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THE INFLUENCE OF SOIL TILLAGE SYSTEM AND FERTILIZATION ON THE DEVELOPMENT AND YIELD OF GRAIN SORGHUM IN THE CONDITIONS OF SĂRĂŢENI, IALOMIŢA

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Abstract

Drought is one of the abiotic stress factors that affect cereal production and represents an important risk factor even for tolerant crops, especially for spring crops. Climate change is putting more and more pressure on the cultivation technology of agricultural land, for which it is necessary to adapt the cultivation technology. This paper presents the results of the research carried out in the period 2020-2022, with the aim of identifying the best interactions between different variants of the basic soil work and some fertilization funds based on nitrogen, phosphorus and foliar fertilizers, thus it will be possible to establish, for the area under study (Sărăţeni-Ialomiţa county), in non-irrigated conditions of sorghum culture, which are the optimal options for obtaining a high production. Analyzing the data from the two years of research, 2021 a year rich in precipitation and 2022 a year with a water deficit, the influence of climatic conditions can be observed. The deeper the loosening of the soil was, the higher the increase in yeald was, tillage by scarification at 35 cm and at 45 cm excelled at all four fertilizations, thus having the highest biomass growth rates in the sorghum crop. The most favorable combination of technological factors that ensured a maximum production yield in 2021 of 8,040 kgha^{-1}, was represented by tillage by scarifying at 45 cm and a fertilization of $N_{100}P_{50}$.

Key words: *Sorghum bicolor L., soil tillage, fertilization, yield.*

INTRODUCTION

According to the purpose for which it is grown, sorghum is divided into four groups: grain sorghum (*Sorghum bicolor* var. *eusorghum*), technical sorghum (for brooms, pulp and paper) (*Sorghum bicolor* var. *technicum*), sugar sorghum (*Sorghum bicolor* var. *saccharatium*) and fodder sorghum (*Sorghum bicolor* var. *sudanense*) (Roman et al., 2006). Therefore, the sorghum culture has multiple and extensive uses on almost all continents, being the staple food of several people (Starodub, 2008).

Sorghum is the main cereal of Africa, due to its high fluoride content, contributing to the enviable appearance of the dentition of the African population (Ștefănescu et al., 2001). In Africa, it is used directly in human nutrition in the form of flour (Axinte et al., 2006).

Sorghum is also cultivated for green fodder or silage, constituting an important source of fodder for animals (Cernea, 2003). Sorghum plants have an increased resistance to drought, heat and make good use of poorly productive soils (Bucur, 2014). The drought tolerance of sorghum is attributed to a dense and deep root system capable of extracting water from deep in the soil (Wright and Smith, 1983; Singh and Singh, 1995), its ability to keep stomata open at low water potential by osmotic adjustment (Ludlow and Muchow, 1990), its ability to produce in a wide range of soil types, thus advancing different growth situations (Lafarge and Hammer, 2002) and the ability to delay reproductive development (Wright et al., 1983). In contrast, maize is significantly affected by water deficit and other environmental factors around anthesis (NeSmith and Ritchie, 1992a; NeSmith and Ritchie, 1992b; Otegui et al., 1995; Andrade et al., 1999). A recent study suggested that similar transpiration but different transpiration rates influence their comparative adaptation to rainfall-limited environments (van Oosterom et al., 2020). Research on the influence of culture technology on sorghum production, carried out in different areas, shows that it reacts favorably to mineral fertilization (Oprea et al., 2017).

In this context, the objective of the research carried out and provided in the paper is to take into account the main technological elements that influence a high production in the culture of sorghum for grains: the basic work of the soil and fertilization with a view to an optimal level of yield in correlation with the conditions in Sărăţeni locality, Ialomiţa county.

MATERIALS AND METHODS

The researches were carried out in the town of Sărăţeni-Ialomiţa county (44°38′11″N 26°55′41″E) between the years 2020-2022 within the Bănică Ion Individual Enterprise on a cambic chernozem. The rainfall regime was high in 2021, with a total of 673.6 mm, thus favoring obtaining a high production. Both at sowing and during the important phases of development, there was an amount of precipitation above normal. During the period of vegetative development of plants (May-August), 280 mm were recorded in 2021, and 96 mm in 2022, the difference between the two years being 184 mm (Table 1). The average monthly temperature for the period of vegetative growth is 20.8°C, and the average for the period 2020-2022 is 22.7°C, which shows us that the area is consistent with global warming.

