3%.

Table 1

Technological cultivation plan implemented in the experiment

Operation	Products used and dosage	Date of operation
Scarification		28. 10. 2022
Fertilized	Compound Fertilizer 15:15:15 (**200 kg/ha)**	29.03.2023
Cultivator		29. 03. 2023 28. 04. 2023
Sowing		11. 05. 2023
Sowing density	220.00 pl/ha	
Insecticide	Gazzelle (**0.1 kg/ha)**	24. 05. 2023
Herbicide	Aloha (**1,5 l/ha)** Dicopur (**1 l/ha)**	12. 05.2 023 09. 06. 2023

RESULTS AND DISCUSSIONS

Table 2

Biotechnological analyses and biometric assessments in the experiment conducted

Nr.	Hybrid	ED (per 10 sqm)			HD	Plant height (cm)	NP (per 10 sqm)			NT (per Plant)		
		R1	R2	R3			R1	R2	R3	R1	R2	R3
1	ADV – SG 2	75	58	103	26.07	115,5	131	99	152	1,4	0,7	0,5
2	ADV – SG 3	67	81	91	24.07	100	128	148	136	0,9	0,8	0,5
3	ADV – SG 4	85	56	111	24.07	99,1	167	142	157	0,9	1,5	0,4
4	ADV – SG 6	86	58	68	11.08	145,5	148	133	68	0,7	1,3	0
5	ADV – SG 7	35	20	29	11.08	181,5	67	51	67	0,9	1,5	1,3
6	ADV – SG 8	111	119	81	19.07	87,5	200	209	165	0,8	0,8	1,0

ED - *Emergence density*; HD - *Heading date*; PH - *Plant height*; NP - *Number of Panicles*; NT - *Number of Tillers*

The table presents comprehensive data on the performance of various sorghum hybrids, examining parameters such as emergence density, heading date, plant height, number of panicles, and the number of tillers per plant across three repetitions (R1, R2, R3).

The results indicate that the **ADV–SG 8** hybrid exhibited the highest emergence density across all repetitions, with values of 111, 119, and 81 plants per 10 square meters, respectively. In contrast, **ADV–SG 7** showed the lowest emergence density, with values of 35, 20, and 29 plants per 10 square meters, highlighting significant variability in adaptability and emergence vigor among the hybrids.

Heading dates also varied considerably, with **ADV–SG 8** heading the earliest (July 19) and **ADV–SG 6** the latest (August 11). This variation in maturity cycles suggests that **ADV–SG 8**, as an early-maturing hybrid, may be better suited for regions with shorter growing seasons.

Plant height ranged from 87.5 cm to 232.5 cm, with **ADV–SG 6** producing the tallest plants, indicative of higher biomass potential. Conversely, **ADV–SG 8**, while being the shortest hybrid, demonstrated superior emergence density and a greater number of panicles.

Both **ADV–SG 8** and **ADV–SG 4** exhibited a high number of panicles in all repetitions, reaching up to 200 and 167 in R1, respectively. This indicates a high productive potential associated with greater inflorescence density.

The hybrids **ADV–SG 4** and **ADV–SG 7** had the highest number of tillers per plant in R2 (1.5), whereas **ADV–SG 6** displayed no tillers in R3, reflecting a limited regeneration capacity under certain conditions.

Overall, the hybrids exhibited significant variability in their characteristics, providing a range of options for adaptation to diverse soil and climatic conditions. **ADV–SG 8** stands out for it's high emergence density and earliness, while **ADV–SG** 6 offers potential for biomass production due to it's tall stature. The final hybrid selection should align with the specific objectives of the crop, whether targeting grain yield or biomass production.

Table 3

Yield outcomes in grain sorghum cultivation

Variant	Y (kg/ha)			AY (kg)	MC (%)	Y (per ha 14% Moisture)	HW (kg)	TKW (g)	P (%)	S (%)
	R1	R2	R3							
ADV – SG 2	4320	5470	5160	4983	14	4983	79,6	23,65	14,1	55,4
ADV – SG 3	4688	5165	4280	4711	16,1	4596	69,9	23,20	14,4	53,4
ADV – SG 4	3668	3774	4255	3899	14,1	3894	76	17,7	14,2	56,6
ADV – SG 6	4320	5616	4625	4854	20,0	4515	79,1	29,75	14,7	56,6
ADV – SG 7	4790	4640	5036	4822	20,3	4469	73,2	28,65	15,1	56,4
ADV – SG 8	4374	4120	3774	4089	16,2	3985	76,6	19,65	14,6	56,9

Y – *Yield*; AY - *Average Yield*; MC - *Moisture Content*; HW - *Hectoliter Weight*; TKW - *Thousand Kernel Weight*; P – *Protein*; S – *Starch*;

The table provides a comprehensive evaluation of the performance of various sorghum hybrids, considering yield, moisture content, hectoliter weight (HW), 1.000 kernel weight (TKW), protein content, and starch content.

