



Study on the Adaptability of some Sorghum Hybrids in the Pedoclimatic Conditions of Jucu, Cluj County

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RESEARCH ARTICLE

Abstract

In the current context of global warming, the sustainable development of agriculture can be achieved by expanding the areas cultivated with drought-tolerant plants with high production potential. Sorghum caryopsis, to be intended for human consumption and animal feed, must be free of phytopathogenic agents and meet a series of essential quality conditions. Unfortunately, in unfavourable storage conditions (too high temperature and humidity), caryopsis is attacked by a wide spectrum of pathogens (*Fusarium*, *Alternaria*).

In this context, the aim of our study is to evaluate the adaptability and productive potential of six sorghum hybrids, identification of pathogens presents on sorghum caryopsis, their quality indices, as well as mycotoxin content. From the data obtained from the notes, observations and analyzes carried out, we can conclude that the percentage of sick caryopses was high in all the hybrids analysed, the microorganisms identified on the caryopses belonged to the genus *Fusarium* and *Alternaria* and the mycotoxin content was very low in all the hybrids analysed. This research highlighted the importance of Sorghum which becomes an alternative because it needs only half of the rainfall required by corn (it succeeds even when there is less than 350 mm annual rainfall), being able to replace the corn crop when there are conditions for a poor corn crop.

Keywords: sorghum, production, feed, phytopathogens, mycotoxins

INTRODUCTION

Climate change is a complex problem involving varied interactions between the environment, natural resources (land, crops, animals and water) and peoples (Devendra, 2012). Agriculture is considered a more vulnerable sector to climate change (Hasan et al., 2016), climatic conditions being one of the main factors that cannot be controlled and that influence the production of agricultural crops (Hochman et al., 2017). Sorghum is a crop that tolerates the effects of water deficit (Hausmann et al. 2007), being considered an excellent model for drought tolerance (Saxena et al. 2002). In this context, the sustainable development of agriculture can be achieved by increasing the areas cultivated with drought-tolerant plants, but also with high production potential, such as sorghum. Having a chemical composition similar to corn (approx. 75% carbohydrates, 12% protein, 3.8% fat, 2.2% cellulose, 1.3% ash, (Muntean et al., 2014), sorghum grains are used in animal feed (USA, Australia) but also as a staple food in certain areas (Africa, Southeast Asia, India, China and Central America). According to FAO data in 2020, in Europe, sorghum was cultivated on larger areas in France, 115 thousand ha, Italy, 52 thousand ha, Russia, 50 thousand ha, Ukraine 47 thousand ha and Hungary 22.8 thousand ha. According to the same source, in 2020, 9.5

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thousand ha were cultivated with an average production of 3691 kg/ha (<https://www.fao.org/faostat/en/#data/QCL>).

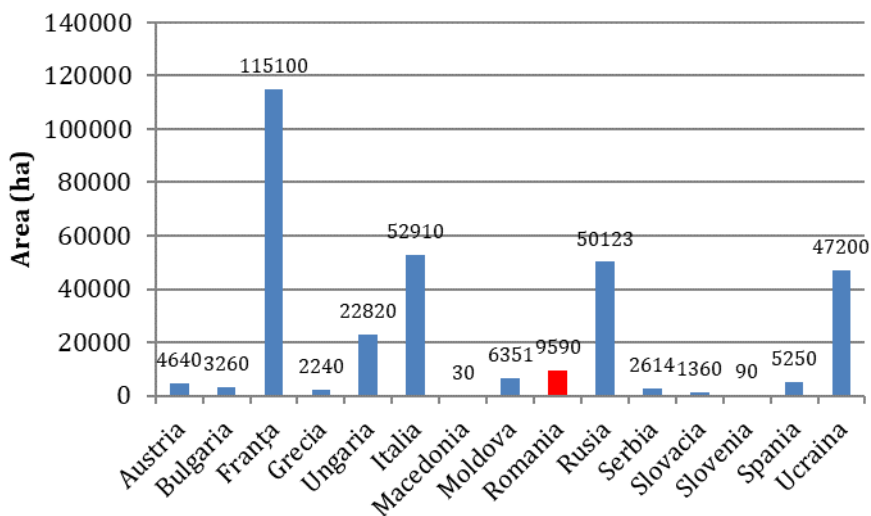


Figure 1. Areas cultivated with sorghum in Europe (<https://www.fao.org/faostat/en/#data/QCL>)

