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TECHNOLOGY ADAPTATION AND ECONOMIC EFICIENCY FOR WINTER WHEAT CROP IN THE CONDITIONS OF CLIMATE CHANGES – SOUTH-EAST ROMANIA, DOBROGEA AREA

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Abstract

The paper presents the behaviour of some wheat varieties under the years 2014, 2016, 2018, 2019, 2020, 2023 conditions in Dobrogea area in demonstrative plots carried out at S.C. SPORT AGRA S.R.L. Amzacea, Constanta County. The main aspects emphasized in this research area have been: climatic conditions, obtained yield, and economical efficiency. Looking to the pathogens, for wheat Septoria tritici showed an AR between 17-27% and Pyrenophora graminea showed a low atack (AR = 4.5-17.5%). The pathogen Puccinia striiformis was present in low precentage (AR = 0-13.5%) in the 2018 April observations. For crop protection against pathogens, 2 foliar tratments with fungicides were applied, Artea 330 EC(ciproconazol 80 g/l + propiconazol 250 g/l) 0,4 l/ha, in March and Priaxor EC (fluxapiroxad 150 g/l + piraclostrobin 75 g/l) 1l/ha and in April respectively. Fungal treatments have stopped the development of foliar and ear diseases.The beneficial effects were found in the good yields obtained in 2014, 2016, 2018, 2019, except the years 2020 and 2023. In 2020 Otilia reached 2,370 kg/ha, Miranda 2,260 kg/ha and Solindo variety 4,297 kg/ha and Ursita 4,165 kg/ha in 2023. All these special yields have been obtained under non-irrigated conditions.

Key words**:** *climate change, winter wheat, technology adaptation, pathogens, yields, Dobrogea, Romania*

INTRODUCTION

Wheat is "the king of cereals" because it is a staple cereal supplying high value grains producing "our bread of everyday" and not only. Wheat is the most cultivated crop worldwide, in the year 2021, being cultivated on 220.7 million ha from which there were harvested 778 million metric tons grains (850 million short tons) [44].

In the year 2021/2022, the most important wheat producers in the world were the European Union, China, and India which together produced 384.7 million metric tons, accounting for 49.38% of the global output. In 2022/2023, China, the EU and India achieved 375.4 million metric tons [45].

In the European Union, in 2022, France was the top producer (34.8 million tons), followed by Germany (22.7 million tons) and Poland (13.2 million tons). Romania being ranked fourth for 9.18 million tons harvested from 2.1 million ha [1].

Romania plays an important role in the EU being among the top producers, exporters and importers of wheat [34, 36]. In this country, wheat production occupies the top position, representing 45.43% of cereals production (18.84 million tons), being followed by maize [30].

In 2022, the highest average yield in the world was obtained by France (7.7 tons/ha), Germany (7.6 tons/ha), Poland (5.2 tons/ha) and Romania (4.2 tons/ha) [1].

Despite that the cultivated area with wheat is increasing from a year to another at the global level, production goes down because of many factors, varying from a country to another, but also due to the negative impact of the climate change [7].

During the last decade, the EU countries were facing extreme meteorological phenomena (huge rainfalls, high temperatures, heat waves, droughts etc) which affected wheat and other agricultural crops, resulting in poorer yields, higher production costs, price volatility, and a lower grains quality [6].

In the last 35 years, Romania was affected by the increase of the annual average temperature and decline in the annual average precipitations and a higher and higher deficit in soil water.

The year 2015 was one of the warmest years with an increase of $+1.96^0$C compared to the average temperature during 1961-1990. During the last seven year 2016-2023 more longer droughts have emerged, Dobrogea area being among the high risk of drought regions in the country, as the annual average temperature is over 11^0C and the rainfalls range only between an average of 351 and 450 mm/year [37].

Romania's agriculture was among the most affected domains by climate change [42].

Wheat, maize, sunflower and other crops registered lower yields in the last decade with large variation in total production and market price both in Romania and in the EU [38, 39, 40].

Dobrogea is an important region of Romania where wheat, maize, barley, sorghum and sunflower are cultivated [15].However, it is recognized as an area with specific climatologic conditions concerning low rainfalls and high temperatures, whose level has deeply changed during the last decade. More and more weak precipitations, mild winters lacked or with a low snow layer, a low water reserve into the soil, higher and higher temperatures, long and strong droughts, pedological droughts have a higher frequency in Dobrogea region and mainly in its South, which are considered arid areas [2, 28].

All these climate factors have influenced the size of the cultivated area, production performance in terms of yield and economic efficiency of crop farming.

In 2022,inConstanta County, situated in the South Dobrogea, there were cultivated 443,347 ha, by 6.34% less than in 2018.

Wheat had the largest area, accounting for 162,688 ha, but by 9.27% smaller than in 2018, which led to a lower share of wheat, from 37.8% in 2018 to 36.6% in 2022, in the county cultivated surface [4, 29].

In 2022, the average wheat production per ha was 4,989 kg, being by 12.12% smaller than in 2018.

Along this period, its level went up and down depending in the variation of the climate factors. The lowest yield was 983 kg/ha in the year 2020 [49].

The lower productions are explained by climate change which favored the attack of pests and diseases appearance, which involved plant protection measures [3, 26, 41].

Under these conditions of climate change in Dobrogea, the scientific research tried to help the farmers looking for and providing solutions to mitigate the negative effects.

Important studies were destined to test different wheat varieties [8, 31, 32, 47], barley and wheat varieties [10, 12, 19, 24], and sunflower hybrids [23] in Dobrogea in order to identify the most resistant cultivars to low precipitations, high temperatures and drought.

Other studies were focused on plant protection measures for winter cereals: barley and wheat [9, 12, 24] .

Other research works were carried out to improve the production technologies regarding the change of the sowing period in relation to water resource into the soil, to avoid the high temperatures during the period of vegetation. Important results were achieved in adapted technologies for wheat growing [14], sunflower [11, 21], and sunflower and sorghum technology [18].

Other research works analyzed the impact of climate change on crop productivity and efficiency (yields, production, price etc). It is about the studies focused on winter wheat

productivity [48], barley and wheat yields [12, 19, 24], wheat, maize and sunflower yields [40], sunflower hybrids yield [21, 23], wheat and maize production [46], sorghum yield [13, 22], sunflower and sorghum yields [18], cereal production [38], cereal production and price [39], gross margin in vegetal production [33] and yield in agricultural crops [35, 37].

Other researchers approached the use of Sorghum as a complementary crop with maize in Dobrogea, taking into account that sorghum is more resistant to drought, high temperatures and even heavy rains and hail [13, 17, 20, 22].

In this context, the paper aimed to analyze the behavior, productivity and economic efficiency in winter wheat growing under climate change conditions in Amzacea Village, South Dobrogea, the most arid and droughty part of the region where Sport Agra Ltd is operating and its manager has found and applied solutions to maintain and increase wheat production performance and profitability in the period 2013-2023.

MATERIALS AND METHODS

Study area

This research work was run in Amzacea Village, Constanta County, South East Dobrogea, Romania, where the agricultural holding Sport Agra Ltd, top 1 in agribusiness in the field of Agriculture, hunting and annex services, is operating.

Data collection

This study is based on multitude of scientific publications which have represented the literature background on the topic regarding the main results in Dobrogea's agriculture.

A part of the data regarding the cultivated area and yields for the main crops grown in Constanta County were provided by the National Institute of Statistics and Agricultural Division of the county.

The meteorological data regarding the monthly and year average temperatures and monthly and year precipitations regimes were provided by National Administration of Meteorology, Amzacea Meteorological Station, Mangalia Meteorological Station and Medgidia Meteorological Station.

The data resulting from the own scientific research works were provided by Sport Agra Ltd for the period 2013- 2023.

Soil type

The experiments were situated on a land belonging to the South Dobrogea Plateau, represented by cambic cernoziom with a profile deeper than other cernozioms, a blackish-brown soil of 40-50 cm thickness, medium texture [5]. The content of nutrients was: mobile P index – 72; N index – 4; K index – 200; humus – 3.11%; neutral pH – 7.2. The climate is deeply temperate continental, with an average annual temperature of 10.7 – 11.7 °C. with a high temperature in the period 20th June to 15th August. This area is the most arid in the country, with 69-year multi-annual average rainfall of 401 litres. In the last 3 years, we didn't reach more than 315 mm./sqm.

Climate conditions

Precipitations regime

Dobrogea is recognized as a region with a low precipitations level in Romania. A comparison regarding the precipitations in different periods across the time is suggestive in this respect.

In the period 1961-2010, Dobrogea registered 451.2 l/m^{2}precipitations, by 131.8 l/m^{2}less than at the level of Romania. Also, in the period, 1971-2000, in Dobrogea there were recorded 451.4l/m^2 precipitations, being by 118.4 l/m^2 lower than in the country.

Table 1. Precipitations regime in Dobrogea versus Romania in the interval 1961-2010 (Agricultural years- September -August)

	MU	1961-1990	1971-2000	1981-2010	1981-2010/ 1961-1990 (%)
Dobrogea	l/ m^2	451.2	451.4	459.6	101.86
Romania	l/ m^2	583	569.8	571.1	97.95
DB- RO	l/ m^2	-131.8	-118.4	-111.5	84.59

Source: National Administration of Meteorology [27].

In the interval 1981-2010, it was also noticed a negative difference of 111.5 l/m^2 between Romania and Dobrogea (Table 1).
The difference of precipitations between Dobrogea and Romania reflects an important deficit and the fact that Romania has a predominantly moderate droughty and droughty pluviometric regime, while Dobrogea has a predominantly droughty regime in South, South East and East areas.

The precipitations regime connected to winter wheat growing at Amzacea, South East Dobrogea, during the interval 2013-2023 is presented in Table 2, from which it is easy to notice the variation of precipitations by month of each agricultural year taken into consideration in this study.

Table 1. Monthly and Annual Precipitations regime related to wheat growing at Amzacea, 2013-2023 (mm)

Crt. no.	Agric. year	IX	X	XI	XII	I	II	III	IV	V	VI
1	2013/14	65	76.5	13	20	113	2	40.5	42	61.5	228.5
2	2014/15	43	151	40	106	83	40	74.5	48	0	25.5
3	2015/16	17	93	40	3	110	30.5	55	20	97	23.5
4	2016/17	23	72	47	3	70	20	40	41	27	29
5	2017/18	5	55.5	65	50	63	120	68	2	92	76
6	2018/19	3	3	57.5	47	36	8	16	35.5	18	14
7	2019/20	37	44	9.5	27.5	2	50	16	15	42	24
8	2020/21	31	18.5	21	100	122.5	34	61.5	35	22	270
9	2021/22	40	115	49	92.5	19	40	42	46.5	14	45.5
10	2022/23	69.5	0	26	21	47	24	21.5	75	18	30.4

Source: Amazacea Meteorological Station [26].

The general trend regarding the annual precipitations is a decreasing one from 661.1 mm in 2013/2014 to 332.4 mm in 2022/2023, which reflects a reduction by about 50%. However, in 2013/2014, 2017/2018 and 2020/2021, it was registered a peak of annual precipitations but their distribution along the agricultural year did not favor yield performance (Fig. 1).

