EVOLUTION AND STRUCTURE OF FOREIGN TRADE IN AGRICULTURAL PRODUCTS FROM ROMANIA IN THE PERIOD 2008-2019

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Abstract. *The paper aims to investigate the foreign trade in agricultural products for the total external trade in agriculture (export/import) and in particular for the territorial area of the European Union. The analysis includes in structure the main sections of products (live animals and animal products; vegetable products; animal or vegetable fats and oils; food, beverages and tobacco). The analysis pursued the comparison of values and percentages towards year 2008, with the previous year and to the total export/import of products by product sections. The analysis highlighted the following conclusions: The total value of agricultural exports registers higher increases compared to the export rates at national level; The amount of export of agricultural products shows differentiations rendered by high weights for vegetable products, food, beverages and tobacco, but also low levels in the case of exports for animals, fats and oils (vegetable/animal); Agricultural exports to the European Union reflect annual increases with significant variations in percentage levels. There is a decrease in exports of live animals and animal products, fats and oils (vegetable/animal) along with an increase in vegetable and food products; The value analysis of the total imports of agricultural products from Romania both on the total and in the structure of the analyzed products, highlights the existence of important increases. Of particular note are the import of animal, vegetable and food products, beverages and tobacco; The total value and the percentage rates of agricultural imports from Romania with the European Union are higher than the total imports, with reference to animal, vegetable and food products, beverages and tobacco; The level of Romania's foreign trade balance, with agricultural products, for the analyzed period, 2008-2019 shows very large oscillations from 456 thousand Euro in 2014, to -1246 thousand Euro in 2019 and to -2181 thousand Euro in 2008.*

Keywords: foreign trade with agricultural products, export/import, export/import value, balance, balance sheet

1. Introduction

The paper aims to highlight the levels of the most important forms and structures in foreign trade of agricultural products in Romania. The analysis made by an expression of the physical and value levels of export / import, for the period 2008-2021, aims to highlight the sequence of existing rhythms. There are both favorable

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growth trends, regression / stagnation, but which are accompanied by annual oscillations sometimes very pronounced.

It should be noted that exports of agricultural products to the EU's territorial area may be growing faster than the dynamics of total agricultural exports. But this form of exchange (export) is maintained at a lower level than imports (the value of agricultural imports from Romania with the European Union is a majority).

At the same time, annual rhythms can be highlighted for animal and vegetable products with reference to the growth and decrease curves for certain periods of years.

The dominant overall of imports is found at animal, vegetable and food products, beverages and tobacco.

Reproduced by summarizing the significance of the foreign trade balance, we can see a trend (for certain products) at which we found a higher export than import and which by the influence on the whole of foreign trade does not determine a favorable balance.

In this context, the paper aimed to analyze the evolution and structure of foreign trade in agricultural products from Romania in the period 2008-2019.

2. Materials and Methods

The investigation methodology was based on annual physical and value levels of the period 2008 - 2019. Appropriate references were made to the structure of the main groups of agricultural products related to foreign trade (export / import).

According to the Nomenclature of the European Union, the nominations of the product groups were: live animals and animal products; vegetable products; animal or vegetable fats and oils; food, beverages and tobacco.

The comparisons were based on both the structural total and the succession of the years of the analyzed period.

It should be mentioned that initially the analysis indicators followed the comparative form which were presented in a trivalent form, respectively: at national level and of the amount delimited by the relations with the EU for the whole export activity; at national level regarding the ensemble/total of agricultural products involved in the activity of foreign trade; in the structure of each of the four groups of agricultural products.

Expressed in value, the balance of foreign trade in agricultural products completed the level of knowledge of the current situation, but especially the possibility of a favorable equilibrium trend [1].

3. Results and Discussions

3.1. The comparative situation of the export of agricultural products from Romania

The overall analysis regarding the foreign trade at national level can be considered a preamble of knowing the structure of all the other directions of investigation.

Table 1 lists such a situation of domestic exports for the period 2008-2019 as follows:

- at national level, the total value of exports for the analyzed period registers a sharp growth rate. If in 2008 there is a level of 33.7 billion € in the last year of analysis, the increase is 67.7 billion € amplification of the succession of years;
- for the export of agricultural products the levels recorded an increase, but for which annual variations are found. If in 2008 the export has a level of only 2.16 billion €, in the last year it reaches 7.18 billion €. In this comparative form of analysis, annual variations in the period 2014-2018 are found, which exceed 10% compared to the national level. At the same time, a comparison with the previous year shows an increase for each of the annual dynamics.

Table 1. Total export value (FOB), from Romania, according to the Nomenclature from the European Union

No.	Specification	MU	2008	2010	2012	2014	2016	2018	2019
1	Total export la national level	Billion €	33.72	37.36	45.06	52.46	57.39	67.72	68.99
		% vs 2008	**100**	110.78	133.63	155.57	170.17	200.81	204.59
2	of which: Total agricultural exports	Billion €	2.16	3.11	4.04	5.57	6.16	6.50	7.18
3	compared to total exports	%	6.42	8.33	8.97	10.63	10.75	9.6	10.41
4	compared to the base year	%	**100**	143.74	186.78	257.58	284.92	300.27	331.84
5	compared to the previous year	%	-	138.79	100.58	105.54	104.24	101.48	110.51

Source: NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [3, 6].

Hence the conclusion that both overall exports at the national level and exports at the agricultural level are increasing. It can be stated that the growth rate for exports of agricultural products is more pronounced than for the overall export of the whole.

3.2. The comparative situation of the export of agricultural products from Romania by structure

The analysis of the export of agricultural products was deepened in the structure of four product groups, the phenomenon being given by adequate comparative elements at the territorial level of the whole and at the EU level.

The total value of agricultural exports from Romania is based on enemy sections for the analyzed periods, as presented in Table 2.

The data from Table 2 present the following aspects:

- for the whole of agricultural exports, its value level falls within a favorable growth rate. Thus, in the last year of the analysis, the level reaches an increase of 3.31 hours compared to the first year. It should be mentioned the annual export variations whose oscillations compared to the previous year are between 1.48% and 38.79%. Significantly, this amount of exports to total agriculture for most years is lower than the level of imports (between 49.8% and 108.90%). Regarding the annual variations, it is possible to limit a growth period signaled for the years 2008-2014 (49.80 → 108.90%) and the period 2015 - 2019 where there is a decline (97.7 → 85.2%);

- for the same period of the product group live animals and animal products, the value of exports increases the value of exports (it reaches more than 3 times in 2019 compared to 2008), to which is added the maintenance of those variations compared to the previous year (between +34.62% and -5.40%). At the same time, the share of these product groups compared to the total level of agricultural exports is very low, to which are added the significant annual variations (between 18.07% and 12.83%);

- the group of vegetable products, through the total value of the export of agricultural products, is predominantly the registered level being between 56.66% and 48.71%. The increase of 2019 is +32.47 compared to 2008, and the fluctuations of the annual surveys are between +51.47 and -6.12%;

- for the group of products fattening the animals and the animals, there is an increase in the annual comparative values (2.24 times) but which continues with a decrease compared to the total products exported from agriculture (between 3.14% and 6.01%). The annual variations are maintained between +86.46% and 24.37% which fall within the product group with the highest amplitudes;

- the group of food, beverages and food products occupies an important position in the total value of agricultural exports from Romania, at which the evolutionary rate reaches 30.01% of the total. The increase registered in the last year (2019) compared to the first year (2008) is 3.69 times. The annual variations register more positive oscillations, being between +0.58% and +38.79%.

The shape presented for the total export of agricultural products indicates a total increase, along with a lower level than imports.

Table 2. Total value of exports (FOB), agricultural in Romania, by sections (according to the Nomenclature of the European Union *)

	Specification	**Indicators of comparative structure**	**MU**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2019**
1	I. Live animals and animal products	Annual value	Th. €	277,985	433,571	731,139	742,755	813,967	895,227	928,064
		Compared to the previous year	%	-	133.1	125.26	99.66	104.12	94.6	103.66
		compared to the base year	%	100	155.96	263.01	267.19	292.8	322.04	333.85
		compared to total agricultural exports *	%	12.83	13.93	18.07	13.31	13.19	13.76	12.91
2	II. Vegetable Products	Annual value	Th. €	1,198,292	1,625,160	1,970,328	3,071,764	3,437,493	3,590,864	3,876,148
		Compared to the previous year	%	-	144.46	93.97	102.91	111.8	102.53	107.94
		compared to the base year	%	100	135.62	164.42	256.34	286.86	299.66	323.47
		compared to total agricultural exports *	%	55.34	52.21	48.71	55.07	55.71	55.23	53.94
3	III. Animal or vegetable fats and oils	Annual value	Th. €	105,538	164,170	182,829	213,371	194,056	224,211	224,491
		Compared to the previous year	%	-	186.46	75.63	88.98	86.75	106.22	100.12
		compared to the base year	%	100	155.55	173.23	202.17	183.87	212.44	212.71
		compared to total agricultural exports *	%	4.87	5.27	4.52	3.82	3.14	3.44	3.12
4	IV. Food, beverages and tobacco	Annual value	Th. €	583,385	889,531	1,160,026	1,549,328	1,723,717	1,791,171	2,156,309
		Compared to the previous year	%	-	126.4	105.59	117.84	93.77	102.51	120.38
		compared to the base year	%	100	152.47	198.84	265.57	295.46	307.03	369.62
		compared to total agricultural exports *	%	26.94	28.57	28.68	27.77	27.94	27.55	30.01
5	TOTAL agriculture (total 1,2,3,4)	Annual value	Th. €	2,165,200	3,112,432	4,044,322	5,577,218	6,169,233	6,501,473	7,185,012
		Compared to the previous year	%	-	138.79	100.58	105.54	104.24	101.48	110.51
		compared to the base year	%	100	143.74	186.78	257.58	284.92	300.27	331.84
		compared to total agricultural exports *	%	49.8	79.4	84.34	108.9	90.87	85.15	85.22

Source, NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [2, 6].

The value of agricultural exports from Romania with the EU is one of the most important aspects of the economic equilibrium policies of the current stage. It is in fact a matter of wanting to know the quantities of agricultural products expressed in values exported to the EU.

Table 3 presents the indicators regarding the export value of the agricultural products in their dynamics.

Table 3. Agricultural export value (FOB), from Romania, with the European Union (according to the Nomenclature from the European Union *)

	Specification/ MU	Indicators of comparative structure	MU	2008	2010	2012	2014	2016	2018	2019
1	I. Live animals and animal products	Annual value	Th.€	233,762	339,318	534,205	541,545	527,775	632,042	593,079
		Compared to the previous year	%	-	123.31	113.12	100.35	92.91	103.68	93.83
		compared to the base year	%	100	145.15	228.52	231.66	225.77	270.37	253.71
		compared to total agricultural exports *	%	16.34	14.82	18.99	15.61	13.78	13.99	12.99
2	II. Vegetable Products	Annual value	Th.€	607,519	1,005,578	1,087,776	1,437,364	1,680,648	2,246,334	1,985,761
		Compared to the previous year	%	-	131.45	86.74	112.34	106.85	111.53	88.4
		compared to the base year	%	100	165.52	179.05	236.59	276.64	369.75	326.86
		compared to total agricultural exports *	%	42.48	43.92	38.66	41.44	43.88	49.75	43.49
3	III. Animal or vegetable fats and oils	Annual value	Th.€	90,039	159,216	178,319	143,954	145,312	181,909	183,061
		Compared to the previous year	%	-	208.39	78.66	66.29	86.14	119.74	100.63
		compared to the base year	%	100	176.83	198.04	159.87	161.38	202.03	203.31
		compared to total agricultural exports *	%	6.29	6.95	6.33	4.15	3.79	4.02	4.01
4	IV. Food, beverages and tobacco	Annual value	Th.€	498,638	785,274	1,012,680	1,345,055	1,475,993	1,454,565	1,803,133
		Compared to the previous year	%	-	125.44	105.65	118.86	93.55	99.17	123.96
		compared to the base year	%	100	157.48	203.08	269.74	296	291.7	361.61
		compared to total agricultural exports *	%	34.87	34.3	36	38.78	38.54	32.21	39.49
5	TOTAL agriculture (total 1,2,3,4)	Annual value	Th.€	1,429,958	2,289,386	2,812,980	3,467,918	3,829,728	4,514,850	4,565,034
		Compared to the previous year	%	-	131.38	96.61	109.47	98.52	106.42	101.11
		compared to the base year	%	100	160.1	196.71	242.51	267.82	315.73	319.24
		compared to total agricultural exports *	%	66.04	73.55	69.55	62.18	62.07	69.44	63.53

Source: NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [6].

The data from Table 3 highlighted the following aspects:

-for the total value of agricultural exports, from Romania, with the European Union, there is an increase of 3.19 times (which represents the level of the last year of analysis compared to the first year). At the same time, we can mention the annual variations that in the majority of the years are represented in the majority by positive oscillations (+ 31.38% and +1.11%). Comparison with total exports from agriculture indicates for the relationship with the EU signals that are worth between 59.94% and 77.7%, hence the possibility of multiple increases;

- for the group of live animals and animal products, the value of exports to the EU is increasing and can be estimated at 2.53 times in 2019 compared to 2008, the annual variations of the period being maintained. With special reference to the comparison with agricultural imports with the EU, between 12.99% and 18.99% are recorded for this section. It can be noted that the period 2012-2019 represents a decrease in the share of exports compared to total agricultural imports with the EU (18.99 → 12.99);

- the vegetable products section can be said to be representative of Romania's exports to the EU, it is in an increase that in recent years is over three years, with the maintenance of some annual variations. Exports of these vegetable groups compared to total agricultural imports with the EU are represented by comparative weights between 38.6% and 49.7%;

- for animal and animal fat and vegetables, there are sharp variations (between -33.31% and +108.39%), an increase that reaches 2.93 in 2019 compared to 2008. Comparisons expressed by the weight of total agricultural imports with the EU represent a decrease in the number of years 7.78% to 3.58%.