Sorghum [*Sorghum bicolor* (L.) Moench] is a source of animal forage, is a traditional food and beverage and biofuel. Biotic and abiotic stress reduce overall productivity of sorghum crop. Biotic stress factors include fungi, bacteria, viruses, nematodes and parasitic plants that cause diseases that can compromise sorghum production and quality (Little and Perumal, 2019).

New challenges due to climate change and also the increased sorghum production will increase the incidence of diseases caused by pathogens (Prom et al., 2021). Pathogens threaten grain quality, safety and nutritional value (some of which are responsible for the production of mycotoxins) both as human and animal feed (Ackerman et al., 2021). The complex of pathogens that cause mold of sorghum caryopsis belong to the genera: *Fusarium spp.*, *Aspergillus spp.*, *Curvularia spp.*, *Colletotrichum spp.*, *Alternaria spp.* and *Epicoccum sorghinum* (Ackerman et al., 2021).

In this context, the aim of our study is to evaluate the: adaptability and productive potential of six sorghum hybrids, determination of some morphological elements, identification of pathogens presents on sorghum caryopsis and their quality indices, as well as mycotoxin content.

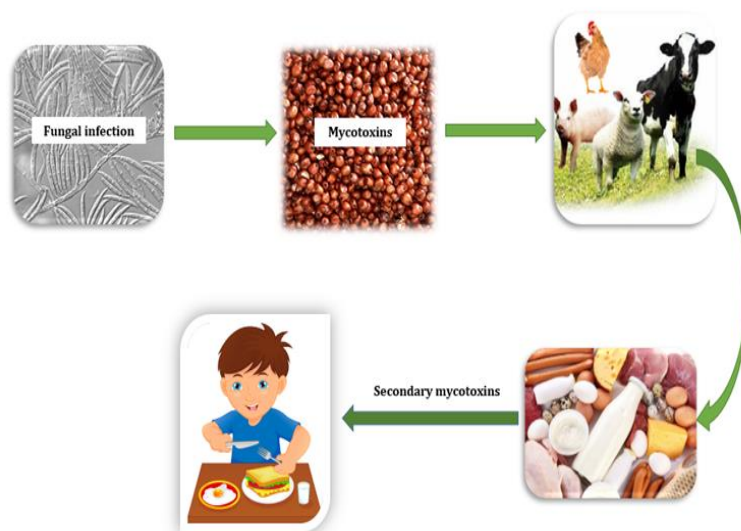


Figure 2. The link between diseased sorghum, mycotoxins, animals and humans (original)

MATERIALS AND METHODS

Plant materials and field experiments

The research was conducted in the experimental field of the Faculty of Agriculture in Jucu, Cluj County a single-factor experiment. The hybrids were Alize, Armorik, Mousson, Foehn, Arabesk and Shamal.

Cultivation technology: the plant preceding sorghum cultivation was clover. In October, the land was ploughed and in May, the following year, the seed bed was prepared, and the sorghum hybrids were sown. During the growing season, the weeds were controlled by two mechanical weeders. The harvest took place in November.

To interpret the results, the experimental technique for monofactorial experiments was used. The calculations were performed according to the variance analysis method using the significance of the differences according to the Student test and the Duncan test and with the help of the EXCEL program to interpret the results.

Agronomic measurements

Determinations in the field: before harvesting, the height of the plants and the number of leaves per plant were determined.