The highest average yield was recorded by the ADV–SG 2 hybrid, with 4.983 kg/ha, followed by **ADV–SG 6** (4.854 kg/ha) and **ADV–SG 7** (4.822 kg/ha), highlighting their substantial yield potential. Conversely, **ADV–SG 4** registered the lowest yield (3.899 kg/ha), suggesting inferior adaptability or productivity compared to the other hybrids.

Moisture content ranged from 14% to 20,3%, reflecting differences in drying rates among the hybrids. **ADV–SG 4** and **ADV–SG 2** exhibited lower moisture levels (~14%), potentially reducing drying costs, while **ADV–SG 7** had the highest moisture content (20,3%), which could increase pre-storage expenses.

When yields were adjusted to the standard moisture level (14%), **ADV–SG 2** remained the top performer (4.983 kg/ha), followed by **ADV–SG 6** (4.515 kg/ha) and **ADV–SG 7** (4.469 kg/ha).

Hectoliter weight (HW) varied between 69,9 and 79,6 kg/hl, with **ADV–SG 2** achieving the highest HW (79,6 kg/hl), indicative of denser and potentially higher-quality grain. **ADV–SG 3** displayed the lowest HW (69,9 kg/hl), suggesting lower grain density or quality.

ADV–SG 6 and **ADV–SG 7** showed the highest TKW values (29,75 g and 28,65 g, respectively), indicating larger grain size, which could positively impact yield. In contrast, **ADV–SG 4** had the lowest TKW (17,7 g), reflecting smaller grain size and possibly reduced yield potential.

Protein content ranged from 14,1% to 15,1%, with **ADV–SG 7** exhibiting the highest value (15,1%), followed by **ADV–SG 6** (14,7%), making these hybrids suitable for nutritional applications. Starch content ranged from 53,4% to 56,9%, with **ADV–SG 8** achieving the highest starch concentration (56,9%), rendering it ideal for industrial applications such as bioethanol production (Table 4).

In summary, **ADV–SG 2** and **ADV–SG 6** emerged as the top-performing hybrids, offering high yields, superior hectoliter weights, and competitive protein content. **ADV–SG 8** is notable for it's elevated starch content, making it a strong candidate for industrial purposes, while **ADV–SG** 7 is well-suited for nutritional applications due to it's high protein levels. The optimal hybrid selection should align with the specific objectives of the crop and considerations for drying and storage requirements.

Table 4

Yields of protein and starch per hectare

Hybrid	Y STAS (kg)	P (%)	S (%)	Q protein / ha	Q starch / ha
ADV – SG 2	4983	14.1	55.4	702.60	2760.58
ADV – SG 3	4596	14.4	53.4	661.82	2454.26
ADV – SG 4	3894	14.2	56.6	552.95	2204
ADV – SG 6	4515	14.7	56.6	663.71	2555.49
ADV – SG 7	4469	15.1	56.4	674.82	2520.52
ADV – SG 8	3985	14.6	56.9	581.81	2267.47

Y – *Yield*; P – *Protein*; S – *Starch*;

ADV–SG 8 exhibited the highest starch content (56,9%), positioning it as an excellent candidate for applications requiring elevated starch levels. Nevertheless, the highest total starch yield per hectare was achieved by **ADV–SG 2**, producing 2.760,58 kg/ha, attributable to it's exceptional overall yield.

In terms of protein content, **ADV–SG 7** stood out with the highest value (15,1%), making it particularly suitable for nutritional applications. However, when considering total protein yield per hectare, **ADV–SG 2** again emerged as the top performer, producing 702,60 kg/ha. This result reflects the hybrid's high overall yield, despite it's moderate protein percentage (14,1%).

CONCLUSIONS

- All tested hybrids proved to be well-suited for cultivation in the Central Moldavian Plateau.
- The highest grain yields were recorded by the hybrids **ADV–SG 2, ADV–SG 3**, and **ADV–SG 6**, showcasing their exceptional productivity.
- **ADV–SG 2** delivered the best protein yield per hectare, positioning it as an optimal choice for food production and mixed feed applications.
- This hybrid also achieved the highest starch yield per hectare, making it highly recommended for food industry uses and bioethanol production.

- **ADV–SG 8,** being the earliest maturing hybrid, is especially suitable for cultivation in northern regions of Romania.
- **ADV–SG 7** produced the highest biomass yield, establishing it as an excellent option for biomass production purposes.

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