The section represented by exports to the EU of food, beverages and tobacco shows a comparative level of growth which in the last year is 3.61 times, at which the annual variations are maintained. Regarding the share of this export in relation to the total value of agricultural exports with the EU, there are significant levels (between 32.21% and 40.58%).

In short, the export of agricultural products to the EU's territorial destination can be higher than the total export of agriculture (the shares being between 59.94% and 77.70%), but it can be added that exports are lower than imports. The structure of the products in sections can be seen as a predominance of vegetable products along with food, beverages and one, both for overall exports and agricultural exports with the EU.

3.3. The comparative situation of the import of agricultural products from Romania

The import of agricultural products from Romania is the side that completes the knowledge of the foreign trade with agricultural products from Romania. To elucidate this problem, the analysis was performed on total imports and continued with the EU area.

* The total value of agricultural imports from Romania is of particular importance in terms of the needs of human consumption, along with the potential of national

production. A first aspect analyzed was the knowledge of the total levels presented in the value and comparative information as presented in Table 4.

Table 4. Total value of imports (FOB), agricultural in Romania, by sections (according to the Nomenclature of the European Union *)

	Specification	**Indicators of comparative structure**	**MU**	2008	2010	2012	2014	2016	2018	2019
1	I. Live animals and animal products	Annual value	Th.€	1,191,297	984,428	1,034,909	1,225,844	1,440,754	1,773,796	1,979,526
		Compared to the previous year	%	-	88.23	107.21	110.04	114.88	105.04	111.59
		compared to the base year	%	100	82.63	86.87	102.89	120.94	148.89	166.16
		compared to total agricultural exports *	%	27.4	25.11	21.58	23.93	21.22	23.2323	23.47
2	II. Vegetable Products	Annual value	Th.€	1,259,344	1,141,133	1,416,336	1,513,741	2,329,388	2,316,611	2,516,267
		Compared to the previous year	%	-	113.79	106.98	104.02	114.34	96.71	108.62
		compared to the base year	%	100	90.61	112.47	120.20	184.97	183.95	199.81
		compared to total agricultural exports *	%	28.97	29.11	29.54	29.56	34.31	30.34	29.85
3	III. Animal or vegetable fats and oils	Annual value	Th.€	227,089	217,195	238,646	163,919	189,372	172,245	173,686
		Compared to the previous year	%	-	135.40	97.22	79.80	102.93	89.73	100.84
		compared to the base year	%	100	95.64	105.09	72.18	83.39	75.85	76.48
		compared to total agricultural exports *	%	5.22	5.54	4.98	3.20	2.79	2.26	2.06
4	IV. Food, beverages and tobacco	Annual value	Th.€	1,669,236	1,577,161	2,105,242	2,217,730	2,829,548	3,372,391	3,761,636
		Compared to the previous year	%	-	102.13	110.16	101.85	109.68	107.15	111.54
		compared to the base year	%	100	94.48	126.12	132.85	169.51	202.032	225.35
		compared to total agricultural exports *	%	38.4	40.23	43.9	43.3	41.67	44.16	44.61
5	TOTAL agriculture (total 1,2,3,4)	Annual value	Th.€	4,346,966	3,919,917	4,795,133	5,121,234	6,789,062	7,635,043	8,431,115
		Compared to the previous year	%	-	102.52	107.86	103.41	112.12	102.85	110.42
		compared to the base year	%	100	90.17	110.3	117.81	156.17	175.64	193.95
		compared to total agricultural exports *	%	125.15	122.6	124.88	121.57	118.99	118.86	116.61

Source: NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [4, 6].

From the data shown in Table 4, the following aspects have been highlighted:

-regarding the total imports of agricultural products, through the annual records in the analyzed period, there is a succession of increases which in comparison with 2019 compared to 2008 is 1.93 times. The annual variations are maintained with moderate oscillations (between -12.05% and +13.41%). Considered a main comparison of the total import of the agricultural sector compared to the import from the EU where the population from 2008-2019 exceeds 100% (variations of surpluses being between +25.47% and 18.86%);

- the section of products that includes the import of certain live and animal products inherits an ascent which in the last year reflects an increase of 1.66 times compared to the first year, but whose oscillations are between -11.77% and + 14.88%. At the same time, this level of imports compared to the total annual agricultural imports represents oscillating levels between 21.58% and 29.18%, with the mention of an annual decrease (from 27.40% in the first year to 23.16% in the last year);
- the imported vegetable products can be considered by the preponderance the value of the imported vegetable products reflects an increase of 1.99 times, but with variations, being signaled variations and very high seas (between -18.98% and +66.16%). Comparison with the total value of agricultural imports is significant import for these products with levels between 26.23% and 34.31%;

- the products represented by fattening (animals + plants) are represented by this category whose manual import rate is decreasing the variations being delimited between -29.47% and + 8.09%. At the same time, this group of products represents the structural level that indicates the lowest ones from agricultural imports (it reaches only 2.06 of the total in 2019), being found a successive annual decreasing trend (5.22% → 2.06%);

- foodstuffs, beverages and the maintenance of the priority in the total value of imports (in comparison with the total import levels are between 38.40% and 44.61%). At the same time, there is an increase in annual increases compared to this total of imports compared to the previous year (between -7.49% and +26.12%).

It can be concluded that the import of the agricultural products analyzed in value by the total value as a result of the structure for the majority of the annual levels increases with the maintenance of some variations in the dynamics of the analyzed periods. Priority is given to animal, vegetable and food products, beverages, of which the cumulative share is over 90%.

* The total value of agricultural imports from Romania with the European Union represents a section with a special importance in foreign trade. Both total and continuous structure investigations were performed, the total and comparative levels of which are shown in Table 5, which showed the following:

- for the total value of agricultural imports from the EU it is in an increase where it can be said that the last year is double the first year (by comparing 2019 to 2008 the level is 208.1%). Simultaneously with the total agricultural imports, these imports from the EU are between 79.90% and 85.74% (year 2021);

-for the section live animals and animal products, the value of imports in the analyzed dynamics is an increase whose level in the last year reaches a level of 1.71 times compared to 2008. It should be mentioned the annual variations whose oscillations are signaled between -6.02 % and 12.37%. The comparison with the total agricultural import for this form of import is signaled a decrease from 32.16% to 33.82% in the first years to 26.62% and 26.58% in the last years of the analyzed period;

Table 5. Value of agricultural import (FOB) from Romania, with the European Union (according to the Nomenclature from the European Union *)

	Specification	Indicators of comparative structure	MU	2008	2010	2012	2014	2016	2018	2019
1	I. Live animals and animal products	Annual value	Th. €	1,117,326	920,248	982,663	1,179,805	1,388,165	1,709,986	1,921,647
		Compared to the previous year	%	-	87.99	108.42	109.62	115.01	105.19	112.38
		compared to the base year	%	100	82.36	87.95	105.59	124.24	153.04	171.99
		compared to total agricultural exports *	%	32.16	28.78	25.59	28	24.33	26.62	26.58
2	II. Vegetable Products	Annual value	Th. €	955,239	910,875	1,184,624	1,235,260	1,912,876	1,802,710	2,046,688
		Compared to the previous year	%	-	116.63	110.39	103.16	115.90	94.42	113.53
		compared to the base year	%	100	95.36	124.01	129.31	200.25	188.72	214.26
		compared to total agricultural exports *	%	27.50	28.49	30.85	29.32	33.53	28.06	28.31
3	III. Animal or vegetable fats and oils	Annual value	Th. €	160,666	181,029	195,139	138,962	165,676	145,622	145,124
		Compared to the previous year	%	-	138.72	96.51	84.97	107.47	88.57	99.66
		compared to the base year	%	100	112.67	121.46	86.49	103.12	90.64	90.33
		compared to total agricultural exports *	%	4.63	5.66	5.08	3.30	2.90	2.27	2.01
4	IV. Food, beverages and tobacco	Annual value	Th. €	1,240,018	1,184,946	1,477,208	1,658,414	2,238,742	2,765,064	3,116,153
		Compared to the previous year	%	-	*104.4*	*108.5*	*103.4*	*117.0*	*110.5*	*112.7*
		compared to the base year	%	100	*95.6*	*119.1*	*133.7*	*180.5*	*223.0*	*251.3*
		compared to total agricultural exports *	%	35.7	*37.1*	*38.5*	*39.4*	*39.2*	*43.0*	*43.1*
5	TOTAL agriculture (total 1,2,3,4)	Annual value	Th. €	3,473,249	3,197,098	3,839,634	4,212,441	5,705,459	6,423,382	7,229,612
		Compared to the previous year	%	-	*103.4*	*108.4*	*104.3*	*115.8*	*103.6*	*112.6*
		compared to the base year	%	100	*92.0*	*110.5*	*121.3*	*164.3*	*184.9*	*208.2*
		compared to total agricultural exports *	%	79.9	*81.6*	*80.1*	*82.3*	*84.0*	*84.1*	*85.7*

Source: NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [6].

-the import situation for vegetable products seems to increase, so that the growth rate is 2.14 times higher in the last year (2019) than in the first year (2008). The trend of annual oscillations is maintained by oscillations between -18.25% and + 15.90%. With special reference to the levels that represent the comparison with the total agricultural import with the EU, we can see an evolution that outlines a curve that in the first part of the period initially reflects an increase, but which in the analyzed dynamics continues through a decrease;

-for fats and oils (animals or vegetables) both the comparative levels compared to the base year and the rhythms reflect situations in the decrease of the years of the period. The share of total agricultural products in relation to total agricultural imports with the EU is lower than 2.5 times;

-food, beverages and tobacco recorded significant increases, which in the last year amounted to 2.51 times compared to the base year (2008). Further to the total agricultural import from the EU, in the succession of the years, increases of 35.70% → 43.10% are highlighted.

It is possible to deduce a differentiation in the overall evolution of imports which shows both growth trends with regard to food, beverages and tobacco, a stagnation with a tendency to decrease for plant products, a definite decrease for live animals and animal products, along with fats. In summary, the comparative analysis shows that the value level of the total of these agricultural imports decreases, but that the levels of agricultural imports with the EU increase.

3.4. The balance of agricultural products from Romania

Regarding the synthesis given by the balance of the whole trade with agricultural products resulting from the export-import comparative structures, the final meanings + and - of the annual values are indicated by the favorability of these forms of trade. In total foreign trade and with the EU, the tables are explicitly presented in values.

Balance of foreign trade in agricultural products in Romania si presented in Table 6.

Table 6. Balance of foreign trade with agricultural products from Romania, (Export-Import) at the national level

.	Specification	MU	2008	2010	2012	2014	2016	2018	2019
1	I. Live animals and animal products	mil €	-913.3	-550.9	-303.8	-483.1	-626.8	-878.6	-1,051.5
2	II. Vegetable Products	mil €	-61.1	484.0	554.0	1,558.0	1,108.1	1,274.3	1,359.9
3	III. Animal or vegetable fats and oils	mil €	-121.6	-53.0	-55.8	49.5	4.7	52.0	50.8
4	IV.Food, beverages and tobacco	mil €	-1,085.9	-687.6	-945.2	-668.4	-1,105.8	-1,581.2	-1,605.3
5	TOTAL agriculture (total 1,2,3,4)	mil €	-2,181.8	-807.5	-750.8	456.0	-619.8	-1,133.6	-1,246.1

Source: NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [5, 6].

According to the dynamics of the levels of values ± shown in Table 6, it can be found:

- in the structure of the product sections, the total exports of vegetable products and fats/oils (animal/vegetable) showed a positive trend with positive results (especially since the second half of the period);

- a completely negative situation due to the values of the packaging can be found for the animal product along with food/beverages/tobacco (the balance of the export / import comparison has negative values in the analysis);

-on the whole exported agricultural products the fluctuations and the annual balance sheets limit the levels can be delimited in the following periods: period 2008-2012 for which the negative meaning indicates a decrease of exports compared to imports; the period 2014-2015 with positive values that indicate the most favorable values from the achieved levels; period 2015-2019 which is represented by a favorable upward increase in balance sheet values.

Synthetically, by interpreting these figures / meanings of the balances for the total agricultural exports, there is an overall negative trend of these activities, but in the structure the levels are evolutionarily positive for vegetable products and fats / oils.
* Balance of foreign trade in agricultural products from Romania with the European Union. The value levels given in Table 7 indicate the differentials whose interpretative meanings can be considered by the following:

- negative trend for the whole dynamics of the years for live animals / animal products and food/beverages/tobacco;

- the existence for certain years with favorable levels for vegetable products and fats/oils.

Table 7. Balance of foreign trade with agricultural products, from Romania, (Export-Import) with the European Union

	Specification	MU	2008	2010	2012	2014	2016	2018	2019
1	I. Live animals and animal products	mil €	-883.6	-580.9	-448.5	-638.3	-860.4	-1,077.9	-1,328.6
2	II. Vegetable Products	mil €	-347.7	94.7	-96.8	202.1	-232.2	443.6	-60.9
3	III. Animal or vegetable fats and oils	mil €	-70.6	-21.8	-16.8	5.0	-20.4	36.3	37.9
4	IV.Food, beverages and tobacco	mil €	-741.4	-399.7	-464.5	-313.4	-762.7	-1,310.5	-1,313.0
5	TOTAL agriculture (total 1,2,3,4)	mil €	-2,043.3	-907.7	-1,026.7	-744.5	-1,875.7	-1,908.5	-2,664.6

Source: NIS, 2021, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 [6].