Determinations in the laboratory: mass of one thousand grains (MMB), mycotic load on sorghum caryopsis (analysis method on absorbent paper).

Qualitative indices and mycotoxin content: lipids were determined by the Soxhlet method, protein content was determined by the Kjeldahl method and ash by calcination; the content of mycotoxins was determined by the ELISA method.

RESULTS AND DISCUSSIONS

The climatic conditions during the vegetation period are decisive for the harmonious development of the plants and the obtaining of superior productions quantitatively and qualitatively. In table 1, the thermal and pluviometric regime from Jucu, Cluj County during the sorghum vegetation period is presented. The average temperature during the sorghum vegetation period was 14,58°C. The warmest month was July, with an average temperature of 22.3°C. During the sorghum vegetation period, 377 mm of precipitation fell, the rainiest month being July with 131 mm. From the data presented in Table 1, we can conclude that the climatic factors in 2021 were favourable for sorghum cultivation.

Table 1. The thermal and pluviometric regime in Jucu, Cluj County during the sorghum vegetation period (April - November 2021)

Month	Air temperature (C)			Rainfall (mm)	
	Average	Maxim	Minim		
May	14.1	27	0.0	April	77
June	19.7	35	7.0	May	34
July	22.3	34	13.0	June	131
August	19.3	32	8.0	July	69
September	14.6	33	5.0	August	32
October	7.9	22	-4.0	September	12
November	4.2	23	-6.0	October	22
Average	14.58			Total	377

(Sursa: https://rp5.ru/Arhiva_meteo_%C3%AEn_Cluj-Napoca)

The data related to morphological characters and production elements are presented in Table 2.

In the pedoclimatic conditions of Jucu, Cluj County, the height of the sorghum hybrids was between 112 cm (Alize) and 129 cm (Arabesk). Comparing the height of the hybrids with their average, significant differences are found in the Arabesk hybrid. Interpreting the results obtained by the Duncan Test, it is found that there are no significant differences in terms of plant height between Armorik and Arabesk hybrids.

Table 2. Height of sorghum hybrids (2021, Jucu, Cluj county)

Hybrid	Height (cm)	% to control	Difference/Significance	The Duncan Test
Average of hybrids	117.44	100.0	control	-
Alize	112.67	96.0	-4.78	a
Armorik	119.0	101	1.56	ab
Mousson	115.33	98	-2.11	a
Foehn	116.67	99	-0.78	a
Arabesk	129.67	110	12.22*	b
Shamal	111.33	95	-6.11	a

LSD (p5%) 12.11 LSD(p1%) 17.22 LSD (p0.1%) 24.93

The average number of leaves per plant was 8.5. The number of leaves identified in the hybrids taken into account was different, but the differences were small and not statistically supported by analysis of variance. The Duncan test shows us significant differences in the number of leaves identified in the Arabesk hybrid and the rest of the hybrids (Table 3).

Table 3. The correlation among the measured parameters.

Hybrid	Height (cm)	% to control	Difference/Significance	The Duncan Test
Average of hybrids	8.50	100	Control	-
Alize	8.67	102	0.17	b
Armorik	8.67	102	0.17	b
Mousson	9.00	106	0.50	b
Foehn	8.67	102	0.17	b
Arabesk	7.00	82	-1.50	a
Shamal	9.00	106	0.50	b

LSD (p5%) 1.63 LSD(p1%) 2.32 LSD (p0.1%) 3.35

The mass of one thousand grains (MMB) was between 21.12 g (Alize) and 26.08 g (Shamal). In the Shamal hybrid, significant differences were found in the MMB compared to the control (the average value of the hybrids). The Duncan test shows that there are no significant differences in MMB between Armorik, Foehn and Shamal hybrids (Table 4).

