

RESEARCHES AND CONTRIBUTIONS TO PLANT SORGHUM CROP IN THE CONDITIONS OF CLIMATE CHANGES

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Abstract. *Dobrogea is the most drought area of Romania (average 1961-2016 :464 mm rainfall precipitation). Climate change in recent years has accentuated this phenomenon .For farmers from this area sorghum crop is a solution. At Sport Agra in Amzacea, in the last few years there have been experimented new sorghum crop technologies designed to face the current climate changes. These technologies include the following elements: changing the planting epoch with one month before the usual period recommended by classical technologies; (beginning of April in order to benefit from the soil's humidity la 4-5 cm depth boosting the germination process); choosing early hybrids in order to avoid the drought season which starts in June; applying adequate crop protection treatments, with pre-emergent and post-emergent herbicides and last generation insecticides. The agricultural crops in this area are not irrigated, so the authors proposed a new technology, planting the crops earlier. In this way the plants will benefit from the moisture of the soil accumulated in the winter. The obtained production from sorghum crop was over 10t/ha for most of the hybrids tested.*

Keywords: Sorghum, climate changes, technologies

1. Introduction

The history of sorghum it is written that it has been appeared in the 9th century in Zanzibar. From Asia it has been transported by a brush American citizen Franklin. In the 13th century, it was cultivated in Italy (Filipescu, 1943) [5]. At the level of 1943, Italian sorghum was produced in Romania for export.

At the level of 1986 there were cultivated 90,000 ha with an average production of 1,860 kg ha (Statistical Yearbook 1990) [12]. At the level of 2003, in Romania there were cultivated 11,092 ha in 8,765 farms (Muntean et al, 2008) [9].

Sorghum is a plant with rooted fascicle that grows in the soil reaching up to 1.25 meters, thus ensuring the water needed during the vegetation period (drought tolerance).

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2. Crop Technology

The crop taking into study is sorghum, which is recommended for these arid areas; called "the camel of crops" due to its drought resistance (Ayana and Bekele, 2004)[1], sorghum requires the following technological elements: Selecting early hybrids to overcome the drought periods that occur between the 5-10th of June until the 20-25th of August(Manole D., 2018)[8]. There are recommended hybrids with shorter vegetation period (Poschiscanu et al.,2015) [11].

Sorghum planting is recommended between 20th April and 10th May (Trotus et al. 2015) [13] ensuring a minimum of 120-140 kg/ha of Nitrogen (Owen, 1967) [10], treatment of seeds before planting with chemicals containing thiamethoxam, (Manole D., 2018)[7] pre-emergence herbicide with Dual Gold (metalacolor) 1.5 l/ha and post-emergence with Buctril Universal 0.8 l/ha (bromoxinil+2.4D).

The results from comparative crops in a 4-year dynamics have demonstrated sorghum crops with outstanding yields of over 10 t/ha.

The agricultural crops in this area are not irrigated, so the authors proposed a new technology, planting the crop earlier by about a month. This way the plants will benefit from the moisture of the soil accumulated in the winter time, and passing the dry period starting from June to July.

Table 1. Experience of Sorghum in Constanta County 1961-Research Station "Valu lui Traian"

Hybrid	Plant height cm	Vegetation period days	Yields Kg/ha	+ -
NK 210	117	144	8,413	3,359
NK 300	156	143	8,152	3,098
NK 120	118	128	7,905	2,851
X 3000	109	125	7,646	2,592
X 3021	129	135	7,611	2,557
X 3057	170	130	7,476	2,422
X 3007	108	148	7,322	2,268
NK 310	113	146	7,057	2,003
NK 230	103	136	6,867	1,854
NK 145	225	130	6,815	1,761
NK 135	122	131	6,670	1,616
NK 135 11	136	145	6,657	1,603
X 3037	102	145	6,459	1,405
NK 140	118	138	5,741	687
HD 302 (corn)	220	132	5,054	-

Note: As shown in Table 1 all 14 hybrids of sorghum at the level of 1961 have surpassed the hybrid HD 302 of corn between 687 – 3,359 Kg/Ha in the Research Station "Valu lui Traian".