Of all these, it is not possible to say that there is a lower export than the unimportant import which does not determine a favorable balance. Only for vegetable products, oils and fats/oils is there a favorable trend.

Conclusions

The analysis of the foreign trade with agricultural products from Romania for the period 2008-2021 presented in terms of export/import value levels can be summarized as follows:

(1) The whole of the foreign trade expressed by the total value of the agricultural export registers increases, at which variations are signaled, but at which it can be mentioned that these amplifications are more accentuated compared to the succession of the existing rhythms at national level.

(2) In the case of the analysis of the amount of export of agricultural products, we find that they can be part of a favorable growth trend, the trend being maintained by comparison with total agricultural imports. In the structure of the products from the analysis carried out in the period 2008-2019, it appears that in relation to total exports agricultural products can be reported differences in high weights for plant products, food, beverages and tobacco, along with low levels for exports to animals, fats and oils (vegetable/animal). It can be mentioned that for the whole structure of the products there is an increase but accompanied by annual value oscillations sometimes very accentuated.

(3) The analysis of these agricultural exports to the EU shown by appropriate comparative elements are reflected in annual increases, but by comparison with total agricultural exports the levels are delimited by pre-percentage levels ranging between 59.94% and 77.7%. At the same time, there is a decrease in the export of live animals and animal products, fats and oils (vegetable/animal) along with an increase in vegetable and food products. In short, the export of agricultural products to the EU's territorial area can be in line with higher than the dynamics of total exports from agriculture, but it can be added that exports remain below imports.

(4) The value analysis of the total imports of agricultural products from Romania both as a whole and in structure shows that for most of the annual levels there are increases but with the maintenance of some variations in the dynamics of the analyzed period. The dominant ensemble of these imports is owned by animal, vegetable and food products, beverages and tobacco.

(5) The value of the agricultural import from Romania with the European Union represents a majority amount (compared to total imports), with reference to the sections that include the products of special importance (which include animal, vegetable and food products, beverages and tobacco). At the same time, from the analysis of the annual rhythms for animal and vegetable products, growth and decrease curves can be observed for certain periods of years.

(6) The interpretation of the meanings of the foreign trade balance indicates an overall negative trend of this activity. It can be mentioned that in the final period analyzed the levels of the balance sheet result of certain products is evolutionarily positive (with reference to vegetable products and fats/oils). It can be mentioned that there is for some products an export higher than the import but which on the whole of the foreign trade does not determine a favorable balance.

R E F E R E N C E S

[1] Constantin M., Explanatory dictionary of agromarketing, Ed. Of the Romanian Academy of Scientists, Bucharest (2021).

[2] Council Directive 74/409/EEC on the harmonization of the laws of the member states related to honey.

[3] National Institute of Statistics, Statistical Yearbook of Romania (2015).

[4] National Institute of Statistics, Contact details of living standards in Romania, Population earnings and consumption (2015).

[5] National Institute of Statistics, Food Balances, (2008-2015).

[6] National Institute of Statistics, Foreign trade, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 20, 2021 (2021).

QUALITATIVE HEALTHY BEHAVIOUR THROUGH MOUNTAIN SERVICES. EVIDENCE FROM CENTRAL AND EASTERN EUROPEAN ENTREPRENEURSHIP

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Abstract. *The purpose of the paper is to present the benefits of the mountain services on qualitative healthy behaviour. Mountain services referring in the article are connected with Arts, entertainment, recreation and other service activities Eurostat sectors, being analysed various entrepreneurship indicators. Mountain scientists considers that this type of relief develop healthy behaviours and qualitative arts and services because of the less-polluted ecosystem. The results of the paper present the situation of mountain arts and services entrepreneurship in Central and Eastern Europe and measures for increased degree of mountain development. These countries are important vectors in European mountain science. European mountain arts and services present a major potential for the entrepreneurs around the world.*

Keywords: entrepreneurship; health and services; healthy behaviour; mountain services; Central and Eastern Europe

1. Introduction

Mountain scientists consider that mountain services, especially arts, entertainment and recreation, has numerous benefits for human health, this area being nutritional and recreational superior than other types of relief because of the less polluted water-air-soil ecosystem [2, 12, 13,16,17].

Health promotion has a key role in disease prevention and the adoption of healthy lifestyles and the call to develop the “science” of health promotion or the need to develop a greater degree of reliability has led to various initiatives aimed at developing different standards of practice. Laverack's article draws attention to several vital and interdependent aspects. Health promotion work is both science (research and theory) and art (intuition and experience). Although art is subjective, based on a history and certain interpretations, it is hoped for a aggregation of generally accepted practices and the establishment of models or the emergence of opinion leaders. In many cases, practitioners lack experience and do not know how to apply the many theories, models and approaches they have at their disposal, for the different contexts in which they work [9].

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A synthesis report published by the Health Evidence Network WHO: *What is the evidence on the role of the arts in improving health and well-being? A scoping review (2019)*, demonstrates how interventions through art can contribute to improving health and well-being, contributing to the prevention of a variety of mental problems and physical illnesses and support in the treatment or management of a range of acute and chronic conditions that occur throughout life. As such, artistic interventions are often low-risk, highly cost-effective, integrated and holistic treatment options for complex health challenges to which there are no current solutions [7].

According to the *Intersectoral action summary: the arts, health and well-being* (WHO, 2019), the arts, including the performing arts, visual arts, design and crafts, digital and electronic arts, literature, cultural activities and events, have a crucial role to play in ensuring a healthy life and the promotion of well-being throughout life. Involvement through the arts sector can help social health factors such as the development of social cohesion, the reduction of loneliness and social isolation, the construction of individual and group identity, etc. Art programs have been shown to reduce conflict by promoting intercultural understanding by developing tolerance and cooperation between different groups. In addition, art programs can help reduce both social inequalities and increase equity in health by developing skills, promoting and strengthening the capacity for social inclusion and can give each child a better start in life (through more effective language acquisition), improving the mother-child connection, etc. It has been found that programs involving art lead to a better degree of health awareness, promote a healthier diet and reduce risky behavior such as drug and alcohol use or engaging in unprotected sex. Art programs improve empathy, encourage positive attitudes toward people with mental and physical illnesses, and promote resilience among people with health conditions. The arts are also effective in reaching people at higher risk to health such as children in care, the homeless and people who may be discriminated against on the basis of race, ethnicity, gender or sexuality [22].

In the report *A systematic review of the subjective wellbeing outcomes of engaging with visual arts for adults ("working-age", 15-64 years) with diagnosed mental health conditions*, Tomlinson et al. [21] demonstrated and argued that visual arts and related artistic, creative, and craft practices have the potential to enhance the subjective well-being of adults affected by mental health conditions. The potential for progressive recovery, for the re-employment of people whose confidence and capacity have been rebuilt and restored, was based on the encouragement and construction of a new identity of "artist". Using research techniques combined with appropriate theories and using standardized wellness measures, research would lead us to a better understanding of the capacity of the visual arts and can better guide us in helping to improve the well-being of adults facing mental health problems. Such research could inform and lead to a better understanding of the precise contexts and mechanisms of the effectiveness of art interventions.

A consistent and well-documented report prepared by APPG [1], sends us three key messages: the arts can help us maintain good health, can help us recover and sustain a longer and better lived life; the arts can positively prevent the major challenges facing health and social care (aging, better long-term conditions, loneliness and mental health); the arts can help save money on health and welfare services.

Artists can help facilitate the creative state that leads to open access to feelings of flow and maybe even spirituality. Health artists are not shamans or healers or therapists but facilitators of the transcendent power of art. They can help and support caregivers and staff in their painful and highly meaningful experiences of caring for others and managing medical situations, the complexity of life and death [18].

As both artistic therapies and the arts in the field of health care grow and health promotion practices are established, numerous “subset” disciplines will be developed in this field. In music, these include medical music therapy, medical ethnomusicology, ethno-musical therapy, recovery music, community music therapy, neurological music therapy, and countless individual methods that “apply” or involve music in health practices. Moreover, there are additional social and individualized uses of the arts outside of discrete environments, such as daily coping practices, the use of MP3 players as a coping resource, and so on. Music is explored more regularly to promote health and based on conventional scientific evidence, it is applied instead of more invasive, risky and expensive health interventions. In healthcare and biomedical systems around the world, where highly technical, pharmacology-based treatments are normal, art therapy is making significant progress. As a low-risk and cost-effective intervention, music and other art forms have the potential to improve health outcomes while reducing the number of injuries and deaths from invasive medical tests and treatments [19].

The subject of arts, entertainment, recreation and others services for human health presents higher interests in Central and Eastern Europe entrepreneurship, especially for the mountain area. The authors consider as a case study the screening of the mountain entrepreneurship for arts, entertainment, recreation and other services which support the human health. The paper present important data for current and future arts and services mountain entrepreneurs.

2. Materials and Methods

Data has been extracted from Eurostat [4, 5, 6] (for the country which report data to European Commission) and Statista [20] and processed in Excel and SPSS. In SPSS it has been realized the descriptive statistics, presenting the histogram, normal Q-Q plot, detrended normal Q-Q plot and the interquartile diagram. Data has been verified through M-Estimators, as Huber's M-Estimator (the evaluation of the constant was 1.339), Tukey's Biweight (the evaluation of the constant was 4.685), Hampel's M-Estimator (the evaluation of the constant was 1.700, 3.400 and 8.500) and Andrews' Wave (the evaluation of the constant was 1.340*pi). Regarding the normality tests it has been applied Kolmogorov-Smirnova and Shapiro-Wilk.

In the discussed period, Eurostat data regarding *Arts, entertainment, recreation and other service activities* sectors, show increases for the *Population of active enterprises* index, respectively Bulgaria (29.53%), Croatia (3.29%), Hungary (25.52%), Lithuania (94.19%), Romania (81.87%) and Slovakia (15.23%). On the other hand, Austria (-14.20%) reduced the population of active enterprises, but it increased the value of *Arts, entertainment, recreation and other service activities* sectors. In the period 2016-2017, increases of the activity were in the Czech Republic (3.19%), Estonia (4.17%), Poland (7.30%) and Slovakia (9.07%), while Latvia (-5.91%) reduced its activity. Specific for the mountain area *Population of active enterprises in t – number* present fluctuation in Bulgaria 16.66%, Czech Republic -3.99%, Croatia 15.92%, Austria 0.39%, Poland 8.56% (2016/2017), Romania 33.48%, Slovakia 49.62%.

3. Results and Discussions

Entrepreneurship regarding *Arts, entertainment, recreation, and other service activities* for rural and urban area presents between 2015-2017 period important fluctuations in Central and Eastern European countries. In the analyzed period, the index *Population of active enterprises* grew up in Austria with 2.96%, Bulgaria 7.11%, Croatia 25.01%, Czech Republic 5.46%, Estonia 10.01%, Hungary 23.73%, Lithuania 16.26%, Romania 18.63%, Slovakia 15.35% and Latvia decrease -5.91%.

Specific for *Arts, entertainment and recreation,* in 2013-2018 period, Eurostat data presents relevant indicators which influenced the entrepreneurship from Central and Eastern European countries. *Population of active enterprises in t – number* changed in Austria -14.00%, Bulgaria 34.06%, Czech Republic 34.02%, Estonia 24.04%, Croatia 73.20%, Hungary 47.78%, Lithuania 63.51%, Latvia 103.20%, Romania 74.99%, Slovakia 68.72. *Enterprises newly born in t-1 having survived to t – number* fluctuate in Austria -21.36%, Bulgaria 20.22%, Czech Republic 45.84%, Croatia 15.84%, Hungary 129.43%, Lithuania 62.03%, Latvia 96.79%, Romania 113.84%, Slovakia 90.76%. *Persons employed in the population of active enterprises in t – number* variate Austria -7.22%, Bulgaria 23.44%, Czech Republic -17.91%, Estonia 36.84%, Croatia 24.02%, Hungary 67.20%, Lithuania 5.00%, Latvia 12.43%, Romania 25.67%, Slovakia 34.33%. *Employees in the population of active enterprises in t – number* changed in Austria -1.18%, Bulgaria 20.84%, Czech Republic -24.98%, Estonia 65.77%, Croatia 21.29%, Hungary 64.31%, Lithuania -2.31%, Latvia 2.85%, Romania 14.14%, Slovakia 15.10%. *Persons employed in the population of enterprises newly born in t-1 having survived to t – number* fluctuate in Austria -9.10%, Bulgaria 2.66%, Czech Republic -12.08%, Croatia 35.09%, Hungary 89.56%, Lithuania 20.86%, Latvia 60.12%, Romania -19.14%, Slovakia 16.24%. *Persons employed in the year of birth in the population of enterprises newly born in t-1 having survived to t – number* variate in Austria -21.51%, Bulgaria 3.25%, Czech Republic -22.13%, Croatia 22.63%, Hungary 97.78%, Lithuania -13.46%, Latvia 14.70%, Romania 58.79%, Slovakia 64.10%. *Birth rate: number of enterprise births in the reference period (t) divided by the number of enterprises active in t – percentage* changed in Austria 1.50%, Bulgaria 7.24%, Czech Republic 34.62%, Estonia 21.57%, Croatia 1.79%, Hungary 17.26%, Lithuania -38.34%, Latvia -16.42%, Romania -26.88%, Slovakia 87.21%.