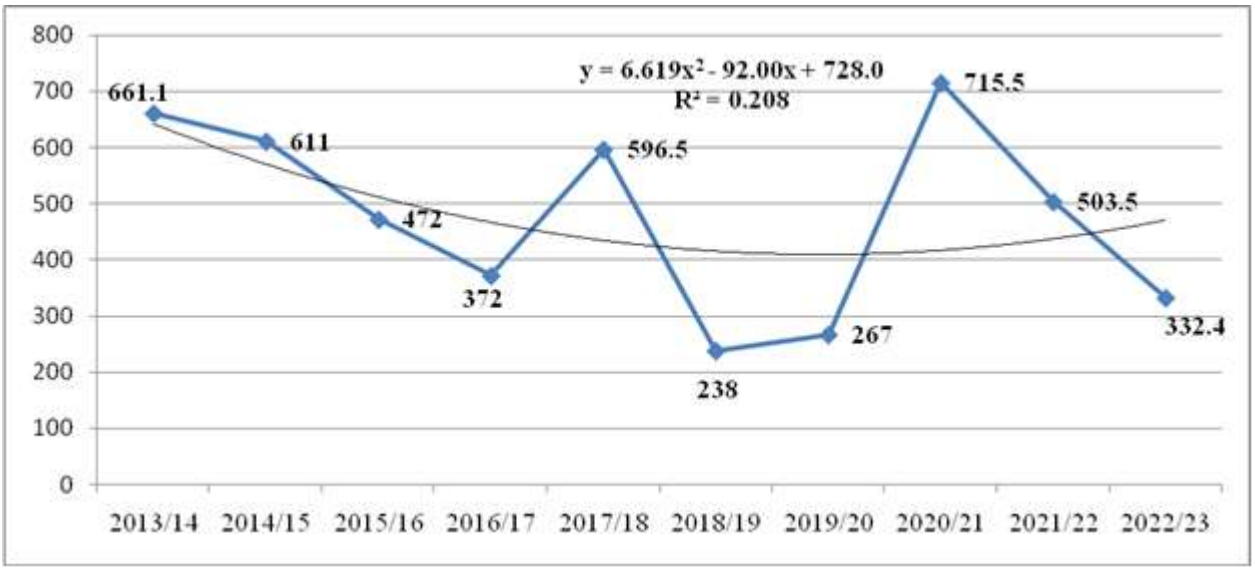

Fig. 1. Dynamics of annual precipitations level connected to winter wheat growing at Amzacea, along the ten agricultural years in the interval 2013-2023 (mm)
Source: Own design based on the data from Amazacea Meteorological Station, 2023 [26].

The descriptive statistics for annual precipitations at Amzacea, in the interval 2013-2023, reflects an average precipitation level of 476.9 mm/year, a 53.42 mm/year

standard error of the mean, and a high variation coefficient equal to 35.42 %, as shown in Fig.1.

Temperature regime

In Dobrogea, the average annual temperatures are completely different than in other regions of the country, during the last decade being higher and higher since May till late in the Fall season, being intensified by hot waves which caused the drought and compromised many crops which could not reach their maturity and led to important production losses.

The comparison between the distribution of average air temperatures by month of the agricultural year 2022-2023 related to wheat crop, registered in the South of Dobrogea at Mangalia and Medgidia Meteorological Stations is a suggestive example which shows large variations even though these stations are situated very close to each other.

The differences reflect that in Mangalia area the average monthly air temperatures were superior to the temperature level in Medgidia areaby a surplus ranging between +2.1 ^{0}C in December and +0.1 ^{0}C in April. The months of March and May were exceptions, as in these months it was registered the same temperature and June, when in Medgidia was recorded + 0.3 ^{0}C more than in Mangalia. The variation of the monthly temperatures were very high, as confirmed by the high level of the variation coefficient which accounted of 48.18% at Mangalia and for 56.04% at Medgidia (Table 2).

Table 2. The monthly air temperature in the agricultural year September 2022-June 2023, connected to wheat growing in the South of Dobrogea

Month	**Average air temperature (^{0}C)**		
	Mangalia Meteorological Station	Medgidia Meteorological Station	Differences between Mangalia and Medgidia Meteorological Stations
September	19.4	19.1	+0.3
October	14.7	14.1	+0.6
November	11.2	9.5	+1.7
December	6.5	4.4.	+2.1
January	6.7	5.7	+1.0
February	4.6	3.2	+1.4
March	7.7	7.7.	0
April	10.3	10.2	+0.1
May	15.7	15.7	0
June	20.9	21.2	- 0.3
Average temp.	11.7	11.08	+0.62
Standard Deviation	±1.79	±1.96	-
Coefficient of variation (%)	48.18	56.04	-

Source: Mangalia and Medgidia Meteorological Stations, 2023 [16, 25].

Because Amzacea Sport Agra Ltd is closer to Mangalia than to Medgidia Meteorological Station, we could easily understand why wheat crop was really affected during its period of vegetation till harvest.

Therefore, during the period 2013-2023, climate has deeply changed at Amzacea reflecting a critical decreasing trend in the precipitations regime (low rainfalls and lack of snow layer) and an increasing trend in high temperatures, heat waves and long and severe droughts, with a strong impact on wheat production, which determined the manager of the company to identify the proper solutions to sustain wheat crop.

Experiments organization

In the fall of the year 2019, like in every year, it was organized a field of applied research with 10 wheat varieties, as shown in Table 3.

Table 3. Technological sheet for demonstrative plots for winter wheat at Sport Agra Ltd., Plot A211/A209, Amzacea 2019-2020

Variety	Predecessor crop	Area sq.m.	Seed norm Kg/ha	Sowing date	Emergence date	No. of plants at 13 January 2020	No. of ears at 8 June 2020	No. of grains by ear	Plant height cm	Yield Kg/ha
Glosa	Wheat	400	240	16 Oct.	25 Oct.	680	308	16	35	1,870
Miranda	Wheat	400	215	16 Oct.	25 Oct.	610	372	16	38	2,260
Otilia	Grau	400	215	16 Oct.	25 Oct.	660	416	15	32	2,370
Apilco	Grau	400	220	16 Oct.	25 Oct.	690	160	9	19	550
Avenue	Grau	400	220	16 Oct.	25 Oct.	700	0	0	17	0
Katarina	Grau	400	240	16 Oct.	25 Oct.	620	0	0	15	0
Kraljica	Grau	400	240	16 Oct.	25 Oct.	700	0	0	20	0
Mobile	Grau	400	200	16 Oct.	25 Oct.	610	28	10	20	110
Combin	Grau	400	250	16 Oct.	25 Oct.	640	212	10	25	805
Rubisko	Grau	400	240	16 Oct.	25 Oct.	680	52	14	27	276

Source: Original.

Photo 1, 2, 3. Plant vegetation phase on June 8, 2020.
Source: Original.

Table 4. Technological sheet for autumn crops in 2018

Variety	Seed norm (kg /ha)	Plant density in the autumn 14.11.2017	Plant density in the spring 11.01.2018	Inflorescence emergence date	Flowering date	Plant height (cm)	Yield (kg/ ha)	Quality index	
								M Hl (kg/hl)	Protein (%)
Two-rowed Autumn Barley + Autumn Barley									
Bingo	220	520	888	April 20	April 28	73	7,375	70.5	-
Panonic	220	522	868	April 26	May 3	101	8,500	70.6	-
Predator	220	534	848	April 23	May 2	86	7,875	70.6	-
Wheat									
Avenue	250	440	772	April 27	May 4	71	8,026	74.6	11.9
Katarina	250	422	828	April 30	May 7	70	7,475	76.9	12.0
Miranda	250	468	660	May 3	May 8	94	7,425	75.6	12.3
Litera	250	495	684	May 4	May 8	95	7,125	74.2	12.4
Kraljica	250	484	812	May 1	May 5	68	8,300	74.5	12.3
Spranjka	250	534	784	May 1	May 9	65	8,106	75.2	11.9
Fifi	250	472	732	May 3	May 9	76	6,666	77.0	14.5
Silvja	250	445	672	May 2	May 7	80	7,675	77.2	12.7
Bubimir	250	432	764	May 2	May 7	71	6,575	77.5	12.6
El Nino	250	476	796	April 30	May 5	75	8,125	76.5	12.5
Tata Mata	250	502	772	May 4	May 9	87	7,475	70.4	12.5
Pepeljura	250	464	784	May 4	May 9	91	7,920	73.1	11.9

Source: Original.

Table 5. Autumn cereals phytosanitary status -May 8, 2018

Two-rowed Autumn Barley + Autumn Barley									
Variety	*Rhynchosporiumsecalis*			*Pyrenophora teres*			*Pyrenophoragraminea*		
	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)
Bingo	6	2	0.1	3	1	0.01	10	5	0.5
Panonic	0	0	0	0	0	0	0	0	0
Predator	0	0	0	2	1	0.01	8	5	0.4
Wheat									
Variety	*Septoria tritici*			*Pyrenophora graminea*			*Puccinia striiformis*		
	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)
Avenue	5	2	0.1	0	0	0	5	1	0.05
Katarina	0	0	0	5	2	0.1	0	0	0
Miranda	0	0	0	0	0	0	0	0	0
Litera	0	0	0	10	5	0.5	0	0	0
Kraljca	8	2	0.1	0	0	0	2	1	0.02
Spranjca	5	2	0.1	0	0	0	5	2	0.1
Fiji	0	0	0	10	5	0.5	7	1	0.07
Wheat									
Variety	*Septoria tritici*			*Pyrenophora graminea*			*Puccinia striiformis*		
	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)
Silvja	5	3	0.1	0	0	0	0	0	0
Bubimir	8	2	0.1	0	0	0	2	1	0.02
El Nino	5	2	0.1	10	4	0.4	5	1	0.05
Tata Mata	10	3	0.3	0	0	0	0	0	0
Pepeljura	5	2	0.1	0	0	0	0	0	0

Source: Original.

Table 6. Technological sheet for autumn crops, 2019

Variety	**Seed norm (kg /ha)**	**Plant density in the spring 01.02.2019**	**Inflorescence emergence date**	**Flowering date**	**Yield (kg/ ha)**	**Quality index**	
						M Hl (kg/hl)	Protein (%)
Two-rowed Autumn Barley + Autumn Barley							
Pleter	220	440	May 7	May 12	6,200	67.9	-
Preator	220	424	May 7	May 12	6,275	68.6	-
OSK6.2/3-13	220	484	May 7	May 12	7,012	69.1	-
OSK	220	436	May 9	May 12	6,812	69.8	-
OSK	220	424	May 9	May 12	6,450	65.9	-
Panonic	220	420	May 9	May 12	6,587	66.1	-
Wheat							
Glosa	255	468	May 15	May 17	6,187	80.7	11.6
Avenue	260	512	May 12	May 15	6,000	78.9	10.8
Renata	260	488	May 14	May 17	5,750	81	12.1
OSK 51.117	260	480	May 15	May 19	6,375	79.3	10.8
OSK 110/17	260	440	May 15	May 19	5,750	78.9	11.7
OSK 159/17	260	504	May 15	May 19	6,125	80.2	12.1
OSK 84/116	260	516	May 16	May 19	6,187	80.2	12.4
Borealis	260	496	May 13	May 17	5,562	61.9	12.9
Icona 2S	260	524	May 14	May 17	5,287	79	13.6

Source: Original.

In the agricultural year 2020, an amount of only 267 mm was registered, and this was the cause for which large surfaces cultivated with wheat were calamity in Constanta County and Sport Agra Ltd.

In the experimental field, the Romanian varieties looked to be better adapted to the soil and climate conditions so that the Otilia

variety achieved 2,370 kg/ha, Miranda 2,260 kg/ha and Glosa 1,870 kg/ha. The foreign varieties Avenue, Katarina, Kraljica could not be harvested as shown in Table 3.

The plant height of the foreign varieties was affected compared to 68-70 cm recorded in case of the Romanian varieties.

This happened to: Miranda 38 cm, Otilia 35 cm, and to the foreign varieties Katarina 15 cm, and Avenue 17 cm.

The low temperatures recorded in the period 5 – 12 April of - 6 and -8 C° affected the number of grains on the ear and plant density. As a result, the average yield carried out in Constanta county was only 983 kg/ha.