Table 1. Climatic conditions during sorghum plant’s vegetative period at Sărăţeni-Ialomiţa

	Temperature (ºC)			Rainfall (mm)		
	Normal (1981-2010)	2020-2021	2021-2022	Normal (1981-2010)	2020-2021	2021-2022
Octomber	11.4	14.4	9.8	37.9	24.4	58.6
November	5.0	5.6	7.2	34.6	15.9	37.5
December	0.0	3.9	2.3	33.4	84.1	56.2
January	-1.1	1.9	1.9	23.6	78.7	3.8
February	0.4	2.8	4.2	22.3	23.5	3.7
March	5.3	4.9	4.0	27.2	77.0	13.0
April	11.4	9.5	11.8	41.1	51.0	38.0
May	17.6	17.0	17.8	50.5	36.0	15.0
Jun	21.4	20.7	22.7	71.2	175.0	26.0
July	23.2	24.9	25.5	61.9	33.0	31.0
August	22.6	23.6	24.8	46.8	36.0	24.0
September	17.3	16.8	17.2	47.8	3.4	0.0
Avg. (ºC) Sum (mm)	11.2	12.1	12.4	498.3	638.0	306.5

The experiment was placed in randomized blocks, in 3 repetitions with the analyzed factors: Factor A-basic soil work with graduations: a_1-Plow at 25 cm; a_2-Scarified at 35 cm; a_3- Scarified at 45 cm; a_4-Disc 10 cm; and factor B - fertilizations with graduations: b_1- N_0P_0 (Control); b_2- $N_{100}P_0$; b_3-$N_{100}P_{50}$; b_4-Borocal 1.5 l/ha (Foliar).

The biological material studied was the hybrid ES Abanus, a simple hybrid with white grains, excellent vigor when starting vegetation with compact panicles and very good tolerance to drought and shaking. It shows high tolerance to *Fusarium*, the plant size is small with very good resistance to falling.

Tillage and fertilization were applied according to the graduations. The predecessor plant was corn.

Chemical fertilizers were administered before sowing, and foliar fertilization was applied to the vegetation.

Sowing was carried out at a density of 230,000 grains/ha, and after sowing pre-emergent herbicide was used with Dual Gold 960 EC herbicide at a dose of 1.2 l/ha.

RESULTS AND DISCUSSIONS

The influence of fertilization on the height of sorghum

The influence of fertilization on the height of sorghum, carried out in June, includes the period of intense vegetative growth in all experimental variants. The plants had a height between 70.8 cm in the non-fertilized-plowed version and 95.5 cm, in the version fertilized with foliar fertilizers-scarified at 45 cm (Table

2). Compared to the unfertilized control, the application of fertilizers determined the obtaining of more vigorous plants, the best results were found in the case of the variants fertilized with nitrogen and phosphorus, tillage by scarification at 35 cm and at 45 cm.
Fertilizing the soil with phosphorus-based fertilizers brought the biggest differences compared to the non-fertilized variants, the largest being 9.1 cm for the variant a_1- Plow 25 cm + b_3- $N_{100}P_{50}$.
By comparison with the unfertilized control variant, against the background of the application of nitrogen ($N_{100}P_0$) and phosphorus ($N_{100}P_{50}$) fertilization, the plantsa had lower heights, but a higher twinning.

Table 2. The influence of the agrofund on the height of sorghum plants in different tillage systems

Variant	Year	b1 - N_0P_0			b2 - $N_{100}P_0$			b3 - $N_{100}P_{50}$			b4 - Foliar (Borocal 1.5 l/ha)		
		cm/plant	%	Dif.	cm/plant	%	Dif.	cm/plant	%	Dif.	cm/plant	%	Dif.
a1 - Plow 25 cm	2020-2021	70.8	100	C	79.5	112.2	8.7	79.9	112.8	9.1	78	110.1	7.2
	2021-2022	83.4	100	C	86.1	103.2	2.7	85.9	102.9	2.5	85.2	102.1	1.8
	Avg.	77.1	100	C	82.8	107.3	5.7	82.9	107.5	5.8	82.8	107.3	5.7
a2 - Scarified 35 cm	2020-2021	80.4	100	C	76.3	94.9	-4.1	76.1	94.6	-4.3	80.5	100.1	0.1
	2021-2022	83.3	100	C	84.5	101.4	1.2	87.6	105.1	4.3	85.1	102.1	1.8
	Avg.	81.8	100	C	80.4	98.2	-1.4	81.8	100	0	82.8	101.2	1
a3 - Scarified 45 cm	2020-2021	80.6	100	C	85.2	105.7	4.6	76	94.2	-4.6	88.2	101.9	7.6
	2021-2022	92.4	100	C	89	96.3	3.9	92.5	100.1	0.1	95.5	103.3	3.1
	Avg.	86.5	100	C	87.1	100.6	0.6	84.2	97.3	-2.3	91.8	106.1	5.3
a4 - Disc 10 cm	2020-2021	78.9	100	C	73.9	93.6	-5	72.3	91.6	-6.6	88.2	103.1	9.3
	2021-2022	81.5	100	C	80.5	98.7	-1	83.9	102.9	2.4	81.4	99.8	-0.1
	Avg.	76.2	100	C	77.2	101.3	1	78.1	102.4	1.9	81.4	106.8	5.2