Regarding *other service activities*, the Eurostat analyzed indicators variate considerable in 2013-2018 period. *Population of active enterprises in t – number* having fluctuation in Austria 20.51%, Bulgaria 21.16%, Czech Republic -6.71%, Estonia 21.22%, Croatia 7.24%, Hungary 67.82%, Lithuania 37.49%, Latvia 33.38%, Romania 31.44%, Slovakia 58.90%. *Enterprises newly born in t-1 having survived to t – number* variate in Austria 37.90%, Bulgaria 0.06%, Czech Republic -23.89%, Croatia -0.61%, Hungary 256.81%, Lithuania 13.92%, Latvia -6.42%, Romania 59.47%, Slovakia 55.85%. *Persons employed in the population of active enterprises in t – number* variate in Austria 6.28%, Bulgaria 13.29%, Czech Republic -24.45%, Estonia 16.46%, Croatia -0.54%, Hungary 80.02%, Lithuania -1.13%, Latvia 14.20%, Romania 16.58%, Slovakia 43.85%. *Employees in the population of active enterprises in t – number* changed in Austria -1.79%, Bulgaria 4.17%, Czech Republic -22.11%, Estonia 30.73%, Croatia 4.38%, Hungary 70.59%, Lithuania -14.16%, Latvia 15.38%, Romania 8.66%, Slovakia 15.52%. *Persons employed in the population of enterprises newly born in t-1 having survived to t – number* fluctuate in Austria 37.19%, Bulgaria -8.71%, Czech Republic -37.65%, Croatia -13.01%, Hungary 296.59%, Lithuania -15.03%, Latvia -24.81%, Romania 29.97%, Slovakia 31.19%. *Persons employed in the year of birth in the population of enterprises newly born in t-1* having survived to t – number variate in Austria 18.21%, Bulgaria 0.45%, Czech Republic -42.32%, Croatia -9.20%, Hungary 281.72%, Lithuania -41.93%, Latvia -33.81%, Romania 48.14%, Slovakia 39.65%. *Birth rate: number of enterprise births in the reference period (t) divided by the number of enterprises active in t – percentage* changed in Austria 15.57%, Bulgaria 4.32%, Czech Republic -3.56%, Estonia 10.94%, Croatia -3.78%, Hungary 13.97%, Lithuania -30.90%, Latvia -32.05%, Romania -25.65%, Slovakia 37.61%.

In 2008-2017 period, Austrian *population of active enterprises* decrease by -8.38%. In 2011-2017 period, Romanian population of active enterprises has been increased by 81.87% (Fig. 1).

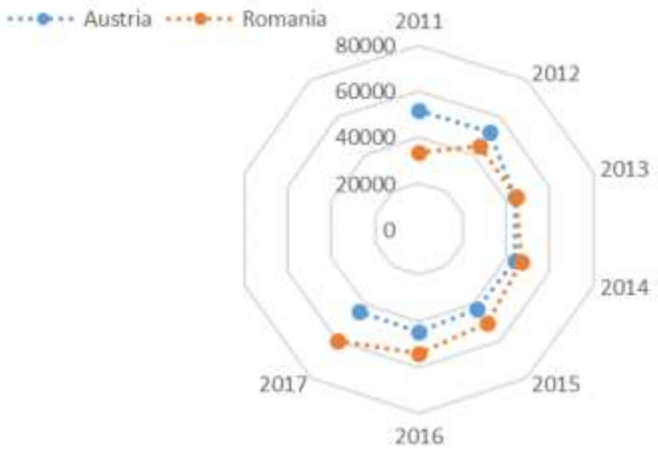

Fig. 1. Population of active enterprises in Austria and Romania
Source: Designed by authors according to Eurostat [4, 5, 6].

As seen in Fig. 1, in 2011-2017 period, the dynamics for Romanian *population of active enterprises* has been more sustained in Romania than in Austria.
Specific for Austrian Tyrol region and for its counties, respectively for the Romanian North-East region and its counties, the index Art, entertainment and recreation, and other activities follow trends from these country (Fig. 2).

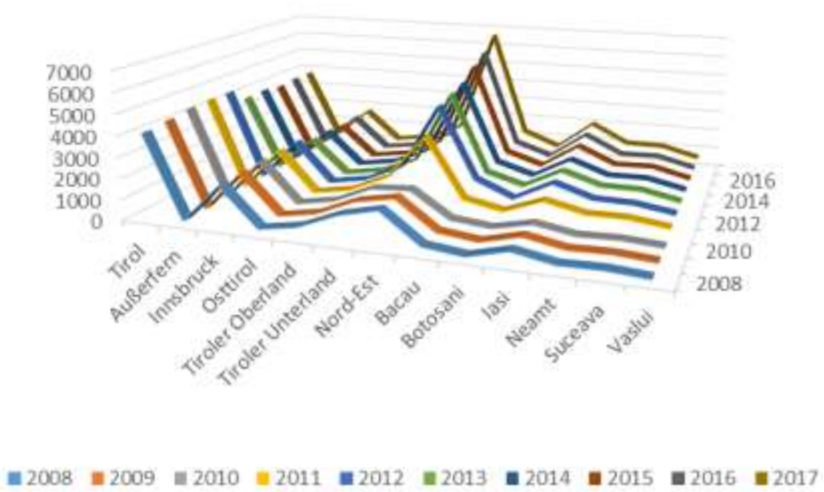

Fig. 2. Population of active enterprises in Tyrol and North-East, respectively its counties
Source: Designed by authors according to Eurostat [4, 5, 6].

In 2008-2017 period, Tyrolian Außerfern county increase its index with 21.01%, expansion based on entertainment and recreation services for tourists, especially in rural area. It was developed a tourism based on educational and agriculture issues.

According to Statista [20], the share of economic activity in the primary, secondary and tertiary sectors in GDP changed significantly, between 2008 and 2016, in the North-East region of Romania [3]. Thus, agriculture reduced its volume of activity by 33.84%, industry by 14.29%, while services registered average increases by 12.36%. The most important explanation is related to the development of the *entertainment and hospitality* sector, especially in the case of people of Romanian origin who live in other countries and who come to Romania occasionally, preferably during the summer months or seasonal holidays. North-Eastern Botosani county increase its index by 405.22%, based on clusters and services from entertainment. The degree of entrepreneurship of the North-East region of Romania has increased considerably based on the financial power of emigrants who have invested heavily in their businesses in their native places [8].

Specific for the North-East area of Romania, the descriptive statistics for *Art, entertainment, recreation, and other activities services* (Fig. 3 - panels a, b, c, d) show an average of 3,527.88 with a standard error of 594.480, 95% confidence interval with the lower limit of 2,122.15 and the upper limit of 4,933.60, value lower average 5% of 3,531.03, median of 4,046, variance of 2,827,251.839, standard deviation of 1,681.443, minimum of 1,478 in 2010, maximum of 5,521 in 5,521, interval of 4,043, interquartile range of 3,267, stroke of -284 with a standard error of .752, Kurtosis of -2.115 with a standard error of 1.481.

At a first analysis, the distribution curve is relatively symmetrically central, and the scores around the average are very concentrated, with the aspect of leptocurticity, although the distribution is unimodal.

Working hypothesis for the North-East region of Romania: the distribution of scores is considered normal and, therefore, parametric tests will be applied. The extreme values of the distribution, although they are in very small numbers, change the appearance of the histogram, by inducing a positive asymmetry, being still clinically important. The concentration of a large number of scores around the average (M = 3,527.88) produces a certain leptocurticity of the distribution, due to the related phenomena in the Romanian economy. The logarithm of the values obtained, on to the universally accepted statistical rules, allowed to balance the distribution according to the normal Gauss-Laplace curve.

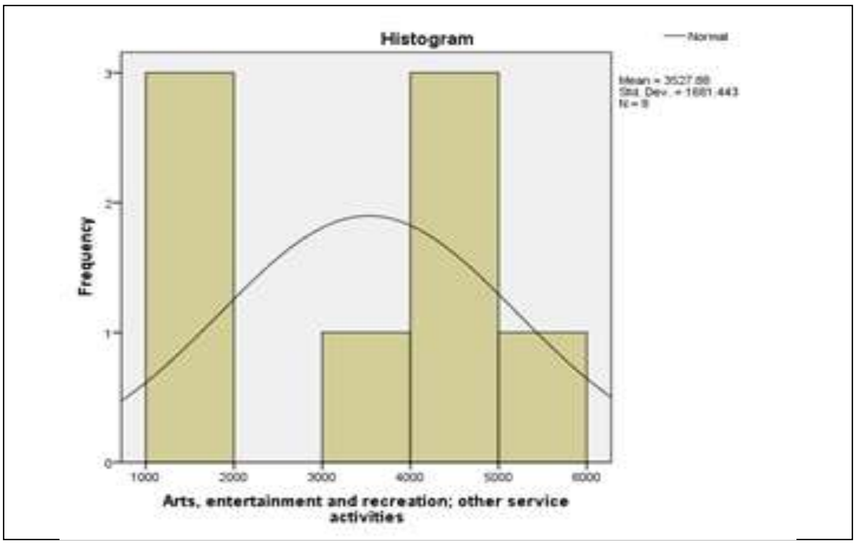

Fig. 3 panel a. Histogram

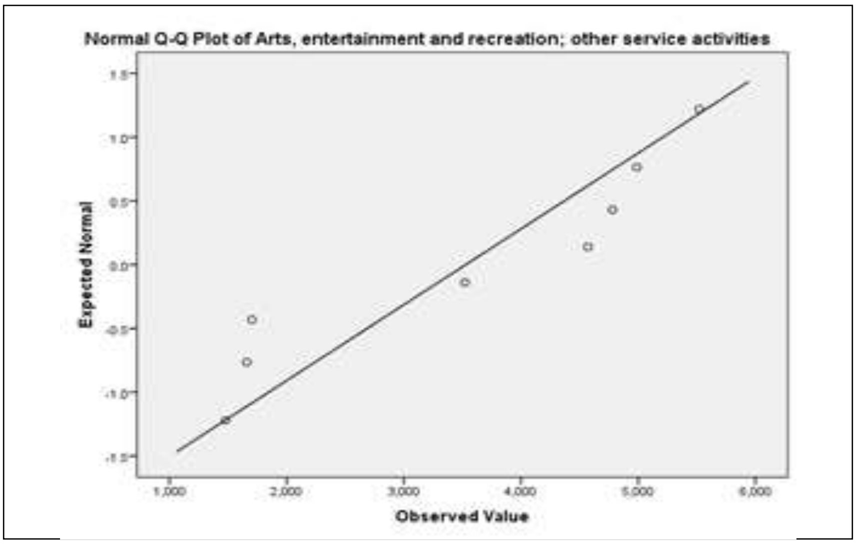

Fig. 3 panel b. The graph of the Q-Q normal plot distribution, after logarithm

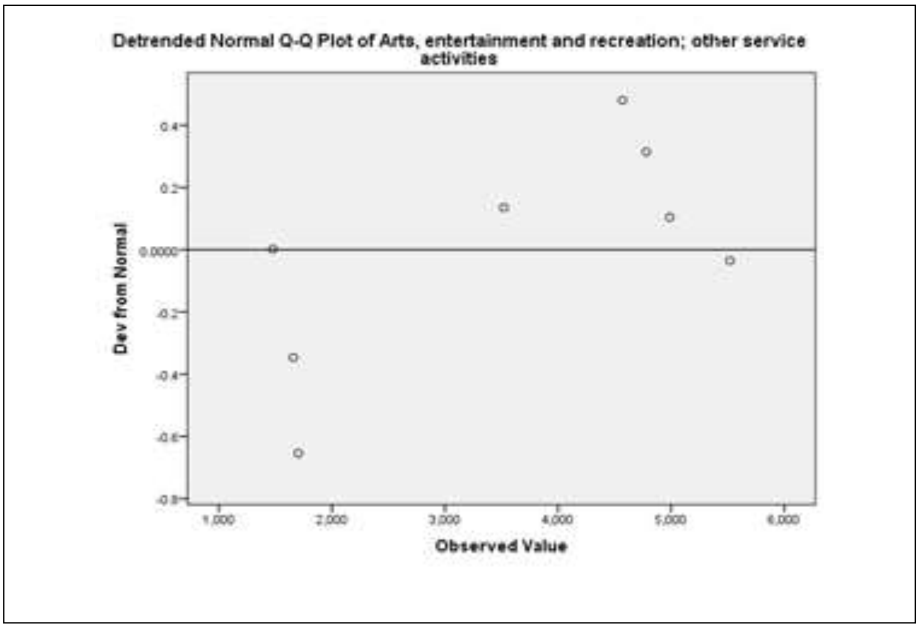

Fig. 3. panel c. The dispersion of the observed scores, compared to normal, by the Q-Q detrended plot test, after logarithm

Fig. 3 panel d. Inter-quartile diagram

Fig. 3. Descriptive statistics for Arts, entertainment, recreation, and other services in the Romanian North-east region

Source: Processed by author according to Eurostat [4, 5, 6].

The normal Q-Q plot test, after logarithm, shows a distribution of real scores around normal values, represented by the oblique line in the graph, which corresponds to a normal distribution. The Q-Q detrended plot test, on the dispersion of empirical scores to normal, represented by the right with the score z = 0 for the mean and standard deviation 1, after logarithm, shows that they fall within a standard deviation, corresponding to a normal distribution.

The central trend for this sector in the analyzed period, amounting to 3,527.88 (average), shows that the north-eastern population of the active enterprises in the analyzed sector increased from 2008 (1,703) to 2015 (5,521). During the analyzed period, the hypothesis H1 (intensification of the activity) was verified, the frequency having a total variation of 1.5 - from 0.5 to 1.5.

The statistics, presented above, and the histogram confirm the high agglomeration and the development trend of this sector in the northeastern region of Romania. At the same time, statistics confirm the intensification of the sector growth, especially for arts and entertainment.