Table 7. Autumn cereals phytosanitary status – April 18, 2019

Two-rowed Autumn Barley + Autumn Barley									
Variety	*Rhyncosporiumsecalis*			*Pyrenophora teres*			*Pyrenophoragraminea*		
	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)
Pleter	40	20	8	30	10	3	70	15	10.5
Predator	40	10	4	90	20	18	40	5	2.0
OSK 6.2/3-13	20	10	2	80	25	20	80	30	2.4
OSK	20	15	3	10	30	3	50	20	10
OSK	30	10	3	20	40	8	30	30	9
Panonic	30	20	6	10	20	2	40	20	8
Wheat									
Variety	*Septoria tritici*			*Pyrenophora graminea*			*Puccinia striiformis*		
	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)	F (%)	I (%)	AR (%)
Glosa	80	20	16	70	20	14	25	5	1.25
Avenue	90	25	23.7	25	20	5	20	10	2
Renata	70	20	14	70	25	17.5	0	0	0
OSK 51.117	70	30	21	45	20	9	0	0	0
OSK 110/17	80	25	20	35	15	5.3	20	5	1.0
OSK 159/17	75	25	18.7	45	10	4.5	30	5	1.5
OSK 84/116	80	25	20	80	15	12	90	15	13.5
Borealis	90	30	27	70	25	17.5	0	0	0
ICONA 2S	80	25	20	40	30	12	20	7	1.4

Source: Original.

Therefore, we can firmly assert that the heavy rainfall from March 2018 and 2019, favored the rise of pathogens. Both in April 2018 and in May 2019, after the application of the product PRIAXOR EC, it could be observed that the degree of attack was significantly reduced.

Photo 4. Autumn grain crops - field trial
Source: Original photo.

Photo 5. Phytosanitary status
Source: Original photo.

To prevent and control the pathogens that cause diseases in autumn cereal crops, two treatments with fungicides were necessary under climatic conditions of 2018 and 2019.The beneficial effects were found in the good yields obtained. For barley crop, the

pathogen *Pyrenophora gramminis* showed reduced attack rates compared to *Pyrenophora teres* or *Rhyncosporium secalis* in both years of experience. For wheat crop, pathogens *Septoria* sp. and *Pyrenophora* sp. showed a reduced attack rates, compared to *Puccinia* sp., in both years of experience. The productions obtained these years were very good, considering that they were obtained using a non-irrigation technology. Thereby, under 2018 conditions, the yields obtained ranged between 7,375 and 8,500 kg/ha and good quality index (hectolitre weight = 70.6 kg/hl) for barley and for wheat yields recorded were between 6,575 (Bubimir) and 8,300 (Kraljica) kg/ha Osijek Institute Croatia. In 2019, the yields obtained varied between 6,200 and 7,012 kg/ha for barley, and between 5,287 kg/ha (Icona 2S) and 6,375 (OSK 51.117) kg/ha for wheat.

Photo 6. Autumn grain crops – experimental field – 2016
Source: Original photo.

Table 8. Autumn cereals phytosanitary status - 2016

Variety	***Rhincosporium secalis***			***Pyrenophora teres***			***Pyrenophora graminis***		
	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)
Two-rowed Autumn Barley									
Metaxa	50	3	1.5	60	3	1.8	-	-	-
Wendy	30	2	0.6	70	3	2.1	-	-	-
Henriette	20	4	0.8	40	3	1.2	30	3	0.9
Wheat									
Variety	*Septoria* sp.			*Pyrenophora graminis*			*Puccinia striiforme*		
	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)
Katarina	20	5	1.0	30	5	1.5	-	-	-
Petur	50	8	4.0	60	9	5.4	-	-	-
Genius	60	3	1.8	50	7	3.5	-	-	-
Joker	30	5	1.5	40	5	2	-	-	-
Mulan	30	2	0.6	20	5	1	30	2	0.6
Felix	40	10	4.0	25	10	2.5	30	5	1.5
Hyty	30	3	0.9	20	5	1	-	-	-
Hybiza	50	3	1.5	60	8	4.8	-	-	-
Hylux	80	8	6.4	70	10	7	-	-	-
Avenue	50	2	1.0	60	3	1.8	50	5	2.5
Soobel	50	10	5.0	40	5	2	-	-	-
Sofru	70	10	7.0	80	3	2.4	-	-	-
Solveg	60	5	3.0	70	10	7	-	-	-
Winter Gold	90	9	8.1	70	8	5.6	-	-	-
Pescador	50	3	1.5	60	10	6	30	5	1.5

Source: Original.

Table 9. Experimental fields with wheat varieties in 2016

Variety	Seed norm (kg /ha)	Date of sowing	Emergence date	Number of plants in the emergence	Number of plants in the spring	Yield (kg / ha)	Quality index	
							U %	M Hl
Two-rowed Barley								
Metaxa	180	19-Oct	28 Oct	284	584	8,612	13.1	64.0
Wendy	180	19-Oct	28 Oct	288	620	8,450	12.6	64.2
Henriette	180	19-Oct	28 Oct	292	640	8,800	12.3	65.0
Wheat								
Katarina	220	19-Oct	29 Oct	372	736	8,400	14.8	79.1
Petur	220	19-Oct	29 Oct	356	704	8,000	14.4	76.4
Genius	220	19-Oct	29 Oct	344	680	8,300	14.3	80.6
Joker	220	19-Oct	29 Oct	372	712	8,040	14.7	79.9
Mulan	220	19-Oct	29 0ct	352	700	7,340	14.1	79.1
Felix	220	19-Oct	29 Oct	368	720	6,800	14.4	77.0
Hyfi	80	19-Oct	29 Oct	152	692	7,140	14.5	81.0
Hybiza	80	19-Oct	29 Oct	232	670	4,740	14.2	76.7
Hylux	80	19-Oct	29 Oct	212	682	5,465	14.7	74.6
Avenue	180	19-Oct	29 Oct	348	696	4,860	14.1	75.4
Soobel	180	19-Oct	29 Oct	336	672	6,702	14.4	80.1
Sofru	180	19-Oct	29 Oct	368	700	7,544	14.6	77.5
Solveig	180	19-Oct	29 Oct	352	684	7,122	14.5	77.0
WinterGold	180	19-Oct	29 Oct	356	700	6,500	14.4	81.0
Pescador	180	19-Oct	29 Oct	348	690	6,245	14.6	80.0

Source: Original.

After the 3 fungicide treatments, foliar diseases were stopped at basal leaves (you can look the Photo 5 pg.9) The last 3 leaves and the ear were protected due to phytosanitary treatments, which contributed to the achievement of high productions of about 8 tons in the two-rowed barley and 4 wheat varieties.

The yields obtained in experimental plots are shown in Table 9.

For two-rowed barley crop, the lowest yield was 8,450 kg/ha for Wendy variety and the best yields were 8,800 kg/ha for Henriette variety.

Table 10. Autumn cereals phytosanitary status - 2014

Variety	***Rhincosporium secaris***			***Pyrenophora teres***			***Pyrenophora graminis***		
	F (%)	I (%)	DA (%)	F (%)	I (%)	DA (%)	F (%)	I (%)	DA (%)
Wheat									
Variety	*Septoria* sp.			*Pyrenophora graminis*			*Puccinia striiforme*		
	F (%)	I (%)	GA (%)	F (%)	I (%)	GA (%)	F (%)	I (%)	GA (%)
Katarina	30	7	2.1	50	3	1.5	-	-	-
Ilinca	70	4	2.8	50	5	2.5	60	5	3.0
Andelka	50	5	2.5	60	5	3.0	50	10	5.0
Renata	20	5	1.0	30	5	1.5	-	-	-
Genius	60	3	1.8	50	7	3.5	40	5	2.0
Joker	30	5	1.5	40	5	2.0	-	-	-
Florian	30	2	0.6	20	5	1.0	30	8	2.4
Akratos	40	10	4.0	25	10	2.5	30	5	1.5
Hystar	30	3	0.9	20	5	1.0	-	-	-
Apache	50	3	1.5	60	8	4.8	-	-	-
Renan	60	8	4.8	70	10	7.0	-	-	-
Altigo	50	2	1.0	60	3	1.8	-	-	-
Jindra	50	10	5.0	40	5	2.0	-	-	-
Epos	70	10	7.0	80	3	2.4	-	-	-
Einstein	60	5	3.0	70	10	7.0	-	-	-
Ewina	50	9	4.5	70	8	5.6	-	-	-
Arkeos	50	3	1.5	60	10	6.0	50	5	2.5
Ingenio	50	8	4.0	60	9	5.4	-	-	-
Illico	70	5	3.5	60	7	4.2	-	-	-

Source: Original.

The highest yields in wheat were obtained with Genius (8,300 kg/ha) and Petur varieties (8,000 kg/ha). Quality indices of wheat grains were between 74.6 for Hylux variety and 81.0% hectoliter mass for Winter Gold variety. To prevent and control the pathogens that cause diseases in autumn cereal crops, in the climatic conditions of the 2016 year, there were needed 3 treatments with fungicides. *Rhyncosporium* and *Pyrenophora* pathogens showed a low degree attack to two-rowed barley. In wheat crop, pathogens *Septoria* and *Pyrenophora* showed reduced attack degrees, as the pathogen *Puccinia striiforme*. The yields obtained in conditions of 2016 ranged from between 8,000-8,800kg /ha for two-rowed barley, and between 4,740 kg/ha (Hybiza variety) to 8,400 kg/ha (Katarina variety) for wheat. For all varieties analyzed, the hectoliter weight was influenced by rainfall, showing values between 74.6 to 81.0 (Table 9).

Table 11. Experimental fields with wheat varieties in 2014

Variety	Seed norm (kg /ha)	Date of sowing	Emergence date	Number of plants in the emergence	Number of plants in spring	Yield (kg / ha)	Quality index	
							U %	M Hl
Wheat								
Katarina	200	16-Oct	28-29 Oct	520	928	7,930	13	78
Ilinca	200	16-Oct	28-29 Oct	422	828	7,100	14.1	78
Genius	200	16-Oct	28-29 Oct	504	1,160	6,313	13.8	78.5
Joker	200	16-Oct	28-29 Oct	620	788	7,000	14.2	78.7
Florian	200	16-Oct	28-29 Oct	412	868	6,600	13	77.7
Akratos	200	16-Oct	28-29 Oct	448	812	4,700	13.2	77.2
Hystar	80	16-Oct	28-29 Oct	168	692	7,100	13.2	73.6
Apache	180	16-Oct	28-29 Oct	552	1,172	5,100	12.4	74.6
Renan	180	16-Oct	28-29 Oct	460	1,112	4,300	13.4	76.6
Altigo	180	16-Oct	28-29 Oct	320	1,192	7,200	13.4	74
Jindra	180	16-Oct	28-29 Oct	480	800	5,900	12.7	76.8
Epos	180	16-Oct	28-29 Oct	560	852	4,600	13	75.2
Einstein	180	16-Oct	28-29 Oct	460	1,132	5,600	13.6	74.3
Evena	180	16-Oct	28-29 Oct	480	816	5,000	14.1	77.6
Arkeos	180	16-Oct	28-29 Oct	540	732	4,250	13.8	70.9
Ingenio	180	16-Oct	28-29 Oct	400	828	7,600	12.9	72.5
Illico	180	16-Oct	28-29 Oct	520	660	7,500	14.1	76.2

Source: Original.

Photo 7. Autumn grain crops - 2014
Source: Original.

The data on yields obtained in experimental plots in the year 2014 are shown in Table 11. In autumn two-rowed barley crops were obtained yields of 5,600-6,200 kg/ha. In barley crops, productions ranged between 5,858 - 8,000 kg/ha. The wheat productions varied from 4,250 to 7,930 kg /ha. The production quality indexes in most wheat crops were over 76.6 hectoliter mass.