Table 4. Mass of a thousand grains in sorghum hybrids (2021, Jucu, Cluj County)

Hybrid	Height (cm)	% to control	Difference/Significance	The Duncan Test
Average of hybrids	23.40	100.0	Control	-
Alize	21.12	90	-2.28	a
Armorik	24.97	107	1.57	bc
Mousson	21.75	93	-1.66	a
Foehn	23.87	102	0.47	abc
Arabesk	22.62	97	-0.78	ab
Shamal	26.08	112	2.68*	c

LSD (p5%) 2.66 LSD(p1%) 3.78 LSD (p0.1%) 5.47

In the pedoclimatic conditions of Jucu, Cluj County, all the sorghum hybrids taken in this study obtained productions of over 5t/ha. The average production of the hybrids was 5578.98 kg/ha. The most productive sorghum hybrid was Shamal with significantly positive differences compared to the control. Between the rest of the corn hybrids studied, the differences are small and not statistically ensured by the analysis of variance. Between Mousson and Shamal sorghum hybrids, no significant differences in production can be found by the Duncan test (Table 5).

Table 5. Sorghum hybrids production (2021, Jucu, Cluj County)

Hybrid	Yield (kg/ha)	% to control	Difference/Significance	The Duncan Test
Average of hybrids	5578.98	100	Control	-
Alize	5543.05	99	-35.93	a
Armorik	5418.88	97	-106.09	a
Mousson	5781.11	104	202.13	ab
Foehn	5061.94	91	-517.04	a
Arabesk	5153.05	92	-425.92	a
Shamal	6515.83	117	936.85*	b
LSD (p5%) 862.58	LSD(p1%) 1226.18	LSD (p0.1%) 1775.44		

During the research, the caryopses were followed as they germinated on the sugative, in order to be able to observe and identify pathogens or saprophytic fungi that can develop simultaneously with their germination. Pathogenic agents were identified by macroscopic examination of the symptoms on the seeds (exudate, mycelium, spores) and microscopic by obtaining some preparations from the affected parts in order to be classified in the general from which they originate. Pathogens of the genera *Fusarium* and *Alternaria* were identified on sorghum caryopes.

According to the data presented in table 6, we can see that the *Fusarium fungus* developed in a very high percentage on the sorghum caryopes, between 21 and 43%. The hybrid with the lowest percentage of caryopes attacked was Arabesk (21.33%), an aspect also confirmed by the fact that this hybrid is described as a hybrid resistant to *Fusarium attack*. Shamal hybrid (28.67%) also has a low percentage of diseased caryopsis. At the opposite pole is the Alize hybrid, with the highest percentage of contaminated caryopsis. Between the six hybrids there are no statistically guaranteed differences, also confirmed by the Duncan test (Table 6).

Table 6. The percentage of caryopsis with attack by *Fusarium spp.* in sorghum hybrids

Hybrid	<i>Fusarium spp.</i> (%)	% to control	The difference from the control	The meaning of difference	The Duncan Test
Alize	21.33	100.0	0.0	Control	a
Armorik	35.33	165.6	14.0	-	a
Mousson	28.67	134.4	7.33	-	a
Foehn	35.33	165.6	14.0	-	a
Arabesk	33.33	156.3	12.0	-	a
Shamal	43.33	203.1	22.0	-	a
LSD (p5%) 22.16	LSD(p1%) 31.50	LSD (p0.1%) 45.61			

Regarding the attack by *Alternaria spp.* we can observe that the percentage of caryopsis attacked is different, in the six hybrids analysed. Distinctly significant and very significantly negative differences are observed between the percentages of attacked caryopsis, compared to the control variant. The Shamal hybrid recorded the lowest percentage of caryopsis with *Alternaria spp.* (19.33%). Percentages of attacked caryopses, over 40%, were noted in Arabesk (42.0%) and Foehn (44.67%) hybrids (Table 7).