Regarding European mountain entrepreneurship, the sectors *Arts, entertainment, recreation, and other service activities*, variate for the indicator *Population of active enterprises in t - number* as follow in Bulgaria with 90.39%, Czech Republic -35.48%, Spain 18.94%, France 45%, Croatia 2.93%, Italy 6.44%, Austria -4.95%, Poland 8.56%, Portugal 8.29%, Romania 312.29%, Slovakia 47.59%. *Enterprises newly born in t-3 having survived to t – number* variate in Bulgaria -1.29%, Czech Republic -32.69%, Croatia -15.38%, Austria -10.93%, Poland -2.18% (2016/2017), Romania 0.20%, Slovakia 196.60%. *High growth enterprises measured in employment (growth by 10% or more) – number* changed in Bulgaria -1.11%, Czech Republic -26.32%, Croatia -30.00%, Austria -17.24%, Romania 166.67%, Slovakia 28.57%. *Persons employed in the population of active enterprises in t – number* fluctuate in Bulgaria 3.28%, Czech Republic -26.21%, Croatia 28.03%, Austria 2.74%, Poland 4.40%, Romania 26.49%, Slovakia 40.25%. *Birth rate: number of enterprise births in the reference period (t) divided by the number of enterprises active in t – percentage* having fluctuation in Bulgaria -0.56%, Czech Republic 3.82%, Croatia 22.49%, Austria 7.36%, Poland 15.93% (2016/2017), Romania -40.44%, Slovakia 52.22%. *Death rate: number of enterprise deaths in the reference period (t) divided by the number of enterprises active in t – percentage* presents variation in Bulgaria 13.28%, Czech Republic 6.30%, Croatia -29.54%, Austria 14.19%, Romania -24.91%, Slovakia -9.40%. *Survival rate 3: number of enterprises in the reference period (t) newly born in t-3 having survived to t divided by the number of enterprise births in t-3 – percentage* changed in Bulgaria 0.31%, Czech Republic 61.02%, Croatia 81.89% (2016/2017), Austria 1.45%, Romania -73.62%, Slovakia 33.41%. *3-year-old enterprises' share of the business population – percentage* fluctuate in Bulgaria -

15.32%, Czech Republic -29.92%, Croatia -27.10%, Austria -11.18%, Poland - 9.88%, Romania -24.81%, Slovakia 98.28%. *Employment share of 3-year-old enterprises: Number of persons employed in enterprises newly born in t-3 having survived to t, divided by the number of persons employed in the population of active enterprises in t – percentage* variate in Bulgaria 1.68%, Czech Republic - 19.82%, Croatia -44.80% (2016/2017), Poland - 6.84% (2016/ 2017), Romania - 14.92%, Slovakia 73.26%.

The paper presents the situation of arts, entertainment, recreation and others services for human health from the Central and Eastern Europe entrepreneurship and behaviors, especially for the mountain area. Reading the article, entrepreneurs should understand the behavior regarding Central and Eastern European arts and services, especially from the mountain area. The entrepreneurs could understand the tendencies from different countries, in order to place their investments in one country or another [14]. European arts and services business mountain environment present a major potential for entrepreneurs around the world.

The article show that qualitative choice and healthy behavior could be implemented at the superior level in the mountain area because the natural ecosystem of this area is better developed than low-land areas. An additional argument in favor of the mountain area is the lower degree of pollution, which, as a consequence, may offer more opportunities for business development in this region [10, 11, 15].

As seen, the expansion from Central and Eastern European countries (except Austria), and their regions, is considerable. But, differently from Austria, the entrepreneurship of the other Central and Eastern European countries is based on European funds insertion, and other volatile funds, and not to real economy growth. Potential investors could have important contributions on real economic growth from Central and Eastern European countries, especially from the mountain area. Understanding the behavior of European mountain arts and services consumer, the entrepreneurs should be able to offer adequate market response.

Conclusions

(1) The paper demonstrates that the mountain entrepreneurship regarding arts, entertainment, recreation and other services for human health, increased continuously in Europe, especially in Central and Eastern Europe. Austria represent a model to be followed by the other European countries, and not only. In Austria, the population is educated to understand the benefits of the arts, entertainment, recreation and other services on human health. An emergent country in this sense is Romania, another country from Central and Eastern Europe.

(2) A key challenge for the future of health promoting will be the development of a framework where capable professionals will reduce the gap between theory and practice, and thus others will be able to apply "art and science" in various medical contexts, including vulnerable populations. But understanding how to best apply both art and science in this field requires not only scientific supremacy but also the ability to judge real and be realistic. For health professionals, the arts can facilitate the explanation of diseases, can develop understanding and diagnostic skills, can explain symptoms through the use of various art forms. It has been found that art programs applied in medical education and health care organizations improve the mental health and well-being of staff and reduce stress and burnout. It has been found that similar community programs for informal caregivers improve resilience.

R E F E R E N C E S

[1] APPG, Creative Health: The Arts for Health and Wellbeing. Second Edition. All-Party Parliamentary Group on Arts, Health and Wellbeing - Inquiry Report, (2017), https://www.culturehealthandwellbeing.org.uk/appg-inquiry/Publications/Creative_Health_Inquiry_Report_2017_-_Second_Edition.pdf, Accessed on February 8, 2021.

[2] Bentivoglio, D., Savini, S., Finco A., Bucci, G., Boselli, E., Quality and origin of mountain food products: the new European label as a strategy for sustainable development, Journal of Mountain Science, Vol. 16, No. 2, 428-440 (2019), https://doi.org/10.1007/s11629-018-4962-x, Accessed on January 30, 2021.

[3] Chilian, M. N., Evolution of Regional and Sub-Regional Disparities in Romania–A Sectoral Shift-Share Analysis, Romanian Journal of Economic Forecasting, Vol. 15, No. 1, 187-204, (2012), http://www.rjef.ro/rjef/rjef1_12/rjef1_2012p187-204.pdf, Accessed on February 10, 2021.

[4] Eurostat, Business Demography Statistics, (2020a), https://goo.gl/fpmXZA, Accessed on February 8, 2021.

[5] Eurostat, Regional GDP, (2020b), https://goo.gl/EoyR38, Accessed on February 8, 2021.

[6] Eurostat, Structural Business Statistics, (2020c), https://goo.gl/KMtkVV, Accessed on February 8, 2021.

[7] Fancourt, D., Finn, S. Health Evidence Network synthesis report 67. What is the evidence on the role of the arts in improving health and well-being? A scoping review, WHO, (2019), https://apps.who.int/iris/bitstream/handle/10665/329834/9789289054553-eng.pdf, Accessed on February 5, 2021.

[8] Jula, D., Jula, N. M. Economic growth and structural changes in regional employment, Romanian Journal of Economic Forecasting, Vol. 16, No. 2, 52-69, (2013), http://www.ipe.ro/rjef/rjef2_13/rjef2_2013p52-69.pdf, Accessed on February 10, 2021.

[9] Laverack, G. The Challenge of the ‘Art and Science’ of Health Promotion, Challenges, Vol. 8, No. 2, 22 (2017), https://doi.org/10.3390/challe8020022, Accessed on February 5, 2021.

[10] Maikhuri, R. K., Rawat, L. S., Negi, Vikram S., Purohit, V. K., Rao, K. S., Saxena, K. G., Managing natural resources through simple and appropriate technological interventions for sustainable mountain development, Current Science, Vol. 100, No. 7, 992-997 (2011), https://www.currentscience.ac.in/cs/Volumes/100/07/0992.pdf, Accessed on March 5, 2021.

[11] Melkania, U., Prasad, H. J. S., Prasad, J., Natural resource management in mountains. Current Science, Vol. 91, No. 6, (2016), https://www.currentscience.ac.in/Downloads/article_id_091_06_0740_0741_0.pdf, Accessed on March 5, 2021.

[12] Misbahuzzaman, K. Traditional farming in the mountainous region of Bangladesh and its modifications, Journal of Mountain Science, Vol. 13, No. 8, 1489-1502 (2016), https://doi.org/10.1007/s11629-015-3541-7, Accessed on January 30, 2021.

[13] Negi, G. C. S., Agrawal, D. K. Measuring and valuing ecosystem services: Himalayan mountain context, Current Science, Vol. 91, No. 5, 119-136, (2006), https://www.currentscience.ac.in/cs/Downloads/article_id_091_05_0573_0575_0.pdf, Accessed on January 30, 2021.

[14] Oztemel, E., Ozel, S., A conceptual model for measuring the competency level of Small and Medium-sized Enterprises (SMEs), Advances in Production Engineering & Management, Vol. 16, No. 1, 47–66, (2021), https://doi.org/10.14743/apem2021.1.384, Accessed on March 5, 2021.

[15] Parlevliet, J., Xenogiani. T., Report on informal employment in Romania, OECD Development Centre Working Papers, 271:1, (2008), https://issuu.com/oecd_development_centre/docs/wp_271report_on_informal_employment_in_romania, Accessed on March 5, 2021.

[16] Peng, L., Wang. X.X. What is the relationship between ecosystem services and urbanization? A case study of the mountainous areas in Southwest China, Journal of Mountain Science, Vol. 16, No. 12, 2867-2881 (2019), https://doi.org/10.1007/s11629-019-5390-2, Accessed on February 5, 2021.

[17] Sati, V.P., Vangchhia, L. Food security status in rural areas of Mizoram, Northeast India, Journal of Mountain Science, Vol. 14, No. 4, 795-805 (2017), https://doi.org/10.1007/s11629-016-4092-2, Accessed on February 5, 2021.

[18] Schwartz, R. (n.d.). Arts + Health. Research, Practice + Experience. https://www.uvm.edu/sites/default/files/ih_cp_forum_art_and_health.pdf, Accessed on February 8, 2021.

[19] Sonke, J., Music and the Arts in Health: A Perspective from the United States, Music and Arts in Action, Vol. 3, No. 2, 5-14 (2011), https://www.artshealthresources.org.uk/wp-content/uploads/2018/04/2011-Music-and-Arts-in-Health.pdf. Accessed on February 8, 2021.

[20] Statista, Romania: Share of economic sectors in the gross domestic product (GDP) from 2006 to 2016, 2020, https://goo.gl/tFF8uW, Accessed on February 8, 2021.

[21] Tomlinson, A., Lane, J., Julier, G., Grigsby D.L., Payne, A., Mansfield, L., Kay, T., John, A., Meads, C., Daykin, N., Ball, K., Tapson, C., Dolan, P., Testoni, S., Victor, C. A systematic review of the subjective wellbeing outcomes of engaging with visual arts for adults

("working-age", 15-64 years) with diagnosed mental health conditions. What Works Centre for Wellbeing, (2018), https://static.a-n.co.uk/wp-content/uploads/2019/01/Visual-art-and-mental-health.pdf, Accessed on February 5, 2021.

[22] WHO, Intersectoral action: the arts, health and well-being. Synergy between sectors: supporting health through the arts, Copenhagen: World Health Organization Regional Office for Europe, (2019), https://www.euro.who.int/__data/assets/pdf_file/0015/413016/Intersectoral-action-between-the-arts-and-health-v2.pdf, Accessed on February 5, 2021.

RURAL DEVELOPMENT SUSTAINED BY AGRI-TOURISM AND THE NOVELTY OF THE ROMANIAN VILLAGE

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Abstract. *The balancing of the rural-urban ratio aims to find attractors for rural development. Such a demarche is represented by the present study that aims to find solutions for rural development in different regions of Romania with various characteristics in geo-resources, analyzing as* ***attractors****: agri-rural tourism and the capitalization of the novelty of the Romanian village. There is introduced a series of elements regarding farm production and typology, but also applications of the principles of Hospitality Industry in rural tourism. From here also the proposed objectives of the paper to emphasize the diversity of local communities, in function of village categories and, respectively, the structure and definition of tourist destinations from the rural space. The paper also proposes to apply the concepts of the agri-rural tourism in order to find solutions to avoid or counteract socio-economic dangers for the feasible development of the rural areas. Thus, there is described the economic potential, especially on the line of the agri-food system and, implicitly, the settlement of the development through the tourist dimension in correlation with the novelty of the Romanian village. There are established a series of aspects necessary to the bioharmonization of the traditional rural with the modernity of the current decades.*

Keywords: agri-food, farm, rural, tourism, village

1. Introduction

Next to the modern ***urban Romania***, preferred for its dynamism, promptitude and receptivity, there is a ***rural Romania***, much poorer and more traditional, less visible for investors (especially the foreigners), but that, as it is known, counts about 8-9 million inhabitants and detains almost 90 % from the country surface.

The average rural „Out of mind" is although to be seen, among others, by the more and more accentuated tourism, especially its productive form: ***agritourism that through cyclicality"rounds*** off" the farmers 'revenues. ***Agrirural tourism*** as a whole, by potential offers, *archives* the patrimony delimited only by the vivid space and time of the village and imposes an accentuated development of products and touring services. The action is motivated by economic, social, historic needs but, surprisingly, especially **cultural ones**, with dramatic accents to save traditional,

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identity, authentic Romanianism and common sense of the peasant who loves its land [3, 6,12].

Mountain, highland, lowland or wet zone **agri-rural tourism** may lead the respective local community to a trend of *economic growth*. The hope is even greater in the context in which periods of economic crisis go by and, from social point of view, many rural zones are in degradation (as for example some of them from the mountain rural zone), with effect of *demographic desertification* [8, 13]. In this context one observes *the population getting older* and the extinction of the traditional Romanian village, with its cultural model and with all the theories that have tried to explain the wonder of its survival (!).