3. Chemical composition of Corn and Sorghum

Table 2. Chemical composition of Corn and Sorghum

Specification	Protein	Grease	Cellulose	Ash
Corn	9.3-14.7	4.5-5.3	1.9-2.6	1.3-1.7
Sorghum	9.6	3.4	2.2	1.5

Sorghum absorbs from the atmosphere 50-55 to/ha carbon dioxide from deciduous forests 16 to/ha.

Sorghum contains 20-40 kg carbohydrate juice per 100 kg/strains which can result in cheaper fuel (Budescu, 2004) [3].

Very important for sorghum crop it is its contain in essential amino acids and tryptophan which will provide the advantage to feed cattle, pigs and especially chicken (Brouk. M.J. Bean B, 2005)[2].

4. The arable land in Constanta county and the main crops, 2017 – 2019

Table 3. The arable land in Constanta county and the main crops 2017 – 2019

Crop	2017		2018		2019	
	ha	Kg / ha	ha	Kg / ha	ha	Kg / ha
484103 ---- 483671						
Wheat	186,855	4,682	172,122	5,652	194,375	5,084
Barley	28,410	5,116	47,182	6,702	43,200	5,213
Corn	41,032	6,906	49,185	8,475	56,710	5,282
Sunflower	118,635	2,927	95,123	3,512	115,310	2,505

Even if the corn it's a much more profitable then the other crops, because the land is not irrigated, the area cultivated with corn it is not very large: 41,032 ha – 2017 – 56,710 ha – 2019. At the level of the year 2019 wheat and barley were cultivated on an area of 237,575 ha, meaning about 50% of the arable land of Constanta County.

Experimental plots were placed at S.C. Sport Agro S.R.L. Amzacea, Constanta County. The experience was situated on a land belonging to the South Dobroudja plateau, represented by a cambic chernoziom, with a profile deeper than other chernozioms, a blackish-brown soil of 40-50 cm thickness, medium texture (Demeter, 2009) [4]. The content of nutrients was: mobile P index - 72; N index - 4; Humus - 3.11; K index - 200; Neutral pH - 7.2. The climate is deeply temperate continental, with an average annual temperature of 10.7-12.12°C, with a high temperature between June and August. Meteorological data are presented in

Tables 4, 5 and 6 from Research Station "Valu lui Traian", Constanta, starting from 2016 to 2018 in comparison with the average between 1961 – 1990.

5. Precipitation regime

Table 4. Precipitation and temperature during 2016 growing vegetation season (Valu lui Traian Station, Constanta County)

	Month								
	Jan.	Feb.	March	April	May	June	July	Aug.	
Periods	The growing season 2016: Precipitations (mm) for 10-day periods								Sum
1-10	0	12.0	10.0	0	60.0	3.5	56.0	4.0	145.5
11-20	95.0	18.5	19.0	0	21.01	20.0	0	0	173.5
21-30	15.0	0	15.0	20.0	16.0	0	0	0	66.0
Sum	110.0	30.5	44.0	20.0	97.0	23.5	56.0	4.0	385.0
	Average 1961-1990: monthly values of precipitations (mm)								Sum
	27.7	24.0	29.1	31.8	37.7	47.1	38.9	37.4	273.7
	The growing season 2016: Mean air temperature (°C) for 10-day periods								Mean
	2.5	4.1	6.8	10.3	13.9	19.8	22.6	23.2	12.9
11-20	4.8	5.2	7.9	12.9	16.8	21.4	24.2	22.6	14.57
21-30	4.3	5.4	10.2	13.5	18.7	22.1	23.8	21.4	14.92
Mean	3.9	4.9	8.3	12.2	16.5	21.1	23.5	22.4	14.1
	Average 1961-1990 monthly values of mean air temperature (°C)								Mean
	0.4	0.9	4.4	9.7	15.3	19.4	21.9	16.9	12.12

Table 5. Precipitation during 2017 growing vegetation season (Valu lui Traian Station, Constanta County)

	Month								
	Jan.	Feb.	March	April	May	June	July	Aug.	
Periods	The growing season 2017: Precipitations (mm) for 10-day periods								Sum
1-10	60.0	5.0	4.0	0	13.0	18.0	9.0	0	109.0
11-20	10.0	13.5	31.0	35.0	12.0	6.0	0	0	107.5
21-30	0	2.0	5.0	6.0	2.0	4.0	92.0	6.0	117.0
Sum	70.0	20.5	40.0	41.0	27.0	28.0	101.0	6.0	333.5
	Average 1961-1990 monthly values of precipitations (mm)								Sum
	27.7	24.0	29.1	31.8	37.7	47.1	38.9	37.4	273.7