Table 7. The percentage of caryopsis with attack by *Alteraria* spp. in sorghum hybrids

Hybrid	<i>Alternaria</i> spp. (%)	% to control	The difference from the control	The meaning of difference	The Duncan Test
Alize	42.00	100.0	0.00	Control	b
Armorik	44.67	106.3	2.67	-	b
Mousson	19.33	46.0	-22.67	000	a
Foehn	26.67	63.5	-15.33	00	a
Arabesk	40.00	95.2	-2.00	-	b
Shamal	24.67	58.7	-17.33	00	a

LSD (p5%) 9.35 LSD(p1%) 13.29 LSD (p0.1%) 19.24

The qualitative indices determined in the hybrid varieties were protein and lipids. Regarding the protein content, from the data presented in figure 3 we can see that in all sorghum hybrids the value of this quality index is slightly lower than the average of the species. However, the Arabesk variety stands out, in which the protein content has the highest value (7.27%), with this hybrid registering the lowest values of *Fusarium* spp. attack.

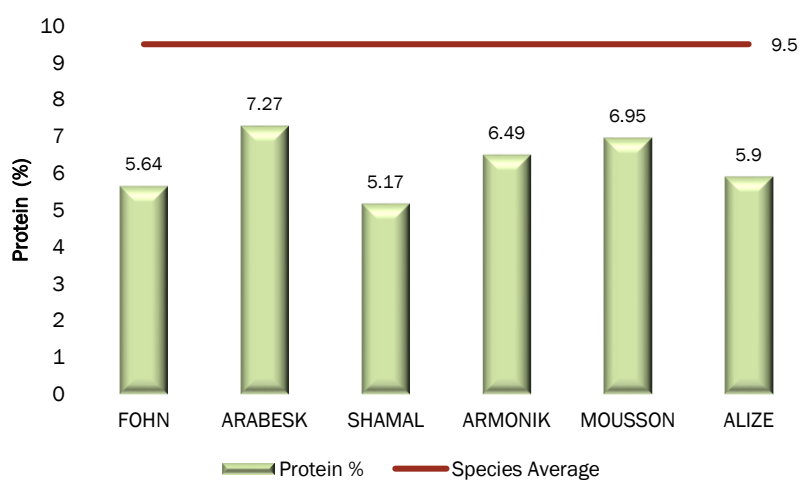


Figure 3. Protein content (%) in sorghum hybrids

The lipid content recorded in the analysed hybrids can be seen in figure 4. From the data presented in this figure, we can see that the lipid content is lower, in all hybrids, compared to the average of the species (3.8%), with the closest values to this average being the hybrids Armonik (3.13%) and Arabesk (3.12%).

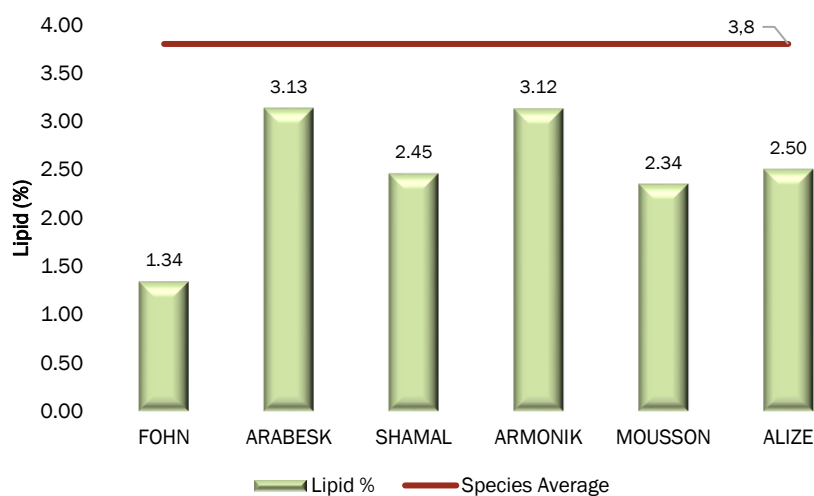


Figure 4. Lipid content (%) in sorghum hybrids

The effects produced by mycotoxins in the animal body depend very much on the species and age. In general, the consequences of the consumption of mycotoxins are not visible in the general condition of the animal, but more quickly, at the level of its immune system, affecting the antibodies. In addition to this effect, mycotoxins also strongly affect liver cells, thus degrading the animal's liver.