Table 12. Technological sheet for experimental field - 2023

Crt. No.	*Variety*	*Predecessor plant*	*Area m^2*	*Seed norm kg /ha*	*Sowing date*	*Plant emergence date*	*Plant density 25.02. 2023*	*Plant density 23.05 .2023*	*Earing date*	*Flowering date*	*Remarks 9.06. 2023*	*Yield kg / ha 11.07. 2023*
1	***Ursita***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*640*	*412*	*11.05. 2023*	*16.05. 2023*	*With hairs*	*4,165*
2	***Brko***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*600*	*400*	*7.05. 2023*	*14.05. 2023*	*With hairs*	*3,875*
3	***Indira***	*Sunflower*	*400*	*230*	*12.10 .2023*	*23.12. 2023*	*534*	*444*	*11.05. 2023*	*16.05. 2023*	*Without hairs?*	*3875*
4	***Garavusa***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*656*	*388*	*16.05. 2023*	*22.05. 2023*	*Without hairs*	*4,050*
5	***OSK 5219***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*642*	*348*	*16.05. 2023*	*21.05. 2023*	*Without hairs Late/Low resistant*	*4,000*
6	***OSK 4172***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*664*	*316*	*16.05. 2023*	*21.05. 2023*	*With hairs Diseases tolerant*	*4,125*
7	***OSK 5317***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*560*	*364*	*11.05. 2023*	*16.05. 2023*	*With hairs*	*4,150*
8	***Montecristo***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*624*	*400*	*16.05. 2023*	*20.05. 2023*	*With hairs Diseases and drought tolerant*	*4,125*
9	***Somtuoso***	*Sunflower*	*400*	*230*	*12.10.20 23*	*23.12.202 3*	*540*	*388*	*16.05. 2023*	*21.05. 2023*	*With hairs Late/ Diseases and drought tolerant*	*4,125*
10	***Flavor***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*648*	*388*	*16.05. 2023*	*22.05. 2023*	*With hairs*	*4,100*
11	***Solindo***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*610*	*384*	*16.05. 2023*	*22.05. 2023*	*With hairs Semi-late/ Diseases and drought tolerant*	*4,297*
12	***Sofru***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*652*	*420*	*14.05. 2023*	*21.05. 2023*	*With hairs / Mid-early/ Diseases and drought tolerant*	*4,125*
13	***Rubisko***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*548*	*344*	*14.05. 2023*	*19.05. 2023*	*With hairs / Diseases and drought tolerant*	*4,000*
14	***PG102***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*538*	*364*	*16.05. 2023*	*19.05. 2023*	*With hairs / Diseases and drought tolerant*	*4,000*
15	***Pitar***	*Sunflower*	*400*	*230*	*12.10. 2023*	*23.12. 2023*	*596*	*416*	*16.05. 2023*	*19.05. 2023*	*With hairs*	*4,000*

Source: Original.

According to the Dobrogea Regional Meteorological Center, the agricultural year 2023 together with the year 2020 are the driest years and with the highest temperatures since the meteorological evidence is registered.

In the fall of 2022, it was established an experiment with 15 wheat varieties, of which

3 varieties were produced in Romania: Ursita, PG102, Pitar, but the other varieties belong to Research Institute in Osijek – Croatia: Brko, Indira, Garavusa, OSK5219, OSK4172, OSK5317, and the remaining 6 varieties belong to RAGT, Lidea. Due to the lack of precipitations in the fall 2022, as seen from Table 12, the emergence phenophase was registered very late in the month of December, despite that the sowing was made in the month of October. This means that the twinning phenophase took place later in Spring of the year 2023. The limiting factor-water, determined that harvesting to be late on July 11, 2023 at a moisture percentage of over 14%. The data from Table 12 highlighted that Solindo variety carried out the highest yield 4,297 kg/ha, followed by Ursita 4,165 kg/ha, Flavor 4,100 kg/ha, OSK5317 4,150 kg/ha.
The following varieties were tolerant to drought and diseases: Solindo, Sofru, Rubisko, PG102. Due to the lack of precipitations and negative temperatures registered in April, as can be seen from Table 12: Ursita variety had a density of 640 plants/m^2 on 25 February 2023, but on 23 May 2023, it had 412 plants/m^2, while Brko variety recorded 600 plants/m^2 on 25 February 2023 and on 23 May 2023 it had only 400 plants/m^2.

Photo 8. Experimental plot with wheat (Left- Sowing on October 20, 2022 and Right- plant phenophase in March 2023)
Source: Original.

Photo 9. Experimental plot 2023 – emergence phenophase, Left- Brko variety 600 plants/m^2, and Right- Ursita variety 640 plants/m^2
Source: Original.

Data processing

The main economic indicators studied in this research on wheat growing have been: cultivated area, wheat yield, wheat production, production costs, income from wheat grains delivery, gross profit, profit rate, cost/ha, cost/ton, income/ha, income/ton, profit per ha, and profit per ton.
The results were tabled and graphically illustrated, pointing out the main trends based

on regression equations and R^2, suitable to the dispersion of the data in the chart.
The descriptive statistics analysis showed the mean, standard deviation and the coefficient of variations levels.
Also, the coefficient of correlation was determined between wheat yield and annual precipitation regime in order to identify how strong or weak was the influence of this climate factor on production performance per ha.

RESULTS AND DISCUSSIONS

Description of the technology applied

In all the years of research and observations, the predecessors plants were especially sunflower, followed by maize and soybean.
The soil was prepared for sowing in the years 2013-2017, using equipments for shredding plant residues and then the soil was plowed to a depth of 20-22 cm.
Starting since 2017, the land was processed through a deep refinement at 20 cm. Till the sowing date, the land was maintained clear of weeds using equipments able to make a shallow tillage of the soil at the depth of 8-10 cm.
For sowing it was used a treated seed which was introduced into the soil at a distance of 12.5 cm and a depth of 4-6 cm depending on the soil moisture.
At the same time with sowing, it was made fertilization using complex fertilizer, assuring an average along all the years of observations of 45-50 kg/ha N, 65-80 kg/ha P_2O_5, 20 kg/ha K_2O. During the vegetation period, there were made two fertilizations assuring a supplement of 80 kg/ha NO_2 active substance.
To combat weeding, it was used the herbicide Tritosulhuron 714 g/kg + Florasulam 54 g/kg applied in a dose of 0.07 kg/ha.
In all the years of observations and research, before sowing, the seeds were treated for protecting the plants till the twinning phenophase using a series of active substances like: Clotianidin (166.7 g/l) + Imidacloprid (166.7 g/l) + Proticonazol (33.3 g/l) + Tebuconazol (6.7 g/l) in a dose of 1.6 l/to in the years 2016-2018-2019, in 2014 - Thiamethoxam + Fludioxnil + Difenoconazole in a dose of 1.5 l/to, and in 2020- 2023 – Teflutrin + Fludioxonil 5 l/to.
The researches demonstarted that the lack of seed treatment with suitable active substances (Thiamethoxam, Imidacloprid) led to compromise large surfaces cultivated with wheat due to the pathogens: Zabrus Tenebrioides, specific to the geographical area of Dobrogea, as well as to the attack of the grains flies due to the high temperatures in autumn seasons.
The attack of cycads in teh absence of seed treatments favors the development of diseases.
the sowing was carried out according to the climatic data, no later than October 25, knowing that from sunrise to the phenophase of twinning, wheat needs 450^0C thermal degrees, so that the tillers to have approximately the same number of grains on the mother plant.

Photo 10. Fields with wheat attacked by pests
Source: Original.

Annualy, there were applied two treatments against foliar diseases and Eurygaster sp. as follows: the first treatment in the period 15-20 March using the following active substances: Cyproconazole 80g/l + Propiconazol 250 g/l in a dose of 0.4 l/ha; the second treatment, at the end of April: Piraclostrobin 150g/l + Fluxapiroxad 75 g/l in a dose of 1 l/ha, Lambda-cihalotrin 50 g/l in a dose of 0.75 l/ha till the year 2017, and in the other years Lambda-cihalotrin in a dose of 0.3 kg/ha.
In the years 2018-2019, it was applied the second treatment cu Lambda-cihalotrin due to the invasion of the grain bugs – *Eurygaster* Sp., in a dose of 0.3 kg/ha.

Photo 11. In 2021, the attack of *Zabrus Tenebrioydes* (cereal ground beetle), the wheat is affected and it was sown together with another crop due to the lack of seed treatment with suitable substances
Source: Original.

Dynamics of wheat cultivated area

Despite that in Constanta County, the area cultivated with wheat is decreasing, at Amzacea Sport Agra agricultural holding, winter wheat was sown on larger surfaces which increased by 24.68% from 370.95 ha in the year 2013/2014 to 462.51 ha in the year 2022/2023. This tendency is confirmed by the coefficient of determination R square whose value reflects that 76.4% of the variation was timely determined, according to farmer's decision in close relation to the assurance of the crop rotation (Fig. 2).

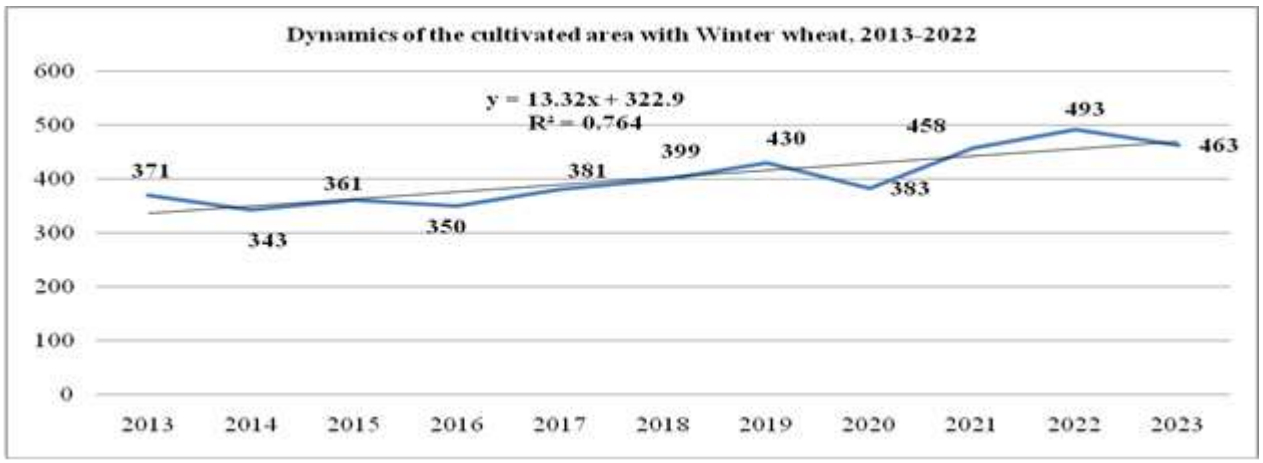

Fig. 2. Dynamics of the cultivated area with winter wheat at Amazacea Sport Agra Ltd. 2012-2022 (ha)
Source: Own design based on the data supplied by Amazacea Sport Agra Ltd. [43].

Dynamics of wheat production

Wheat production varied depending on the technology applied regarding the used varieties, fertilization and plant protection, the timing application of the agricultural works, precipitation and temperatures regime in the interval from sowing to harvesting. Its level ranged between the peak level of 3,818,440

kg in the year 2022 and 87,720 kg in the year 2020, the lowest level registered in the studied interval, practically showing a real calamity in this crop culture (Fig. 3).