Table 6. Precipitation during 2018 growing season of sorghum(Valu lui Traian Station, Constanta, Romania)

	Month								
	Jan.	Feb.	March	Apr	May	June	July	Aug.	
Days	The growing season 2018: Precipitation (mm)								Sum
1-10	0	9	6	2	64	35	98	0	214
11-20	44	31	37	0	28	0	2	0	142
21-31	19	80	26	0	0	41	47	0	213
Sum	63	120	69	2	92	76	147	0	569
	Average 1961-1990 monthly values of precipitations (mm)								Sum
	27.7	24.0	29.1	31.8	37.7	47.1	38.9	37.4	273.7

5.1. Average rainfall - Research Center Amazacea 2010 – 2019

Table 7. Average rainfall – Research center Amazacea 2010 – 2019

Year	Monthly precipitations (mm)												Total year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2010	82.5	74	90	19	56	54	297	0	25	47	16	38	801.5
2011	50.8	25	34	40	54	18.5	96	11	11	78	1	56	475.3
2012	126	34	25	32.5	94	4.5	61	37	10	35	15	81	555
2013	42	17.5	22	25.5	60.5	75.5	85	20	65	76.5	13	20	522.5
2014	113	2	40.5	42	61.5	228.5	30	89	43	151	40	106	946.5
2015	83	40	74.5	48	0	25.5	35	41	17	93	40	3	500
2016	110	30.5	55	20	97	23.5	56	4	23	72	47	3	541
2017	70	20	40	41	27	29	111	6	5	55.5	65	50	519.5
2018	63	120	68	2	92	76	147	0	3	3	57.5	47	678.5
2019	36	8	16	35.5	18	14	44	7	37	44	9.5	27.5	178.5
Average	77.63	37.1	46.5	30.55	56	54.9	96.2	21.5	24.8	76	29.6	44.6	615.53 9 year 595,38 10 year
178.5 mm precipitations between January the first – August 31 2019													

As written in Table 4, the year 2016 provided a higher amount of rainfalls between May and June, 111.3 mm higher than the multiannual average. These precipitations favored the development of sorghum crops. In the Tabel 5 the precipitations in May, June were 55 mm. – 29.8 mm. in comparison with the multianual average of 84.8 mm., but in July it was happened 101.0 mm. The same

it was happened at SC Sport Agra- Amzacea. As shown in Tabel 6, the year 2018 was very rich in precipitations in Research Station Valu lui Traian, May and June registered 168.0 mm and July 147.0 mm. The same rainfall level was in Amzacea as shown in Table 7. Looking at the four years of research, the year 2019 was the dryest year in a total growing season of sorghum, reaching 178.5 mm. Tabel 7 in comparasion with multianual precipitations starting since 2010 the year 2019 was reach only 296,5 mm. total year, wich means a difference of 319,03 mm. and an average of total ten years it was 615,53mm., so a total diference of - 319,03mm..

Regarding the sorghum crop, the main technological links pursued by the research team consisted of the following: Choosing early hybrids to overcome the burning periods that occur between June 5 till August 20-25, Recommending shorter vegetation hybrids, Providing a minimum amount of 120-140 kg/ha of nitrogen, Treatment of seeds before planting with chemicals containing thiamethoxam to combat *tanymecus sp.* in the early stages of vegetation, Pre-emergence herbicide with Dual Gold (metalaclor) 1.5 l/ha and post-emergence with Buctril Universal 0.8 l/ha (bromoxinil+2.4D).



Photo 1. Research field of Sorghum at SC Sport Agra S.R.L. before harvesting 2019 (Original)



Photo 2. Researches field of Sorghum 2017, SC Sport Agra S.R.L. before harvesting (Original)

6. Demonstrative plots for Sorghum - Amzacea 2016

Table 8. Demonstrative plots for Sorghum - Amzacea 2016

Hybrid	Pre-emergent plant	Surface sqm	Seeds/ha	Sowing date	Emergence date	Yields kg/ha	Harvest time
ES Arfrio	Wheat	2,195	230,000	9 April	18 April	10,013	02.sep
ES Aquilion	Wheat	2,195	230,000	9 April	18 April	12,340	02.sep
ES Alize	Wheat	2,195	230,000	9 April	18 April	11,785	02.sep
Arack	Wheat	2,195	230,000	9 April	18 April	11,919	02.sep
Arkanciel	Wheat	2,195	230,000	9 April	18 April	10,022	02.sep
Arkanciel	Wheat	2,195	230,000	2 May	14 May	7,810	18.sep
ES Foehn	Wheat	2,195	230,000	9 April	18 April	8,601	02.sep