Given their incredible resistance both to the action of gastric or intestinal juice and to thermal treatment, they quickly reach the human body where they can lead to serious conditions such as: increased fragility of blood vessels, internal bleeding both in the mucous membranes and of the lungs, necrosis of the liver, bleeding of the lungs.

Regarding the content of mycotoxins, from the data presented in figure 5 we can conclude that it was very low, the values being 0.1 and 0.2 ppm and in the case of the mycotoxin *Fumonisin* being at the detection limit.

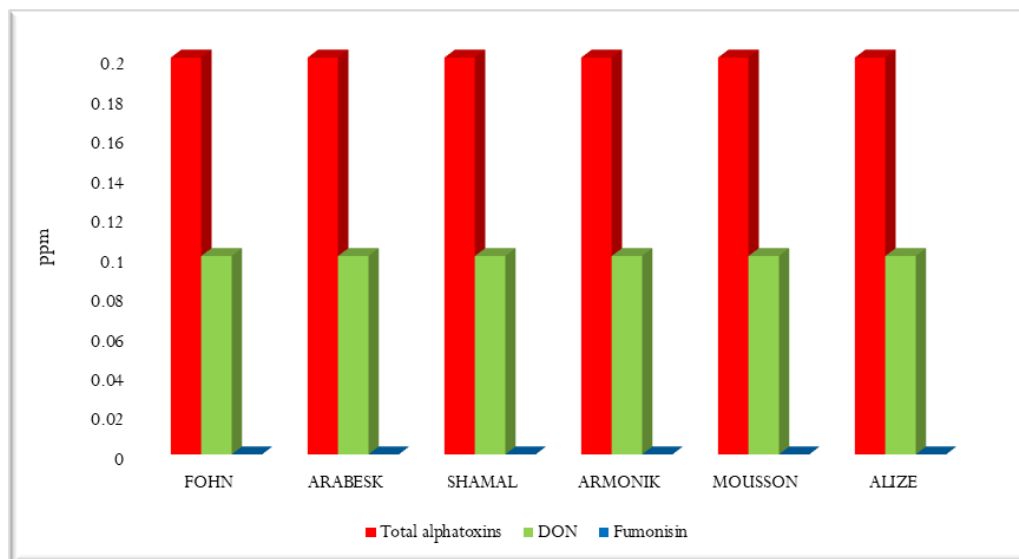


Figure 5. Mycotoxin content in sorghum hybrid

CONCLUSIONS

The height of the sorghum hybrids ranged between 112cm (Alize) and 129cm (Arabesk) and the number of leaves per plant between 7 (Arabesk) and 9 (Mousson and Shamal). In the most productive hybrid, Shamal, the highest MMB value was also identified. The productions obtained from sorghum, in the pedoclimatic conditions of Jucu, Cluj County, rank the sorghum hybrids as follows: Shamal, Mousson, Alize, Arabesk and Foehn. Pathogens that can depreciate quantitatively but especially qualitatively the quality of fodder obtained from sorghum are parasitic fungi of the genus *Fusarium* and the saprophytic fungus *Alternaria spp.* From the point of view of both microorganisms present on the sorghum caryopsis we can say that the Shamal hybrid was the least attacked (28% *Fusarium spp.* and 19% *Alternaria alternata*). The protein and lipid content recorded in the analyzed hybrids is lower, compared to the average of the species, with the closest values to this average being the hybrid Arabesk (7.27% protein, 3.13%, lipids). The mycotoxin content determined in the six hybrids was strongly reduced, without exceeding the norms imposed by the E.U.

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