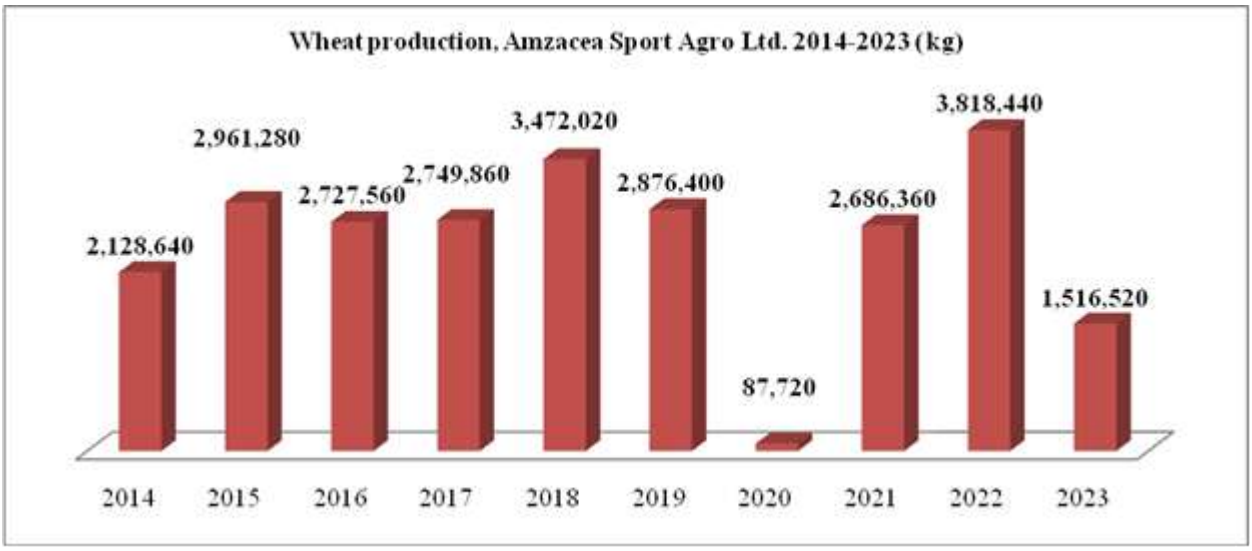

Fig. 3. Dynamics of the winter wheat production at Amazacea Sport Agra Ltd. 2014-2023 (kg)
Source: Own design based on the data supplied by Amazacea Sport Agra Ltd.[43].

Dynamics of wheat yield

In the analyzed interval, wheat yield varied from a year to another, the top level being 8,700 kg/ha recorded in the year 2018 and the lowest level was registered in the year 2020, only 228.28 kg/ha (Fig. 4).

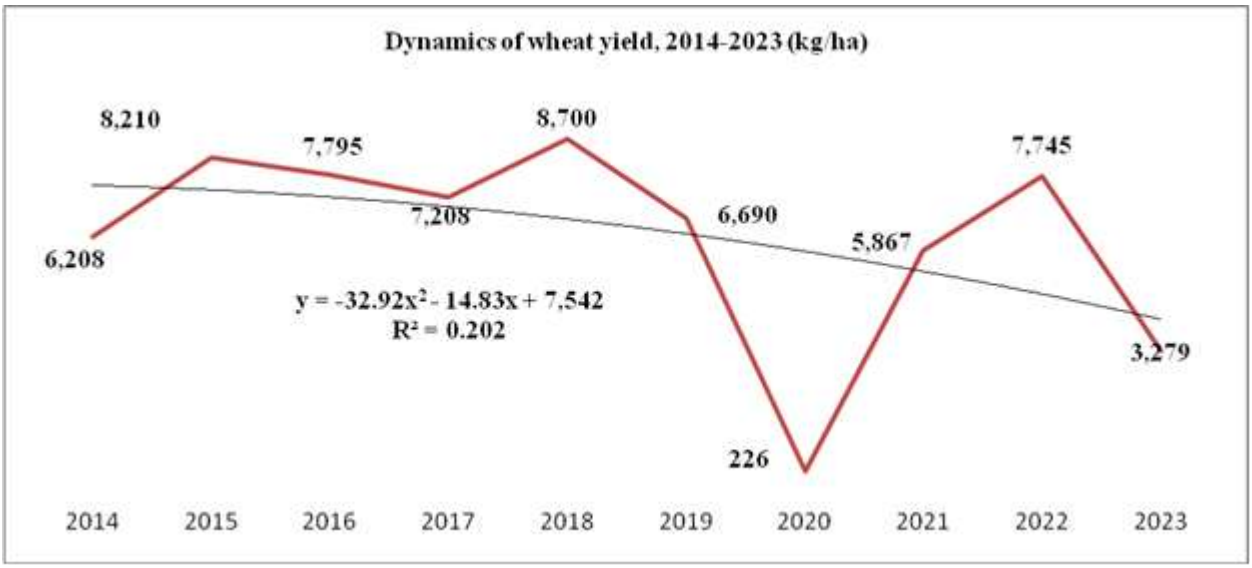

Fig. 4. Dynamics of the winter wheat yield at Amazacea Sport Agra Ltd. 2014-2023 (kg/ha)
Source: Own design based on the data supplied by Amazacea Sport Agra Ltd.[43].

Correlation between yield and annual precipitation level during the wheat growing period

Using the Excel facilities, a positive and strong correlation coefficient, r_{xy} = 0.50, was found between wheat yield and annual precipitations. R square value was 0.2502, meaning that 25.02% of the yield variation is given by the changes in the quantity of precipitations, and the remaining of 74.98% represent the influence of the variation of other factors on wheat yield.

F had the value 2.6696 and Significance F = 0.1409.

Taking into account that in the regression equation, Y = bx + a, "Y" is the dependent

variable, that is wheat yield and "x" is the amount of precipitations, the calculated equation, Y = 7.69 x + 2,523.66, reflects that an increase of precipitations by one unit could lead to an important additional yield. The existence of a significant connection between yield and annual precipitations was confirmed by t Test of the correlation coefficient.

The intercept value 2,523,66 had a standard error of 2,369.18, t stat was equal to 1.065, p-value = 0.3178. And the intercept value was situated in the confidence interval ranging between -2,939.68 the lower 95% and 7,987.01 the upper 95%. X variable 1= 7.6941 had a standard error of 4.709, t stat = 1.633, p-value = 0.1409. The value of X variable 1 was situated in the confidence interval - 3.1648 for lower 95% and 18.553 for upper 95%.

Correlation between wheat production and annual precipitation level during the wheat growing period

In this case, the coefficient of correlation was r_{xy}= 0.447, reflecting a positive and moderate link between the two variables taken into consideration. R^2 value equal to 0.1198 reflects that only 11.98% of the variation of production is caused by the variation in the amount of precipitations during the agricultural year. Therefore, other factors are responsible of the difference of production variation. F was 1.9979 and Significant F = 0.195. The determined regression equation is Y = 2,804.45 x + 1,165,036.81.

The intercept value 1,165,036.81 had a standard error of 998,215.795, t stat was equal to 1.1671, p-value = 0.2767. The intercept value was situated in the confidence interval varying between -1,136,852.9 the lower 95% and 3,466,927 the upper 95%. X variable 1= 2,804.45 had a standard error of 1,984.07, t stat = 1.4134, p-value = 0.2767. The value of X variable 1 was situated in the confidence interval - 1,170.83 for the lower 95% and 7,379.74 for the upper 95%.

Dynamics of production costs

Production costs reflect the financial efforts made by farm manager to sustain production, by assuring farm inputs in terms of certified seeds from various wheat varieties with high production potential, fertilizers and other chemicals for plant protection, fuel for machinery and other materials, salary for work force involved in carrying out the agricultural works.

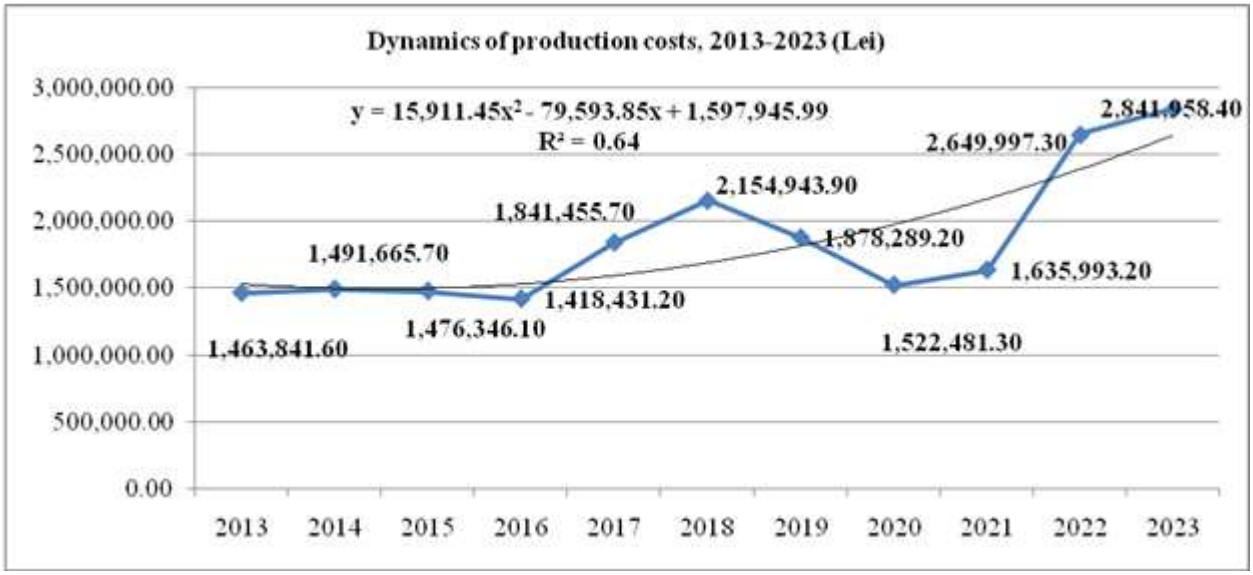

Fig. 5. Dynamics of production costs related to the winter wheat growing at Amazacea Sport Agra Ltd., 2013-2023 (Lei)

Source: Own design based on the data supplied by Amazacea Sport Agra Ltd.[43].

The level of production costs increased from a year to another in the studied period 2013-2023. In the 2023, they reached Lei 2,841,958, being by 94.14% higher than in 2013 and this happened due to the higher and higher price for farm inputs (Fig. 5).

Dynamics of income coming from wheat grains delivery

Income achieved from wheat marketed grains depended on the amount of grains sold in the market and also on the average market price.

In the analyzed period, wheat market price varied between Lei 849.67 per ton in 2013 and Lei 894.66 per ton in 2023. In the analyzed interval, it reached a peak of Lei 1,720 per ton in the year 2022, and the lowest level was Lei 663 per ton in the year 2016 (Fig. 6).

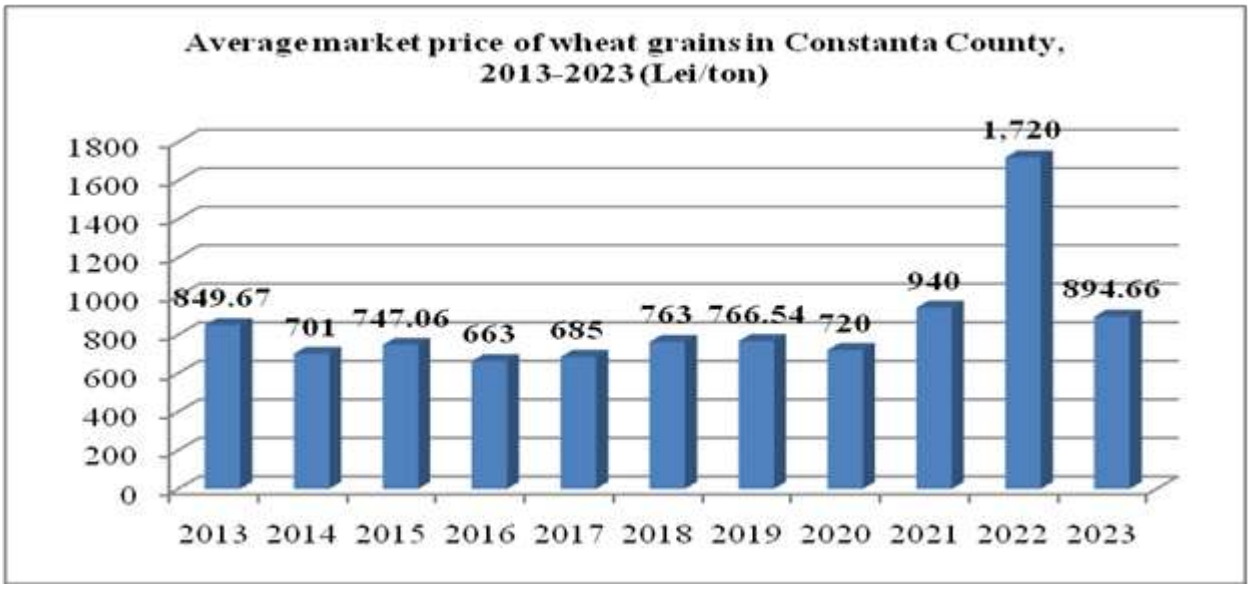

Fig. 6. Dynamics of average wheat grains market price, in Constanta county, 2013-2023 (Lei/ton)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd.[43].