The experiments were carried out in 2016 on 6 hybrids, as shown in Table 8. Most of the hybrids were planted one month earlier (9 April) (Manole D., 2018)[6] compared to the classic technology recommended by specialists (Trotus et al. 2015) [13] and EURALIS. Hybrid Arkanciel was planted and recommended (May 14).

Table 8 shows the data regarding sorghum productivity consisting in very high yields of about 10-11 tons / ha for most hybrids, due to the change of the planting date as the plants to benefit from the moisture accumulated in the soil during the winter and also to avoid the drought crashes beginning in June (Manole D., 2018)

[8]. It can be seen that the Arkanciel hybrid registered a production increase of 2,212 kg/ha, obtained by its earlier planting and also 16 days earlier harvested.

Table 9. Demonstrative plots for Sorghum - Amzacea 2017

Hybrid	Pre-emergent plant	Surface sqm	Seeds/ha	Sowing date	Emergence date	Yields kg/ha	Harvest time
Alize	Wheat	2,195	220,000	4 April	14 April	10,439	24.aug
Foehn	Wheat	2,195	220,000	4 April	14 April	11,504	24.aug
Arkanciel	Wheat	2,195	220,000	4 April	14 April	10,336	24.aug
Arkanciel	Wheat	2,195	220,000	4 May	16 May	6,900	5.sep
Albanus	Wheat	2,195	220,000	4 April	14 April	10,130	24.aug
Typhon	Wheat	2,195	220,000	4 April	14 April	8,859	24.aug
Armorik	Wheat	2,195	220,000	4 April	14 April	10,645	24.aug

The data obtained in the experimental year 2017 are presented in Table 9. The planting took place this year on April 4, and the same hybrid Arkanciel was planted 2 times, first on April 4 and secondly on May 4. From the presented data, it can be seen that this year, due to the earlier planting, led to high production increases of over 10,000 kg / ha. This year, the Arkanciel hybrid recorded an increase of 3,436 kg/ha and Arkanciel was planted on April 4 and harvested 13 days in advance. Table 9 presents the data on the technical sheet of sorghum culture on the two plots. The experiments in the plot 1 were made on 2,195 sqm. The treatment of the seed prior to planting was performed with chemicals containing thiamethoxam (Manole D.,2018) [7]. Pre-emergence herbicide was carried out with Dual Gold (metalacrol) 1.5 l/ha and post-emergence with Buctril Universal 0.8 l/ha (bromoxinil+2.4D).

Table 10. Demonstrative plots for Sorghum - Amzacea 2018

Hybrid	Pre-emergent plant	Surface sqm	Seeds/ha	Sowing date	Emergence date	Yields kg/ha	Harvest time
Albanus	Wheat	2,195	240,000	11 April	24 April	10,100	22. Aug
Foehn	Wheat	2,195	240,000	11 April	25 April	11,000	22. Aug
Arkanciel	Wheat	2,195	240,000	11 April	25 April	10,669	22.Aug
Arkanciel	Wheat	2,195	240,000	20 April	28 April	8,634	09. Sep

The results in the year 2018 are presented in Table 10. As can it can be seen, thanks to the same technologies applied, the Arkanciel hybrid planted on April 11th achieved a production by 2,035 kg / ha higher than the same hybrid planted on April 20th and 18 days harvested before Arkanciel planted on April 20.