All these require as basic **objective** of the study an attentive analyses in order to find solutions to avoid or counteract major dangers for the rural space. This fact may be avoided on one condition, respectively the one through which **agritourism with rural Carpathian, sub-Carpathian or plain incidence –** may be professionally and seriously executed, ***attentively selecting from the special and temporal memory of the rural community***, those TRADITIONAL ELEMENTS completely disappeared from the contemporary European context, with the feeling of **restitution** of an apart cultural patrimony.

2. Materials and Methods

The study is based on a diagnosis of the Romanian rural environment and on analyses and statistic processing. There are considered principles, techniques and regulations specific to ecology and responsible tourism.

Data processing in order to find solutions to achieve the proposed objectives is made by analyzing three dimensions specific to rural environment: - the agri-rural dimension; - the touring dimension; and the cultural dimension by identifying the novelty of the Romanian village.

3. Results and Discussions

3.1. Romania's agri-rural dimension

The rural environment (*Romania's Encyclopedia*), unlike the urban environment, represents all the areas outside the towns and inhabited in our country by the population generically called „peasants", as an antonym for the urban population of „townsmen".

In Romania the rural space represents about 90% of the country surface, and the inhabitants share in the rural environment – among the highest in Europe – is of **45.4%** from the total population, namely 8,636,700 inhabitants (in 2021) (Fig. 1).

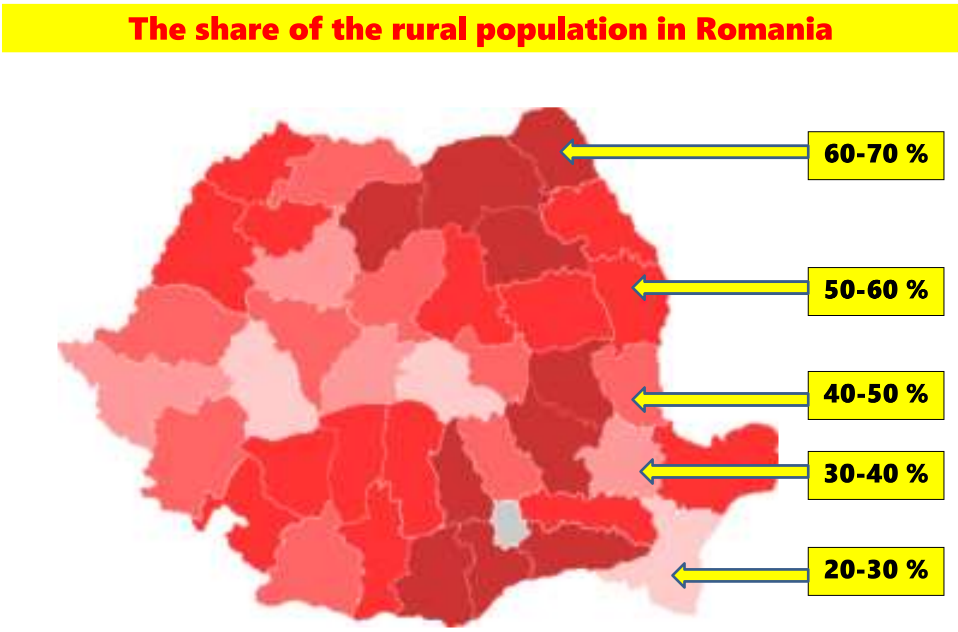

Fig. 1. Rural population share per departments
Source: Encyclopedia of Romania, Rural environment, http://enciclopediaromaniei.ro/wiki/Mediul_rural, Accessed on January 20, 2021 [15].

In the broadest meaning, it is considered that **agri-rural tourism**, which is part of the **responsible tourism** group (tourism responsible in relation with Nature), has as an objective to recreate in rural landscape events or attraction points that are not at disposal in urban zones in order to participate or experiment them. This landscape includes: natural reservations, open rural zones, villages and agricultural zones.

As for understanding the complexity of the **agri-rural tourism,** we mention the following basic concepts in *„agriculture-tourism-natural environment* interface [3]:

- ***The concept of rural-tourism*** – concerns the organization of the touring activity within the rural community, a zone, a region, a micro region or from the average rural basin;
- ***The concept of agritourism*** – treats the touring phenomenon only from inside the agricultural exploitation (with own pension and food) and activities of the tourists in the farm.
- ***The concept of tourism at the farm*** – treats the touring phenomenon in farm location (hire), but without active peasants, the allocated space being

meant to activities with the tourists (pedagogic farms, farms of equitation, guest houses, health houses, hunting lodges etc.)

From here also results the establishment of responsible tourism structure [2, 4], which is illustrated in Fig.2.

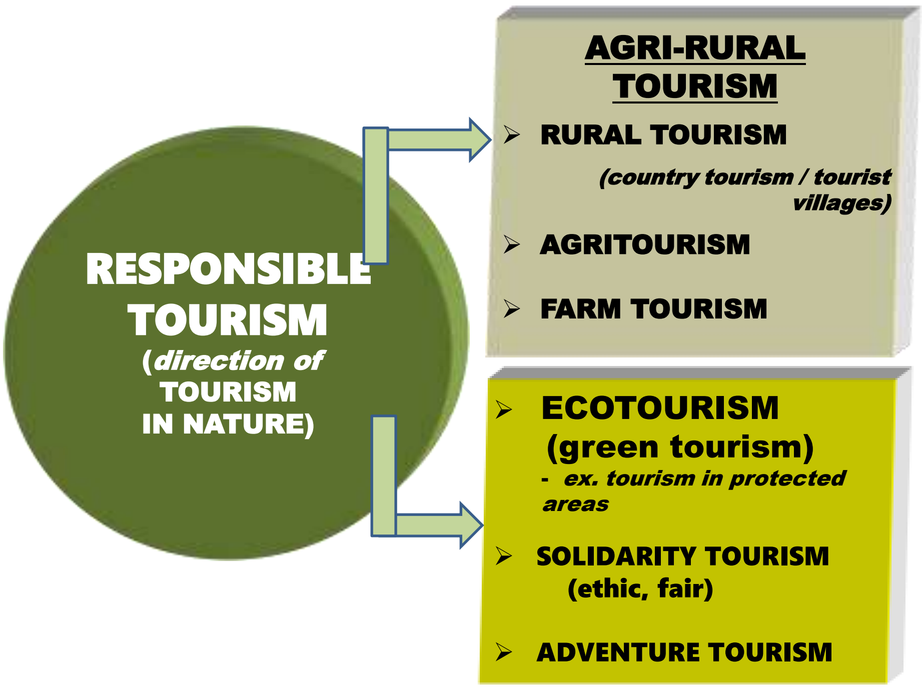

Fig. 2. Components of the tourism industry that have environment in the development equation
Source: Original conception.

The rural society in general and especially hospitality aspects [1, 9, 14, 15], as well as the Romanian rural economy, might remain of traditional type only under conditions of ***resize,*** of adequacy to the modern type of organic ecologic agriculture and, finally, of ***viability***.

Table 1. Structure of the European agricultural properties, per classes of size (ESU)

Country	**U.M.**	**TOTAL**	**0-5 ha**	**6-20 ha**	**21-50 ha**	**51-100 ha**	**over 100 ha**
EU-27	No.	7,816.0	3,921.0	2,405.7	808.3	393.4	287.6
	%	100.0	50.2	30.8	10.3	5.0	3.7
Romania	No.	1,236.0	918.2	289.6	14.9	4.6	8.6
	%	100.0	74.3	23.4	1.2	0.4	0.7

Source: The FSS for 2005 Report, Eurostat, 2006 [17].

The resize can't correlate to the American standard farm (being a practical impossibility), but reaching a quota comparable to EU-27 average (Table 1).

The solution of modernizing agriculture and rural space will inexorable expand over all economic and social structures, and also concerning psychology and communication [7, 10] within such a process, already obvious, the focus in on the main directions described in Table 2.

Table 2. Directions and actions in the development and modernization of the Romanian rural space

DIRECTION OF MODERNIZATION	SPECIFICATION
Direction (1)	• increasing agricultural productivity;
Direction (2)	• economic organization of exploitation structures in agriculture;
Direction (3)	• sustainable development of rural space infrastructure;
Direction (4)	• improvement of the production structure;
Direction (5)	• organization of branches on agri-food products;
Direction (6)	• soil conservation against natural and caused degradations;
Direction (7)	• diversification of cultures in order to ensure economic and ecologic stability;
Direction (8)	• programs to establish youngsters in rural environment;
Direction (9)	• pro-family rural agricultural policies and insurance of alternative sources of income;
Direction (10)	• Village revitalization, but through a new rural cultural model, a new type of rural community, much closer to the urban one.

Source: Original synthesis.

At present, *the structure of the agricultural exploitations* might be a little bit closer to the European model, but obviously completely different from the traditional village, the new defining elements being described by the following proportions (Table 3).

Table 3. Prognosis of the Institute of Agrarian Economy

No.	Category of agricultural holding	Average area	Share in total area (%)	Tendency
1	**Subsistence households**	0.5 - 3 ha	about 13.5	- reduction to about 1,100,000 ha
2	**Peasant exploitations**	3 - 10 ha	about 6.8	- growth to 1,000,000 ha
3	**Commercial peasant exploitations**	40 - 50 ha	towards 6.8	- growth to about 25,000 ha
4	**Family associations**	90 - 250 ha	Towards 20.3	- towards about 15,000 ha

Source: Original synthesis based on various studies made by the Institute of Agrarian Economy.

Of those presented, as a first step towards improvement, it results the indicative recommendation, namely to have as mark the ***average dimension*** of an exploitation 10 ha, and of a family association 200 ha.

3.2. The touring dimension of the Romanian rural space

Deepening the analysis, we will observe that the **touring destination** – *village, farm, pension or rooms from the peasant house* – is not the only touring product, or its single component, as it is known the fact that, as a rule, a destination includes several types of different touring products, adapted to the market [2,11]. Therefore, a **direct** solution is that the Romanian village should be **included in the tourist circuit,** so that it can be found either singular and original, or as a component among ***several types of touring products***, such as for example those from Table 4.

Table 4. The Romanian village in the tourist circuit

No.	TYPE OF RURAL TOURING PRODUCT	SPECIFICATION
1	Destination of holidays in the country	By rural tourism or by agritourism
2	Forms of the tourism at the farm	- farms specialized in receiving people with handicap; - farms specialized in receiving children; - farms specialized in receiving groups; - farms specialized in receiving special classes of nature study (botanic, zoology, biology and others); - farms for fishermen; - horse farms (equestrian) – host of a 7 day seminar for a certain number of participants;
3	Monastic tourism	A night long halt for a circuit at Moldavia or Oltenia under the mountain monasteries;
4	Visits at craft workshops	With observations or getting competences of folk crafts or achieving new performances (ceramics, pottery, carving wood, painting on glass or on eggs, braiding twigs or different fibers etc.);
5	Practicing and/or learning useful activities in urban environment too	The opportunity to practice gardening, cooking, juice and jam preparation etc.
6	Initiation in ethno-folklore	The scene of initiation in the art of folk dance or song.

Source: Original synthesis.

3.3. The novel of the Romanian tourist village

In an efficient strategy of touring development it becomes more than opportune to value the novel side of the Romanian tourist village. The Romanian rural society is relatively well preserved and keeper of a rich ethno folklore, more than that, it is not to be confused with the urban one. Rural touring products are searched and considered to be novel because they emphasize the organization of the society, the economic activities and, last but not least, the relation to space, time and Nature.

For exemplification, for the hearth of the village it is indicated to develop a specific and "successor" architecture for rustic houses or rural pensions (Fig.3), and for zones of rural activity (Fig.4), to apply traditional agri-food techniques „stuffed" with scientific novelty in order to stimulate the quality of the achieved products (ecological, biological ones etc.) (image sources: https://www.google.com/, Accessed on January 25, 2021).

Fig. 3. Conservation and development of the cultural and architectural specificity Source: https://www.google.com [16].

Fig. 4. Part of the Romanian village *soul* Source: https://www.google.com [16].

The strength of the Romanian village, that it has to preserve and diversify, is the authentic and original RURAL CULTURE. In this regard, in rural tourism multiculturalism is aimed by the concept of intercultural counterbalance [5] through which there may be practically observed how the staff from the host country is preoccupied (in a high percentage) to transmit cultural information about its own region or its own country. Thus, generally intercultural exchanges are achieved at the level of symbols, and among the symbols of the Romanian tourism there might be included: music and traditional costume, crafts, gastronomic products, dances, popular instruments, handicraft items and many others.

Novel awareness, of differences and common points, may serve to make authentic tourist products, such as (Table 4): learning the Romanian language, initiation in instrumental and vocal music, learning crafts (pottery, wood sculpture, weaving, painting on glass etc.), learning Romanian folk dances, introduction to Romanian gastronomy etc.

Tourism in rural environment of high complexity and diversity is what stimulates the specialist's creativity. The agri-rural touring offer allows thus a series of complementary activities, such as: - close study of nature (observation of plants and animals/birds, photography, filming); hunting, horse riding, fishing; - knowledge of ancestral values; participation at festivals, traditions, rural customs; - practicing sports that need environment: touring and sport orientation, motoring and motorcycling on various land etc.; - organization of conventions/ symposiums/conferences/seminars on a small or medium scale. Interweaving theoretical actions with practical ones are remarkable (at which reference was made): - visits at traditional craftsmen's workshops; - participation at different activities and house or agricultural work/learning crafts; - participation at the preparation and taste of gastronomic products specific to the zone, drinks and fruit juice, canned vegetable and fruit etc.

A novel element the tourists may discover at local rural community refers to knowing how authentic peasants carry out their life and activity in an ancestral culture that has a real peasant calendar at its basis. This one is structured sometimes religiously, sometimes occupationally, sometimes mythological or sacredly, elements that sustain a novel touring support that, through its repetitive periplus of holidays, commemorations, socializations, superstitions and rest periods manages to cover and relax the fissured and condensed urban time of the traveler escaped from the urban.