The wheat grains volatility is influenced by the demand/offer ratio, knowing that in the years with a high harvest performance, the market price is small, while in the years with low offer, the high demand increases the delivery price.

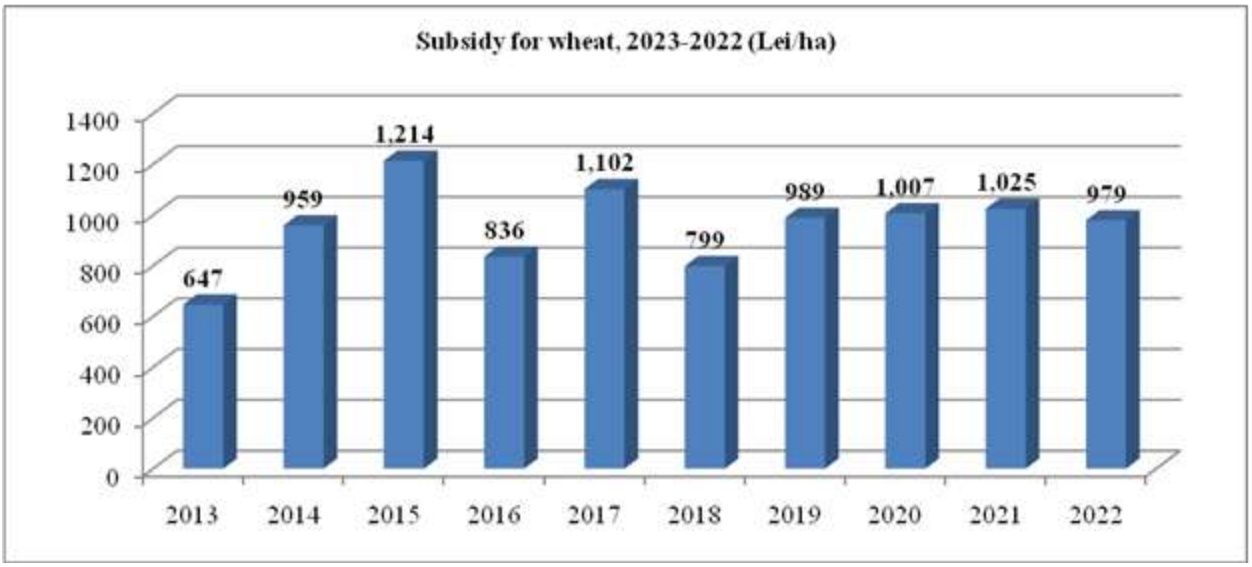

Fig. 7. The unique payment per surface unit cultivated with wheat, 2013-2022 (Lei/ha)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd. [43].

It worth to mention that in the years 2022 and 2023, the wheat market price was influenced by the cereals coming from Ukraine which have upset the market decreasing wheat price which caused a real disappointment to the Romanian producers.

Income got by farmer was also influenced by the unique payment per surface unit cultivated with wheat, as provided by Payments and Intervention Agency for Agriculture- APIA in the period 2013-2022. As it is known, the value of subsidy varied from a year to another as reflected in Figure 7.

According to Emergency Ordinance 3/2015, the role of this unique payment per surface unit is destined to the farmers who have eligible surfaces where agricultural practices with beneficial effects for climate and environment are implemented, like in case of Amzacea Sport Agra Ltd.

Without taking into consideration, the dynamics of income obtained by farmer from wheat growing in the period 2013-2023 varied between Lei 1,613,825.2 in 2013 and Lei 1,356,768.7 in the year 2023, which reflects a decline by Lei 256,855.5, because the income level in the last year of the analysis represented 84.08% of the 2013 level.

Of course, the variation of income from a year to another was caused by the amount of wheat sold in the market and market price. In the years when production performance was affected by climate change, especially by the low precipitations and drought, the income went down.

In this studied interval, the income peak was registered in the year 2022, which could be considered the best agricultural year for wheat at Amzacea Sport Agra Ltd., as the farmer obtained Lei 6,567,716.8. The lowest income level, accounting for Lei 630,864 was achieved in the year 2020, the worst year for wheat crop which was a calamity, a real disaster.

Taking into consideration the subsidy per hectare, the income level ranged between Lei 1,853,628.8 in 2013 and Lei 7,050,363.8 in the year 2022, which was 3.8 times higher than in 2013.

The dynamics of income coming from wheat crop without and with subsidy included at Amzacea Sport Agra Ltd. in the period 2013-2023 is shown in Fig. 8.

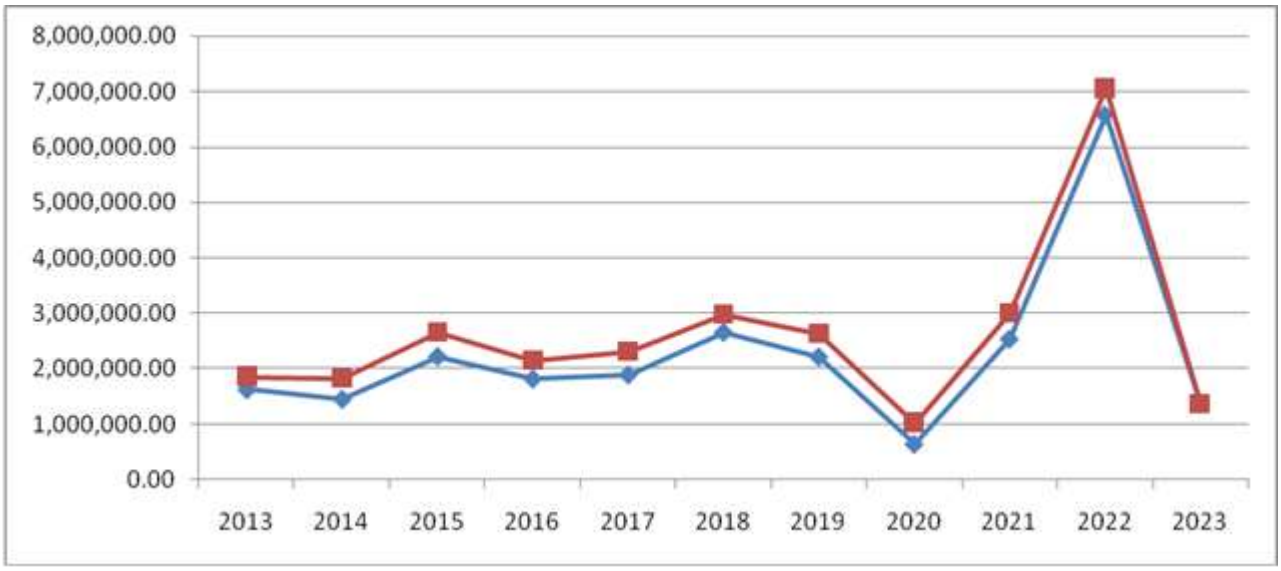

Fig. 8. Dynamics of income without and with subsidy included related to wheat culture in the period 2013-2023 (Lei)

Source: Own design based on the data provided by Amzacea Sport Agra Ltd.[43].

Note: Red line= Income with subsidy; Blue line= Income without subsidy

Dynamics of income only with subsidy included is shown in Fig. 9.

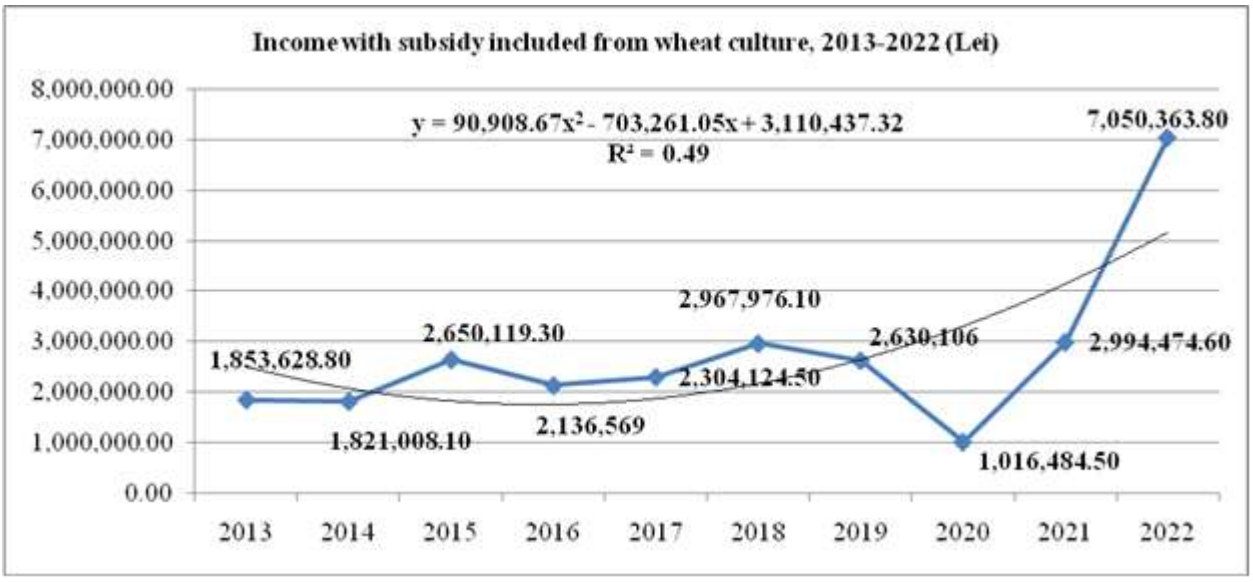

Fig. 9. Dynamics of income with subsidy included related to wheat culture in the period 2013-2022 (Lei)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd.[43].

Dynamics of profit and profit rate coming from wheat culture

In the most years in the studied period, the company registered positive financial results in terms of profit, except the years 2020 and 2023, when it recorded losses.

The best financial year, with the highest profit was 2022, when the company carried out Lei 3,917,719.5 profit, which was 26.15 times higher than the profit achieved in the year 2013. The lowest profit level in this interval was Lei 510.9, achieved in the year 2014.

In 2020, the loss accounted for Lei -891,617.3, while in 2023, it is Lei -1,485,188.7, by 66.57% higher than in the year 2020 (Fig. 10).