Table 11. Demonstrative plots for Sorghum - Amzacea 2019

Hybrid	Pre-emergent plant	Fertilizer		Surface sqm.	Number seeds	Planting	Emergency	Flowering	Level kg/ha	Harvesting	Moisture %	MHL
<i>Foehn</i>	Wheat	Granoro	300 kg	560	250,000	26.03.2019	15.04.2019	01/07/19	6,907	21.08.2019	15.9%	79.6
<i>Alize</i>	Wheat	Granoro	300 kg	560	250,000	26.03.2019	15.04.2019	01/07/19	6,844	21.08.2019	13.8%	77.2
<i>Alize 2</i>	Wheat	Granoro	300 kg	560	250,000	15.04.2019	1.05.2019	01/07/19	5,513	21.08.2019	14.8%	79
<i>Albanus</i>	Wheat	Granoro	300 kg	560	250,000	26.03.2019	15.04.2019	01/07/19	5,323	21.08.2019	14.1%	76
<i>Shamal</i>	Wheat	Granoro	300 kg	560	250,000	26.03.2019	15.04.2019	01/07/19	7,034	21.08.2019	14.6%	76.9
<i>Anggy</i>	Wheat	Granoro	300 kg	560	250,000	26.03.2019	15.04.2019	01/07/19	6,273	21.08.2019	16.3%	75.8

In Table 11, there are the research data of the year 2019, the driest year since the weather observations are made in Romania for the Dobrogea region. The research team has changed the hybrid Arkanciel and planted Alize hybrid to see what it will happen with another genetic potential. Alize hybrid planted on March 26 achieved an average production of 6,844 kg / ha and the same hybrid planted on April 15 of the same year achieved an average production of 5,513 kg / ha, meaning a surplus difference of 1,331 kg / ha and a difference of 1% extra humidity for the Alize hybrid planted on April 15th.



Photo 3. Ph.D. Eng. Dumitru Manole 2019 – before starting Sorghum harvesting (Original)

7. Economical Data, SC Sport Agra SRL Amzacea, Constanta County, 2017 – 2019

All the researches have to be applied for the farmers' benefit following the data presented in the Tables 12 and 13. Sorghum crop is much more profitable than other crops grown in Constanta County such are: wheat, soybean, corn. From our

market information, sorghum crop has to be promoted looking at the climate changes especially in Dobrogea Region.

Table 12. Economical Data SC Sport Agra SRL Amzacea, Constanta County, 2017

Specification	Corn	Soybean	Sunflower	Sorghum	Wheat
Mechanical works	316	318	329	269	377
Seeds	125	204	149	101	92
Fertilizer	165	74	130	156	188
Pesticides	183	124	156	51	137
TOTAL Cost/Ha	789	720	764	577	797
kg/ha	8,364	1,992	3,800	8,859-11,504	7,271
Price / ton	130	299	294	130	164.7
Gross income	1,087	595	1,117	1,151-1,495	1,197
Leu/Euro – 4.65 Lei	+298	- 125	+353	+574-918	+400

Table 13. Economical Data SC Sport Agra SRL Amzacea, Constanta County, 2019

Specification	Corn	Soybean	Sunflower	Sorghum	Wheat
Mechanical works	239	214	192	201	500
Seeds	96	64	82	83	111
Fertilizer	266	98	232	133	112
Pesticides	148	71	150	57	111
TOTAL Cost/Ha	698	447	656	474	834
kg/ha	7,050	1,433	3,431	7,034	6,690
Price / ton	142	277	279	142	162
Gross income	1,001	397	957	999	1,083
Leu/Euro – 4.77 Lei	+303	-50	+301	+525	+249

Conclusions

(1). At Sport Agra Amzacea, there have been experimented in the last few years new and improved sorghum crop technologies in order to adapt to the new climate changes. These technologies comprise the technological elements mentioned below:

(2). Selecting early hybrids to overcome the drought periods that occur between the 5-10th of June until the 20-25th of August. There are recommended hybrids with shorter vegetation period.

(3). Changing the planting period - the hybrids were planted one month earlier (26 March - April 4 and 9).

(4). The results from comparative crops in a 3-year dynamics have demonstrated sorghum crops with outstanding yields of over 10 t/ha.

(5). The agricultural crops in this area are not irrigated, but those data of research demonstrated that the new technologies of planting sorghum one month earlier were much better, even in 2019. In this way the sorghum crop will benefit of much more moisture accumulated into the soil in winter time and will avoid the attack of *Tanymecus sp.* The year 2019 was a very dry year.

(6). During the vegetation period, the amount of precipitations (April, May, June) was 58 mm. The hybrid Alize planted on March 23, 2019 recorded 6,844 kg / ha and the same hybrid planted on April 15, 2019 recorded 5,513 kg / ha, so the difference was 1,331 kg / ha and the difference of grains moisture was 1%.

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