Conclusions

(1) It becomes necessary to impose professional methods for the future of the Romanian rural tourism, in the idea to harmonize the rural space specificity, originality and tradition with globalization modernity and impact.

(2) In order to develop agri-rural tourism a strategy to counteract the present deficiencies must be imagined: the lack of professionalism and reduced number of those specialized in leading and organizing touring activities in rural environment; problems of language and communication with foreign tourists; in-depth ignorance of the principles and methods of hospitality industry in order to successfully apply them in agri-rural tourism (how to organize the arrival and meeting, different ways to spend leisure – other day and night passions and amusements, promotion of recreation and animation etc.).

(3) For a better appreciation of the rural touring product it is necessary to pay a high professional level attention for an original development by emphasizing the novel of the Romanian village (authenticity, traditionalism), through new investment in all modules of agri-rural tourism, from production modules to the accommodation ones (pension, parking area) and recreation (example – the development of sports equipment).

(4) As an indicative mark and first step towards improvement there is indicated ***the average dimension*** of an exploitation as 10 ha, and a family association as 200 ha,

as well as the achievement of a ***strategy*** to solve the low level of general and particular infrastructure in the field of the Romanian rural tourism, the modernization and maintenance of access ways, all this in relation (town hall, agricultural chamber, school, church and others).

R E F E R E N C E S

[1] Cinotti, Y. Etude des dimensions de l'hospitalite percue des maisons d'hotes, (Ecrit par Directeur adjoint du département Centre d'étude du tourisme, de l'hôtellerie et des industries de l'alimentation de l'Université de Toulouse II), http://www.u-bourgogne.fr/leg/ CERMAB/ z-outils/docu- ments/ actes J.RM B/J RM B14- 2009/Cinotti. pdf, Accessed on January 25, 2021

[2] Gruia, R., Management and development in tourism industry (Management and dezvoltare în industria turismului, In Romanian), Lux Libris Publishing House, Brașov (2017).

[3] Gruia, R., Rural tourism (Turism rural), Clarion Publishing House, Brașov, 108-132 (2021).

[4] Gruia, R., Ecotourism, Clarion Publishing House, Brașov, 7-22 (2021).

[5] Hofstede, G., Cultures and organisations, Software of the mind, Mc Graw-Hill Book Company Europe, London, p.112 (1991).

[6] Minciu, R., Tourism Economy (Economia turismului), Uranus Publishing House, Bucureşti, pp.147-151(2000).

[7] Moldoveanu, M., Miron, D., Advertising psychology (Psihologia reclamei), Libra Publishing House, Bucureşti, 76-78 (1995).

[8] Negri, C.C., Fundamentals of Environment Economiy *(Bazele economiei mediului)*, Didactical and Pedagogical Publishing House, p. 32 (1996).

[9] Nistoreanu, B., G., Tănase, M., O., Nistoreanu, P., A holistic approach of hospitality. romanian rural tourism in the context of the sustainable development (O abordare holistică a ospitalităţii. Turismul rural românesc în contextual dezvoltării durabile), Vol. XIX, Tehnopress Publishing House, laşi, pp. 112-117 (2010).

[10] Stanton, N., Communication (Comunicarea), Societatea Ştiinţifică şi Tehnică Publishing House, Bucureşti, p. 163, 1995.

[11] Stapel, J., About 35 years of market research in the Netherlands, in „Markonder-zock Kwartaalschrift", No. 2(1969).

[12] Tănase, M., O., Filip, A., Nistoreanu, P., Sustainable development versus integrated development and tourism (Dezvoltarea durabilă versus dezvoltare integrată şi turismul), In: Romanian rural tourism in the context of the sustainable development (Turismul rural românesc în contextual dezvoltării durabile), Vol. XVII, Tehnopress Publishing, laşi, pp. 49-54 (2009).

e-Bibliography

[13] National Agency of Mountain Zone, http://www.cefidec.ro/page.php72, Accessed on January 20, 2021.

[14] Meiu, G. P., Romanian Hospitality (Ospitalitatea românească), In: Pagini româneşti, February 2005, http://paginiromanesti.com/articol.asp?codart=1-E01-02052, Accesed on January 20, 2021.

[15] Enciclopedia of Romania, http://enciclopediaromaniei.ro/wiki/Mediul_rural, Accessed on January 26, 2021.

[16] Images of Romanian villages, https://www.google.com, Accessed on January 26, 2021.

[17] The FSS for 2005 Report, Eurostat, 2006.

THE IMPROVEMENT OF SUNFLOWER CROP TECHNOLOGY IN DOBROGEA UNDER CLIMATE CHANGES

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Abstract. The experimental field was placed in Amzacea, Constanta County within the climate conditions of years 2018 and 2019. Constanta County (Dobrogea area), had the largest weight regarding the surface cultivated in Romania with sunflower crop (19.6%) in 2018 and (23.8%) 2019 from Constanta County arable land. The area cultivated with sunflower crop in Dobrogea area in 2018 (19.5%) and 2019 (23%). The most drought area in Romania is Dobrogea (average 1961-1990: 464 mm rainfall). Climate change in recent years has accentuated this tendency. The number of hybrids taken into account was fifteen in 2018 and twenty in 2019. Of all tested hybrids, seven of them have been monitorized in both years (Genesis, Janis, Loris, Diamantis, Neostar, P64LE99 and P64LE25). When the sowing was delayed the yield was decreased with over 1,000 kg/ha. The aim of this study was: (i) to see the yield and the behavior of sunflower hybrids to the attack of the main pathogens - *Phomopsis helianthi*, *Sclerotinia sclerotiorum*, *Alternaria helianthi*, and the parasite, *Orobanche cumana*, (ii) how the sowing date influence the yield and (iii) the importance of the pesticides used.

Keywords: sunflower, technological improvement, pest behavior, yield

1. Introduction

Constanta County (Dobrogea area) had the largest weight regarding the surface cultivated in Romania with sunflower crop (19.6%) from arable land in 2018 (NIS, 2019) [8].

Nowadays there is a wide offer for sunflower hybrids which means without a screening of them is hard to decide which are the most suitable for every region. It should exist experimental fields not only for sunflower but for other important crops related to a specific region. The hybrids must be from different seed

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companies eliminating any suspicions. In Dobrogea such experiments were made over the years (Jinga et al., 2016; Manole et al., 2018, 2018b, 2019) which provided results for yield, behavior to the attack of the main pathogens and quality indices [3, 5, 6, 7].

The aim of this study was i) to see the yield and the behavior of sunflower hybrids to the attack of the main pathogens - *Phomopsis helianthi*, *Sclerotinia sclerotiorum*, *Alternaria helianthi*, and the parasite, *Orobanche cumana*, ii) how the sowing date influence the yield and iii) the importance of the pesticides used.

2. Materials and Methods

The experimental plots were organised in 2018 and 2019 in the field of SC SPORT AGRA SRL Amzacea, Constanta County (South-East of Romania) (Figure 1). The number of hybrids taken into account was fifteen in 2018 and twenty in 2019. The soil is a cambic chernoziom with a deeper profile than other chernozioms, a blackish-brown soil of 40-50 cm thickness, medium texture (Demeter, 2009). The content of nutrients was: mobile P index -72; N index -4; K index -200; humus -3.11%; neutral pH -7.2. The area of each plot was 560 m^2. The preceding crop was winter wheat. Sowing date was April 11^{th} in 2018 and March 20^{th} in 2019 at a 7 cm depth.

Fig. 1. Experimental field of SC SPORT AGRA SRL Amzacea, Constanta County, Romania
Source: Original.

The seeds have been treated against (i) *Botrytis* and *Sclerotinia* phytopathogens using Maxim 025 FS (fludioxonil 25g/l) at 0.6 l/100 kg, (ii) *Plasmopara helianthi* using Apron XL (metalaxil 339 g/l) at 3 l/t, (iii) *Agriotes* spp., *Tanymecus dilaticollis Gyll.* using Cruiser 350 FS (350 g/l tiametoxam) at 10 l/t, the most infested area.

Two fungicides were used in vegetative season, to control the pathogens: Mirage 45EC (procloraz 45%) - 1 l/ha 8-10 leaves, and Pictor (200g/l dimoxistrobin + 200g/l boscalid) - 0.5 l/ha before flowering.

To control weeds, the herbicides used were: glyphosate, autumn application, in a dose of 2 l/ha, Frontier Forte (dimetenamid-P) in a dose of 1.4 l/ha, Racer 25EC (fluorocloridon) in a dose of 2 l/ha, mixed up before emergency and Pulsar Plus (25g/l imazamox) in a dose of 2 l/ha (used only for the imazamox rezistant hybrids), at 6-8 leaves.

The soil was fertilized using two complex fertilizers: 10.20.0 + 20 SO_3 (of which 2N organic) - 300 kg/ha and 40.0.0+13 SO_3 -150 kg/ha. Foliar fertilizers were performed using two complex fertilizers: 12.60.0 - 2 kg/ha and 145 SO_3, 5 MgO, 100 B, 2 Cu, 25 Fe, 50 Mn, 0.5 Mo, 20 Zn - 2 kg/ha.

Phytosanitary assessments of plants were performed on August 7th in 2018 and on and July 11th in 2019 over the main pathogens: *Phomopsis helianthi* Munt.-Cvet. et al., *Sclerotinia sclerotiorum* (Lib.) de Bary, *Alternaria helianthi* (Hansf.) Tubaki & Nishihara and the parasite *Orobanche cumana* Wallr.. The degree of attack (DA%) was calculated using formula F x I/100 (F - frequency of the attacked organs, I - intensity of organs attack).

Table 1. Rainfalls during 2018 and 2019 growing season of sunflower (Amzacea, Constanta)

	Month								
	Jan.	Feb.	March	Apr	May	June	July	Aug.	
Days	The growing season 2018: Rainfall (mm) for 10-day periods								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
Days	The growing season 2019: Rainfall (mm) for 10-day periods								Sum
1-10	10	0	10	19	0	10	12	7	68
11-20	26	8	0	1	6	4	22	0	67
21-31	0	0	6	15,5	12	0	10	0	43,5
Sum	36	8	16	35,5	18	14	44	7	178,5
Days	Average 1961-1990: monthly values of rainfall (mm)								Sum
1-31	27.7	24.0	29.1	31.8	37.7	47.1	38.9	37.4	464.0

Source: Valu lui Traian Station, Constanta County, Romania

Technological sheet includes data about number of plants/m^2 after emergency, flowering and harvesting date and the yield at 9% moisture.

Rainfalls during 2018 and 2019 in Amzacea, reveal that, the last year was really dry with 178.5 mm rainfallS during the growing season compared with 2018 when the rainfall sum was 569 mm (Table 1).

3. Results and Discussions

The diseases can affect the yield and hybrids presented a DA greater or less due to their resistance linked with the climatic conditions. Of all tested hybrids, seven of them have been monitorized in both years (Genesis, Janis, Loris, Diamantis, Neostar, P64LE99 and P64LE25).

In 2018, the greatest DA was attributed to *Alternaria helianthi*, with an average of 21.7%. The lowest attack was to *Orobanche cumana*, where DA was under 1% for all hybrids. Among hybrids Suria was the most susceptible hybrid to *Phomopsis helianthi*, *Alternaria helianthi*, *Orobanche cumana* with a DA of 35.75%, 45% and 0.2% respectively (Table 2).

Table 2. Phytosanitary status (DA%) – August 7 2018

Hybrid	Pathogen			Parasite
	Sclerotinia sclerotiorum	*Phomopsis helianthi*	*Alternaria helianthi*	*Orobanche cumana*
Suria	1	35.75	45	0.2
Genesis	0	3	26	0
Janis	8	13.5	40	0
Loris	5	16.5	26	0
Electric	2	8	15	0
Diamantis	1	6	13.75	0.1
Neostar	0	3.75	15.75	0.18
Bacardi	0	9	28	0.2
Gracia	0	8	12	0
5555	5	11	25.5	0
56635	0	13.5	25.5	0
59580	3	8	18	0
P64LE25	2	7	14	0
P64LE99	0	7	9	0
P64LL125	0	5.25	12	0

Source: Original results.

In 2019, the attack of *Sclerotinia sclerotiorum* was lower than in 2018 three of the twenty hybrids being affected. *Phomopsis helianthi* and *Orobanche cumana* had a great DA average than in 2018. Tivolli had the highest average of DA for pathogens and parasite combined (16.75%) (Table 3).

All the hybrids tested had over 6 plants/ m^2 after emergence which means a good an uniform emergence. The average yield of the tested hybrids was 4,009 kg/ha exceeding the national average yield of 2,805 kg/ha reported for 2018 by the NIS, 2019 (Table 4).

Table 3. Phytosanitary status (DA%) – July 11 2019

Hybrid	Pathogen			Parasite
	Sclerotinia sclerotiorum	*Phomopsis helianthi*	*Alternaria helianthi*	*Orobanche cumana*
Diamantis	0	15	14	4
Odessa	0.2	14	24	0
Katana	0	24	5	0
Onestar	0.2	27	14	2.8
Neostar	0	22.5	20.0	4.5
Eiffel	0	14	24	0
Tivolli	0	30	33.25	3.75
Bellona	0	24.5	36.0	0.2
Clayton	0	6.0	20.0	0.2
Aurimi	0	14.0	28.0	12
Terramis	0	14.0	31.5	3.5
Loris	0	10.0	10.5	2.5
Janis	0	5.0	21.0	0.9
Genesis 2	0	21.0	21.0	3.5
Genesis	0	5.0	20.0	1.5
Aromatic	0	1.0	3.0	7
P64LE99	0	5.3	17.5	0
P64LE25	0	10.5	10.0	0
Centros	0	12.5	7.0	15
Rubisol	12	7.5	12.0	15

Source: Original results.