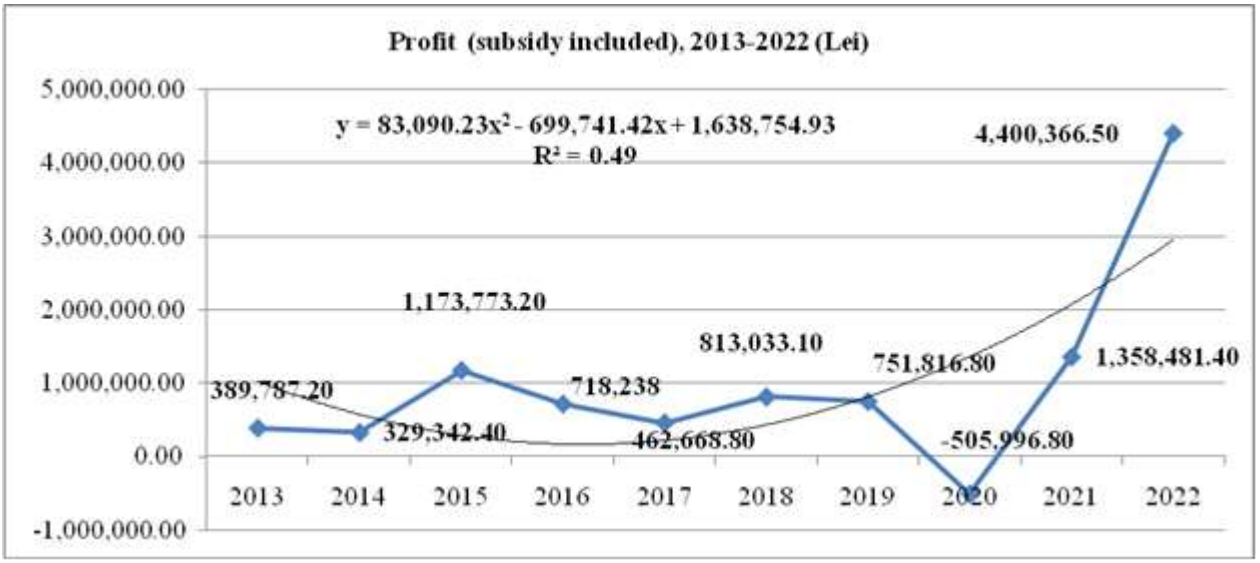

Fig.10. Dynamics of profit (subsidy included) related to wheat culture in the period 2013-2022 (Lei)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd.[43].

Therefore, the worst agricultural years for wheat growing at Amazacea Sport Agra Ltd. were 2020 and 2023, and this happened due to the low production performance caused by the low precipitations and long and severe droughts.

Profit rate in wheat culture

Profit rate shows the efficiency of the spent expenses for wheat growing at Amzacea Sport Agra Ltd. in the majority of the agricultural

years, except the years 2020 and 2023, when we identified discuss about loss rates.

In the analyzed interval, profit rate varied between 166.05%, the highest level, recorded in the year 2022 and 22.07% in the year 2014. Also, in other years, the company achieved good profit rates like: 83.03% in the year 2021, 79.5% in the year 2015, and 50.76% in the year 2016. In 2020, the loss rate accounted for -33.22% (Fig. 11).

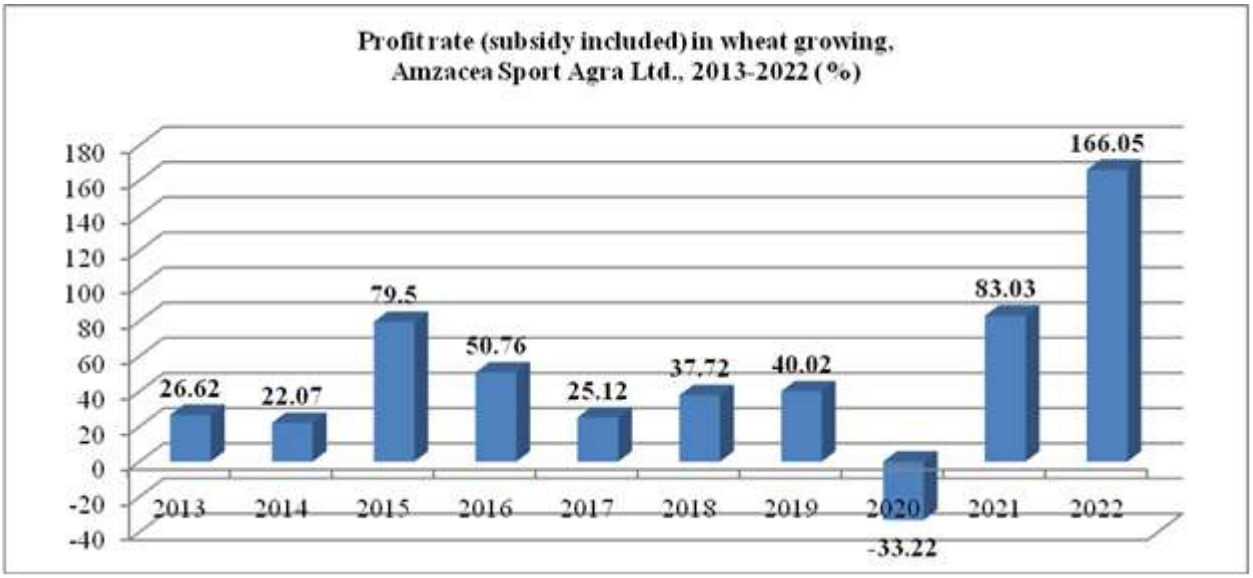

Fig.11. Dynamics of profit/loss rate (subsidy included) related to wheat culture in the period 2013-2022 (Lei)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd.[43].

In 2023, the loss rate accounts for - 52.25% at present, when the subsidy is not year received. But, if the company will get, for example, Lei 1,000 per ha subsidy, the loss rate could be diminished to - 35.98%.

Cost per ha and ton grains wheat

Another studied indicator reflecting economic efficiency in wheat growing is the cost per surface unit and per ton of grains.

To cultivate a hectare with wheat, the farmer spent Lei 3,946.49 in the year 2013 and Lei 6,144.84 in the year 2023, and if we look at the evolution of this indicator in the analyzed years we may easily identify the increasing trend, and this is explained only by the higher and higher price for farm inputs (Fig.12).

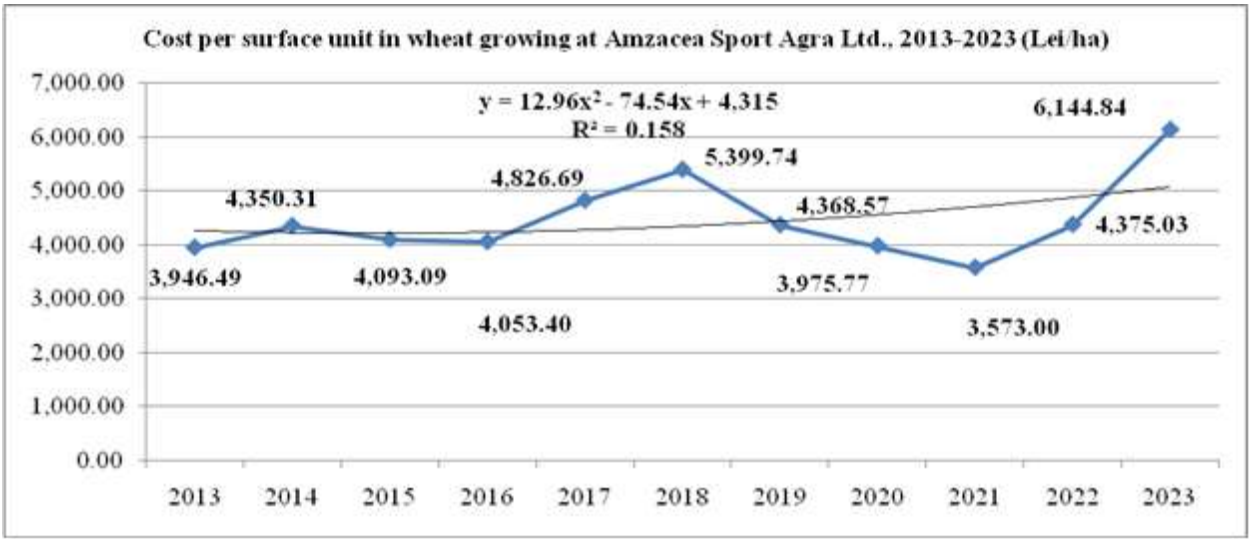

Fig. 12. Dynamics of costs per ha in wheat growing at Amzacea Sport Agra Ltd., 2013-2023 (Lei/ha)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd. [43].

To produce a ton of wheat grains, the farmer spent between Lei 770.80 in the year 2013 and Lei 1,874.00 in the year 2023. Of course, there are variations from a year to another depending on cultivated area, production, and total expenses in close relationship with the factors which influenced wheat growing at Amzacea Sport Agra Ltd.

We have to mention that the worst year for wheat growing was 2020, when the production was almost entirely compromised due to the terrible bad climate conditions in terms of very low precipitations, high temperatures and long and severe drought and pedological drought in the agricultural year 2019-2020. In 2020, wheat production was only 228.80 kg/ha, meaning 87,620 kg harvested from the whole cultivated surface of 382.94 ha. Taking into account, that the total production costs were Lei 1,522,481.3, this means a cost per ton of Lei 17,370.

A high cost per ton is also obtained in the year 2023, when due to the unfavorable climate conditions, wheat seeds production is 1,516,520 kg and the production costs accounted for Lei 2,841,958.4, the highest level in the analyzed interval, In this case, the unitary cost per ton of wheat is Lei 1,874 (Fig. 13).

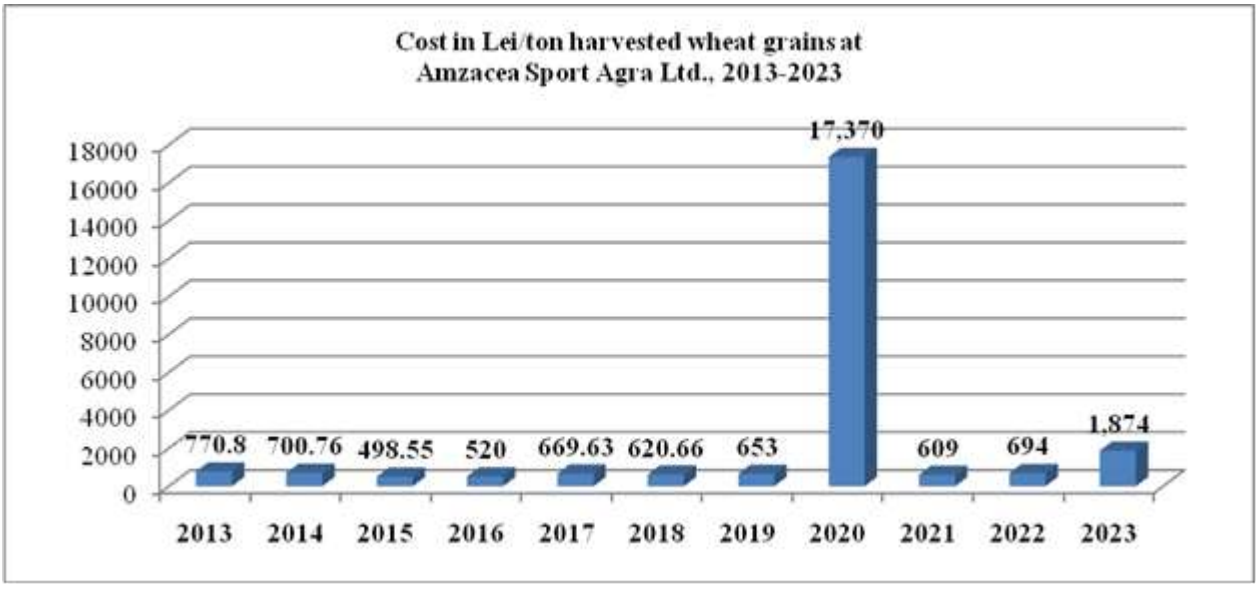

Fig. 13. Dynamics of cost per ton of harvested wheat seeds at Amzacea Sport Agra Ltd., 2013-2023 (Lei/ton)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd. [43].

Profit per cultivated ha with wheat and per ton of harvested production

This indicators also reflect the economic efficiency in a crop cultivation, that is why we analyzed it in this study case at Amzacea Sport Agra Ltd.