Deeper tillage of the soil increases the height of the sorghum plants, regardless of the way it was fertilized (Table 3). The highest values were recorded with scarified tillage at 45 cm: 113.8 cm, unfertilized, compared to the variant worked by discus: 78.9 cm. Scarification at 35 cm and at 45 cm brought similar values regarding the height of sorghum plants to all three fertilization methods.
The deep tillage of the soil by scarification determined a better utilization of the foliar fertilization in the two experimental years, the plants had heights of 10.2 cm and 10.3 cm compared to the conventional tillage system.

Tabel 3. The influence of tillage on the height of sorghum plants through different types of fertilization

Variant	Year	b1- N_0P_0			b2- $N_{100}P_0$			b3- $N_{100}P_{50}$			b4- Foliar(Borocal 1.5 l/ha)		
		cm/plant	%	Dif.	cm/plant	%	Dif.	cm/plant	%	Dif.	cm/plant	%	Dif.
a1 - Plow 25 cm	2020-2021	70.8	100	Ct	79.5	100	Ct	79.9	100	Ct	78	100	Ct
	2021-2022	83.4	100	Ct	86.1	100	Ct	85.9	100	Ct	85.2	100	Ct
	Avg.	77.1	100	Ct	88.2	100	Ct	82.9	100	Ct	82.8	100	Ct
a2 - Scarified 35 cm	2020-2021	80.4	113.5	9.6	76.3	95.9	-3.2	76.1	96.3	-3.8	80.5	103.1	2.5
	2021-2022	83.3	99.8	-0.1	84.5	98.1	-1.6	87.6	101.9	1.7	85.1	99.8	-0.1
	Avg.	81.8	106.1	4.7	80.4	91.1	-7.8	81.8	98.6	-1.1	82.8	100	0
a3 - Scarified 45 cm	2020-2021	80.6	113.8	9.8	85.2	107.1	5.7	76	95.1	-3.9	88.2	113	10.2
	2021-2022	92.4	110.7	9	89	103.3	2.9	92.5	107.6	6.6	95.5	112	10.3
	Avg.	86.5	112.2	9.4	87.1	98.7	-1.1	84.2	101.5	1.3	91.8	110.8	9
a4 - Disc 10 cm	2020-2021	78.9	111.4	8.1	73.9	92.9	-5.6	72.3	90.4	-7.6	88.2	113	10.2
	2021-2022	81.5	97.7	-1.9	80.5	93.4	-5.6	83.9	97.6	-2	81.4	95.5	-3.8
	Avg.	80.2	98.8	-0.9	77.2	87.5	-11	78.1	94.2	-4.8	81.4	98.3	-1.4

The influence of fertilization on sorghum production

Based on the application of 100 kg of nitrogen/ha, an average increase in production of 2,779 kg was recorded compared to the unfertilized control in the variant of tillage by scarifying at 45 cm and an increase of 1,987 kg/ha when scarifying the soil at 35 cm. Foliar fertilization of sorghum brought the smallest increase in production, the maximum difference compared to the control being 674 kg in the scarified version at 35 cm. Analyzing the averages over the two years, the b2-$N_{100}P_0$ variant brought increases starting with 1,987 kg when tilling the soil by discus, up to a maximum increase of 2,779 kg when tilling the soil by scarifying at 45 cm. The application of nitrogen and phosphorus in the sorghum culture greatly influenced the production, the interaction between $N_{100}P_{50}$ and scarified at 45 cm brought the highest level of harvest of 5,525 kg, with an increase in production compared to the unfertilized control: 3,164 kg (Table 4). Analyzing tillage, production increased gradually with deeper tillage. The highest production, on average for all experimental variants, was recorded in the work by scarification at 45 cm of the land together with fertilization with $N_{100}P_{50}$: 8,040 kg/ha.

Deep loosening of the soil gradually increased the production of grain sorghum. Scarification of the soil at 45 cm proved to be the most productive choice even in a year with low precipitation (2022-306.5 mm), where a minimum production of 1,915 kg and a maximum of 3,010 kg was obtained (Table 5). In terms of tillage, production increases start from 102 kg (scarified at 35 cm + foliar fertilization) and reach an average maximum of 884 kg (scarified at 45 cm +$N_{100}P_0$).