Profit per cultivated hectare with winter wheat varied between Lei 1,050.78 in the year 2013 and Lei -3,211.14 in 2023, which in fact it is a loss per surface unit, not a profit.

Along the years included in the interval of analysis, it was also registered a loss per ha of -1,321.30 in the year 2020, when wheat production was almost entirely compromised.

However, the farmer was able to produce the highest profit per ha accounting for Lei 8,925.69 in the year 2022, the best year for wheat crop at Amzacea Sport Agra Ltd.

The lowest profit per ha was Lei 960.48 recorded in the year 2014.

Also, good profits per ha over Lei 3,000 in 2015 (Lei +3,255.23), and over Lei 2,000 per ha were registered in the year 2021 (Lei+2,967.08), in 2016 ((Lei + 2,052) and in 2018 (Lei + 2,037.52)
(Fig. 14).

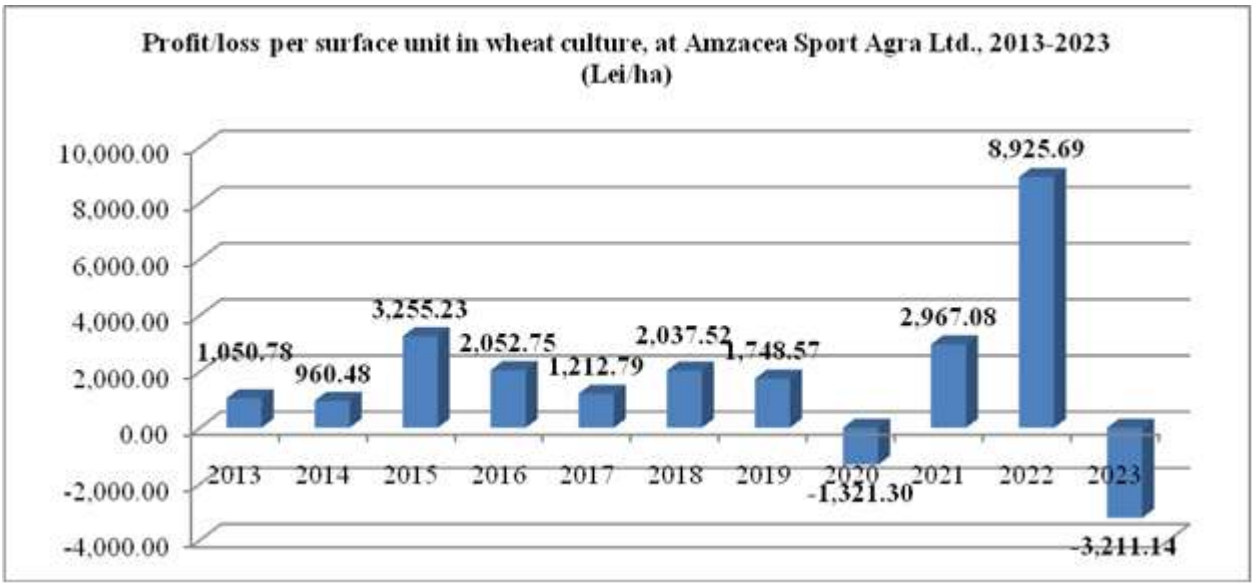

Fig. 14. Dynamics of profit per ha cultivated with wheat at Amzacea Sport Agra Ltd., 2013-2023 (Lei/ha)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd. [43].

Regarding the profit obtained per ton of obtained wheat grains, we found that the level of this indicator varied between Lei +205.24 per ton in 2013 and a loss of Lei -979.33 per ton in 2023.

The best result was registered in the year 2022, when the farmer recorded a profit of Lei 1,152.39 per ton of wheat, and the lowest profit per ton was Lei +154.71 carried out in the year 2014.

Across the interval, the farmers was facing with losses per harvested ton of wheat, it is the case of the year 2020, when the loss accounted for Lei -5,774.90 per ton and the year 2023, as mentioned above, when it was registered a loss of Lei -979.33 per ton (Fig. 15).

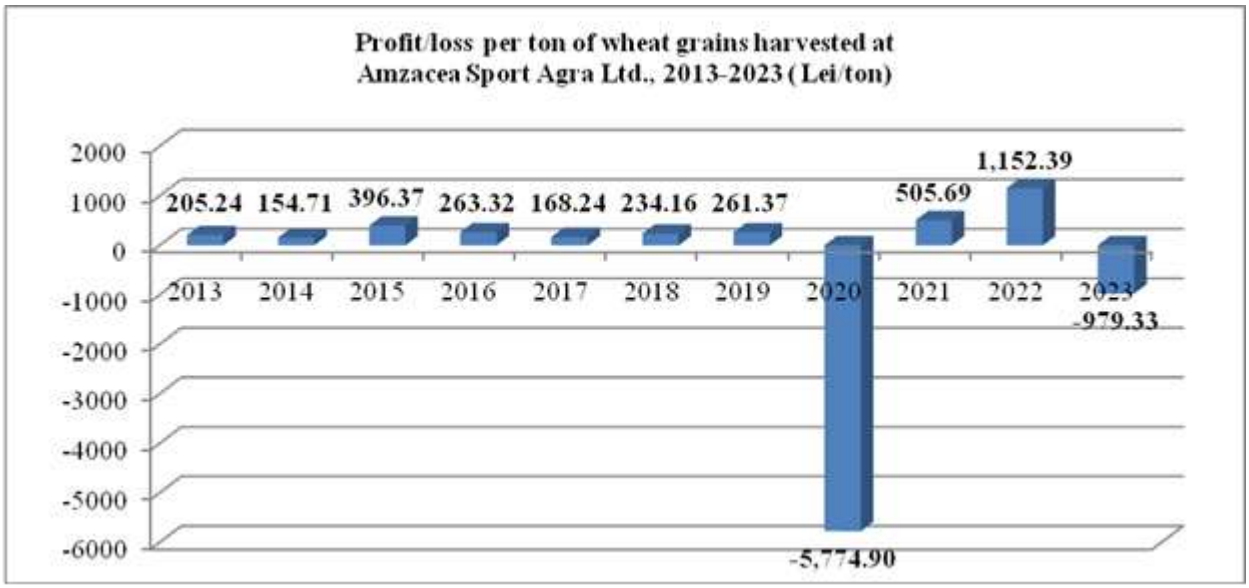

Fig. 15. Dynamics of profit per ton of harvested wheat seeds at Amzacea Sport Agra Ltd., 2013-2023 (Lei/ton)
Source: Own design based on the data provided by Amzacea Sport Agra Ltd.[43].

CONCLUSIONS

Given the pedoclimatic conditions of the geographical area of Dobrogea and especially of the coastal area in this area (Agigea, Topraisar, Amzacea, Comana, Negru-Voda, Albesti, Mangalia, 23 August, Tuzla, Eforie) mainly the temperatures that are increasingly

high in the last 10 years as well as the lack of precipitations, the observations and research results have shown that choosing the sowing period between October 15-20 gave the best results given the extension of the autumn period with high temperatures 20-22 C° even in the months of November - December and the precipitations that fell favored the processes of germination, emergence and twinning. The 450 thermal degrees required for the twinning process were achieved due to the high temperatures. the seed treatment with appropriate substances (thiamethoxam, imidacloprid) for this geographical area is mandatory. Depending on the mass of 1,000 grains when sowing, a minimum of 600 germinating grains/m^2 must be ensured.

Although the seed supply companies recommend 400-450 germinating grains/m^2, in case of the varieties with high twinning capacity (Avenue, Rubisko), the brothers from the spring do not have the same number of grains in the ear as the mother plant.

In the 10 years of observations testing a large range of varieties produced in Romania and in other countries, the early and semi-early varieties: Katarina in 2014 – 7,930 kg/ha, El-Nino 8,125 kg/ha, Avenue 8,026 kg/ha, Kraljica 8,300 kg/ha in 2018 gave the best results, also in 2016 Katarina 8,400 kg/ha, Genius 8,300 kg/ha, Petur 8,000 kg/ha.

Due to the high temperatures that are established in the last decade of May and the first decade of June, 32-34 C°, the early varieties exceed the hot period, which aggravates the ripening and produces the phenomenon of stalling, so that for these varieties, the harvest starts on June 20 compared to July 1-5 in case of the other varieties. The early varieties also show the waist, the height of the plants, between 68 cm. Kraljica, 71 cm. Avenue, 75 cm. El Nino which had this height in the year 2018 when 596 mm were accumulated.

In 2016, the autumn wheat hybrids Hyfi, Hybiza and Hylux were tested for the first time, which achieved average productions between 7,140 kg/ha Hyfi and 4,740 kg/ha Hylux, while the rest of the varieties had productions of over 8,000 kg/ha.

The research results have shown that under non-irrigated conditions, even though in the agricultural year 2015-2016, in the fall of 2015, it had 611 mm./m^2 in the whole year and in 2016, 472 mm./m^2.

The climatic changes have also determined the attack of foliar diseases (Septoria tritici, Puccinia sp.) so that it is necessary to apply at least two treatments in the vegetation period with approved fungicides.

Because in the recent years, in the last decade of April, negative temperatures have been recorded, especially during the nights (-4, -5 C°), the application of treatments during that period will be avoided.

The years 2020 - 2023 recorded the lowest precipitations, 2020 - 267 mm., 2023 - 332.4 mm.

In 2020, thousands of hectares of wheat in Dobrogea were a calamity, the production at the level of Constanta County being 226 kg/ha. This year, the Romanian wheat varieties were better adapted to the climatic conditions, so that the Otilia variety achieved 2,370 kg/ha, Miranda 2,260 kg/ha, Glosa 1,870 kg/ha, while the Avenue variety could not be harvested, the Combin variety achieved 850 kg/ha, Apilco 550 kg/ha, Rubisko 276 kg/ha. The Miranda variety recorded 38 cm. height and Avenue 15 cm.

In the year 2023 with a total of 332.4 mm precipitations, the best results were recorded by the Solindo variety - 4,297 kg/ha and Ursita 4,165 kg/ha.

Due to the low temperatures -4,-5 C° in the first decade of April in 2023, although on February 25 the Ursita variety had a number of 640 plants/m^2 and on May 23rd it presented only 412 plants/sq.m., so that the research we carried out showed that it is absolutely necessary to ensure at least 600 germinating grains/sq.m. at sowing for this geographic area.

In all the years of observation and research, regardless of the varieties used, the level of production/ha was in close correlation with the water reserve from the fall of the previous year, as well as with the cumulative precipitations during the wheat growing season, so that in 2015, 8,216 kg were

achieved /ha, in 2018 – 8,700 kg/ha, in 2022 – 7,745 kg/ha. In 2015, 611 mm./sq.m. were accumulated, in 2018 – 596.5 mm./sq.m. and in 2022 – 503.5 mm./sq.m. while in 2023 only 3,297 kg/ha and accumulated 332.4 mm./sq.m.

Regarding the financial results obtained from the whole cultivated area with winter wheat, we may affirm that this crop was profitable in almost the whole period 2013-2023, except the years 2020 and 2023.

The best agricultural year was 2022, when the profit from wheat cropping reached Lei 3,917,719.5 being 26.15 times higher than in 2013.

In the years 2020 and 2023, the company registered losses accounting for Lei-891,617.3 and, respectively, Lei -1,485,188.7.

Analyzing the financial result per cultivated area, the company carried out Lei 960.48 profit in 2014, the lowest level, a loss of Lei 1,321.30 in 2020 and Lei -3,211.14 in 2023, and the highest profit Lei 8,925.69 in 2022.

Per ton of wheat grains, the company profit ranged between Lei 154.71, the smallest level in 2014, and Lei 1,152.39 in 2022, the highest level. In the worst years, the loss per ton accounted for Lei -5,774.90 in 2020 and for -979.33 in 2023.

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