Table 4. The influence of the agrofund on the height of the plants

Variant	Year	b1 - N_0P_0			b2 - $N_{100}P_0$			b3 - $N_{100}P_{50}$			b4 - Foliar (Borocal 1.5 l/ha)		
		kg/ha	%	Dif.	kg/ha	%	Dif.	kg/ha	%	Dif.	kg/ha	%	Dif.
a1 - Plow 25 cm	2020-2021	2.986	100	Ct	6.753	226.1	3.767	6.900	231	3.914	3.316	111	330
	2021-2022	1.176	100	Ct	1.760	149.6	584	2.500	122.5	1.324	1.331	113.1	155
	Avg.	2.081	100	Ct	4.256	204.5	2.175	4.700	225.8	2.619	2.323	111.6	242
a2 - Scarified 35 cm	2020-2021	2.706	100	Ct	7.490	276.7	4.784	7.420	274.2	4.714	3.380	124.9	674
	2021-2022	1.550	100	Ct	2.103	35.6	553	2.480	160	930	1.610	103.8	60
	Avg.	2.128	100	Ct	4.796	225.3	2.668	4.950	232.6	2.822	2.425	113.9	297
a3 - Scarified 45 cm	2020-2021	2.808	100	Ct	7.715	274.7	4.907	8.040	286.3	5.232	3.402	121.1	594
	2021-2022	1.915	100	Ct	2.565	133.9	650	3.010	157.1	1.095	2.185	114	270
	Avg.	2.361	100	Ct	5.140	217.7	2.779	5.525	234	3.164	2.793	118.2	432
a4 - Disc 10 cm	2020-2021	2.600	100	Ct	6.100	234.6	3.500	6.640	255.3	4.040	2.700	103.8	100
	2021-2022	956	100	Ct	1.430	149.5	474	1.673	175	717	1.116	169	160
	Avg.	1.778	100	Ct	3.765	319.6	1.987	4.156	352.8	2.378	1.908	161.9	130

Table 5. The influence of tillage and fertilization on yield in 2021-2022

Variant	Year	b1 - N_0P_0			b2 - $N_{100}P_0$			b3 - $N_{100}P_{50}$			b4 - Foliar (Borocal 1.5 l/ha)		
		kg/ha	%	Dif.	kg/ha	%	Dif.	kg/ha	%	Dif.	kg/ha	%	Dif.
a1 - Plow 25 cm	2020-2021	2.986	100	Ct	6.753	100	Ct	6.900	100	Ct	3.316	100	Ct
	2021-2022	1.176	100	Ct	1.760	100	Ct	2.500	100	Ct	1.331	100	Ct
	Avg.	2.081	100	Ct	4.256	100	Ct	4.700	100	Ct	2.323	100	Ct
a2 - Scarified 35 cm	2020-2021	2.706	90.6	-280	7.490	111	737	7.420	107.5	520	3.380	110	64
	2021-2022	1.550	131.8	374	2.103	119.4	343	2.480	99.2	-20	1.610	121	279
	Avg.	2.128	102.2	47	4.796	112.6	540	4.950	105.3	250	2.425	104.3	102
a3 - Scarified 45 cm	2020-2021	2.808	94	-178	7.715	114.2	962	8.040	116.5	1140	3.402	102.5	86
	2021-2022	1.915	162.8	739	2.565	145.7	805	3.010	120.4	510	2.185	164.1	854
	Avg.	2.361	113.4	280	5.140	120.7	884	5.525	117.5	825	2.793	120.2	470
a4 - Disc 10 cm	2020-2021	2.600	87	-386	6.100	90.3	-653	6.640	96.2	-260	2.700	81.4	-616
	2021-2022	956	81.2	-220	1.430	81.2	-330	1.673	67	-827	1.116	83.8	-215
	Avg.	1.778	56.6	-303	3.765	88.2	-791	4.156	88.4	-544	1.908	82.1	-415

CONCLUSIONS

Following the research carried out, the following more important conclusions can be summarized regarding the influence of tillage systems and fertilization in grain sorghum culture:

Under the conditions of a cambic chernoziom in the Sărăţeni-Ialomiţa area, the highest height of the sorghum plants was obtained in the variants fertilized with foliar fertilizers, together with tillage by scarification.

With the deeper work of the soil, the height of the sorghum plants also increases, regardless of how it was fertilized.

The biggest increase in production of 3,164 kg was recorded applying a fertilization with $N_{100}P_{50}$. Fertilization only with nitrogen brought an average increase in the sorghum culture for grains of 2,779 kg.

The deep tillage of the soil by scarification at 45 cm brought the highest production on average over the two years: 5,525 kg, with an increase of 884 kg/ha, compared to the control plowed at 25 cm.

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