Table 4. Technological sheet for sunflower - 2018

Hybrid	No. of plants/m^2 after emergence	Flowering date	Harvesting date	Yield at 9% moisture (kg/ha)
Suria	6	June 22	August 16	2,709
Genesis	6	June 17	August 16	5,038
Janis	6	June 17	August 16	4,562
Loris	6	June 21	August 16	4,054
Electric	6.5	June 19	August 16	4,638
Diamantis	6	June 19	August 16	4,805
Neostar	6.5	June 17	August 16	4,364
Bacardi	6	June 18	August 16	4,475
Gracia	7	June 19	August 16	4,003
5555	6	June 16	August 16	4,827
56635	6	June 18	August 16	3,674
59580	6.5	June 16	August 16	3,834
P64LE25	6.5	June 20	August 16	4,322
P64LE99	7	June 21	August 16	4,425
P64LL125	6	June 22	August 16	4,508

Source: Original results.

In 2019 except Genesis 2 all the hybrids had over 6 plants/ m^2 after emergence. Flowering date was different due their genetic hybrids. Considering the hybrids cultivated in both years, all of them had a yield greater in 2018 due to climatic conditions.

In 2019, when Genesis was sown with a delay of 21 days the yield has decreased by almost 1,000 kg/ha (Tabel 5). The same results recorded in literature showed a higher duration for seed maturity increases yield in sunflower crop (Jonhson and Jellum, 1972; Ahmed et al., 2015; Demir, 2019) [4, 1, 2].

Table 5. Technological sheet for sunflower - 2019

Hybrid	No. of plants/m^2 after emergence	Flowering date	Harvesting date	Yield at 9% moisture (kg/ha)
Diamantis	7	June 24	August 21	4,525
Odessa	6	June 22	August 21	4,379
Katana	7	June 22	August 21	4,165
Onestar	6.5	June 20	August 21	4,248
Neostar	6	June 20	August 21	4,128
Eiffel	6	July 1	August 21	3,660
Tivolli	6	June 23	August 21	3,245
Bellona	6	June 23	August 21	3,814
Clayton	6.5	June 25	August 21	3,518
Aurimi	6	July 1	August 21	3,799
Terramis	7	June 20	August 21	3,869
Loris	6.5	June 23	August 21	3,339
Janis	6	June 20	August 21	3,655
Genesis 2	5.5	June 28	August 21	3,474
Genesis	6	June 18	August 21	4,512
Aromatic	6	June 23	August 21	2,534
P64LE99	6	June 25	August 21	3,254
P64LE25	6.5	June 25	August 21	3,543
Centros	6	June 20	August 21	2,763
Rubisol	6	June 20	August 21	2,944

Source: Original results.

Conclusions

(1) In 2018, Suria was the most susceptible hybrid to *Phomopsis helianthi*, *Alternaria helianthi*, *Orobanche cumana* while in 2019 Tivolli had the highest average of DA. *Sclerotinia sclerotiorum* and *Alternaria helianthi* had a lower attack in 2019 than in 2018 while *Phomopsis helianthi* and *Orobanche cumana* had a higher attack in 2019 than in 2018.

(2) Considering the hybrids cultivated in both years, all of them had a yield greater in 2018 due to climatic conditions. When the sowing was delayed the yield was decreased with over 1,000 kg/ha.

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R E F E R E N C E S

[1] Ahmed, B., Sultana, M., Zaman, j., Paul, S.K., Rahman, Md.M., Islam, Md. R., Majumdar, F., Effect of sowing dates on the yield of sunflower. In: Bangladesh Agronomy Journal, vol. 18(1): 1-5 (2015).

[2] Demir, I., The effects of sowing date on growth, seed yield and oil content of sunflower (*Helianthus annuus* L.) cultivars under rainfed conditions. Fresenius Environmental Bulletin, Vol. 28(9): 6849-6857 (2019).

[3] Jinga, V., Dudoiu, R., Lupu, C., 2016. Research regarding the improvement of sunflower crop technology in south - eastern Dobrogea in the context of current climate changes. Romanian Journal for Plant Protection, Vol. 9, pp. 15-21 (2016).

[4] Jonhson, B. J., Jellum, M.D. Effect of planting date on sunflower yield, oil and plant characteristics. Agronomy Journal Abstract, Vol. 64(6): 747-748 (1972).

[5] Manole, D., Giumba, A.M., Jinga, V., Radu I. The behavior of new barley and wheat varieties at S.C. Sport Agra-Amzacea, under 2018 conditions. Romanian Journal for Plant Protection, Vol. 11, pp. 39-43 (2018).

[6] Manole, D., Jinga, V., Giumba, A.M., Dudoiu, R., Cristea, S. Researches regarding new and improved technologies for sunflower and sorghum crops in the context of climate changes in Dobrogea region. Sciendo, Vol. 1(1): 79-85 (2018).

[7] Manole, D., Jinga, V., Grădila, M., Radu, I. New edition on sunflower crop - Romanian technology under climate change conditions in Dobrogea. Scientific Papers. Series A. Agronomy, Vol. 62(1): 348-354 (2019).

[8] National Institute of Statistics. Vegetal production for the main crops in 2018 (Productia vegetala la principalele culturi in anul 2018). Bucharest, Romania (2019).

INTER- AND INTRA- POPULATIONAL MOLECULAR DIFFERENCES OF SPONTANEOUS *Medicago sativa* (L) GENOTYPES OF CERNAVODA ECOSYSTEMS

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Abstract. *The paper presents the molecular aspect of DNA to wild alfalfa plants grown in two different ecosystems over 3 years. The chosen ecosystems were in the close vicinity of the CNN Plant where emissions are considered by the public to be dangerous and clean areas at a distance of 33 km generically called red and green respectively. The established locations were the CNN Plant yard and the Valea Cismelei for the red zone, respectively Oltina and Vlahi for the green zone. The plant samples were collected in two campaigns (spring and fall); genomic DNA was analyzed by CTAB modified method (Sambrook, 1989); using VisionWorks® LS software (UVP, England); the primary data were statistically processed by variance analysis and the similarity clusters. There were highlighted a total of 685 alleles (27 primers) for Medicago spp. with an average of 25.37 alleles/primer. The similarity of the inter-populations was high and significant, emphasizing a high analogy between the DNA of individuals of red and green ecosystems. Compared to the inter-population similarity the variability of the molecular profile of the individuals from the same location was high. From this point o view the activity of the Cernavoda Nuclear Power Plant has not affected the DNA structure of alfalfa plants.*

Keywords: molecular profile, *Medicago sativa* (L), green and red ecosystems

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1. Introduction

Tritium (^3H) is a radioactive isotope of hydrogen (^1H) due to interaction of atmosphere with cosmic radiation. The amount of natural ^3H is very low as trace (2,590,000 TBq) [8]. From current amount of ^3H 11.34 kg the largest part is generated by nuclear plants activity [12]. 93% of ^3H stays in hydrosphere and about 7% is in atmosphere [3]. After Chernobyl (1986) and Fukushima Daiichi (2011) disasters the people are more skeptics and concerned to the nuclear energy even if in the both cases a human error generated them. The Cernavoda Nuclear Power Plant (CNN) is a sensitive subject and generally the people’s fears of unknown situations as well as the Plant activity. Although nuclear power plants are modern and produce cheap electricity, they have effects on the environment through cooling water, gaseous, heat and radioactive waste emissions such as tritium from CANDU-type reactors. Only the proper knowledge about its effluents involvement with environment can develop strengthen the full confidence of its advantages.

For this reason our work was oriented to analyze the flora and fauna chromosomes evolution and DNA molecular profile.

We considered alfalfa plants as a "tritium effect detector" because the tiny roots are in contact with the soil air, the pivoting ones can reach the groundwater and the large leaf mass ensures that the atmospheric air enters the plant and with this and ^3H. The residence time of ^3H is shorter if it is bound to free water (TFWT) and longer if it is organically bound (OBT). The high concentration of tritium into environment is involved with cellular functions and be able to produce injury of DNA. Only in this way can it become dangerous, causing cell dysfunction and even hereditary changes.

In order to have an image regarding the changes produced by ^3H at the DNAs level, were investigated perennial alfalfa genotypes from 2 ecosystems from the red zone which is near the Cernavoda Plant and 2 ecosystems from the green zone which is clean i.e. CNN yard and Valea Cismelei respectively Oltina and Vlahi.

The *main objective*: to establish the impact of Cernavoda Nuclear Plant operation upon the DNA of alfalfa perennial genotypes from the red and green ecosystems.

2. Materials and Methods

The monitoring work of the CNN influence upon alfalfa DNA was carried out in 3 successive years (2013, 2014, and 2015) in two distinct areas green and red in 2 season spring and autumn.

2.1.Biological Material

Alfalfa plants were marked in the spring of 2013 so that shoots of the same genotype could be identified in the following years 2014 and 2015. The number of annual samples was dependent on Danube floods, plant growth, grazing or other unavoidable accidents (Table 1).

Table 1. Code of molecular analysis samples collected from spring and autumn of 2013, 2014 and 2015

Red area				Green area			
Nuclear Plant (CNN)		Valea Cismelei (CV)		Oltina (O)		Vlahi (V)	
Spring (**P**)	Autumn (**T**)	Spring (**P**)	Autumn (**T**)	Spring (**P**)	Autumn (**T**)	Spring (**P**)	Autumn (**T**)
CNN_{U1}13**P**	CNN_{U1}13**T**	VC_S13**P**	VC_S13**T**	O13**P**	O13**T**	V13**P**	V13**T**
CNN_{U1}14**P**	CNN_{U1}14**T**	VC_S14**P**	VC_S14**T**	O14**P**	O14**T**	V14**P**	-
$CNN_0$14**P**	-	-	-	-	-	-	-
CNN_{U1}15**P**	CNN_{U1}15**T**	VC_{S1}15**P**	VC_{S1}15**T**	$O_1$15**P**	$O_1$15**T**	-	V15**T**
-	$CNN_0$15**T**	VC_{S2}15**P**	VC_{S2}15**T**	-	$O_2$15**T**	-	-
CNN_{STA}15**P**	CNN_{STA}15**T**	-	VC_{S3}15**T**	-	$O_3$15**T**	-	-
CNN_{P-TA}15**P**	CNN_{P-TA}15**T**	VC_{N1}15**P**	VC_{N1}15**T**	-	-	-	-
-	-	VC_{N2}15**P**	VC_{N2}15**T**	-	-	-	-
-	-	VC_{Cen}15**P**	VC_{CEN}15**T**	-	-	-	-

Legend:
The ecosystem name/collection point/year/season.
Some sections are empty because no plants were found or the location was flooded by the Danube.
Source: Own results.

For safety reasons additional samples were collected and processed and displayed in dendrograms. These are: in 2013 Vlahi-$V_2$13P and Oltina-$O_2$13T; in 2014 CNN Plant-CNN_{STA2}14P; in 2015, Valea Cismelei-VC_{N2}15T, VC_{S2}15T and VC_{S3}15T; Oltina-$O_2$15T and $O_3$15T; Lac Tibrin LT15T and Seimeni S15T.

2.2.The working methods

For the samples preparation and DNA extraction modified CTAB method was used [2]. The extracted nuclear DNA from each plant sample was evaluated using the NanoDrop 8000, to establish the concentration and DNA quality the spectrophotometric method was used [9]. The OD 260/280 ratio ranged from 1.8 to 1.9 pointing out the proper quality of samples. Due to the high concentration of DNA, each sample was diluted to 100 ng/ml concentration.

The molecular profile was performed based on RAPD (*Random Amplification of Polymorphic DNA*) and ISSR (*Inter Simple Sequence Repeat*) markers [9, 7] (Table 2).

Due to their low results some markers were eliminated and new ones were introduced.

Table 2. The sequence of the primers type used for the assessment of molecular variability (2013, 2014 and 2015)

No.	Code	Primer name	Sequence 5' → 3'	2013		2014	2015
				Spring	Autumn	in both seasons	
1	Pr 3	UBC810	$(GA)_8T$	Yes	Yes	Yes	Yes
2	Pr 4	UBC811	$(GA)_8C$	Yes	Yes	Yes	Yes
3	Pr 6	UBC816	$(CA)_8T$	Yes	Yes	-	Yes
4	Pr 7	UBC820	$(GT)_8C$	Yes	Yes	-	Yes
5	Pr 17	UBC841	$(GA)_8YC$	Yes	Yes	-	-
6	Pr 24	UBC853	$(TC)_8RT$	-	Yes	-	-
7	Pr 28	UBC859	$(TG)_8RC$	-	Yes	Yes	-
8	Pr 30	UBC864	$(ATG)_6$	-	Yes	-	Yes
9	Pr 34	UBC884	HBH $(AG)_7$	-	Yes	-	-
10	Pr 36	UBC886	VDV$(CT)_7$	-	Yes	Yes	-
11	-	A2	$(ACTG)_5$	Yes	Yes	Yes	Yes
12	-	A3	$(GACA)_5$	Yes	Yes	Yes	Yes
13	-	A7	$(AG)_{10}T$	Yes	Yes	Yes	Yes
14	-	A 12	$(GA)_6CC$	Yes	Yes	Yes	Yes
15	-	A 21	$(CA)_6AC$	-	-	-	Yes

Source: Own results.

The amplification products were separated by agarose gel electrophoresis and evaluated by VisionWorks®LS (UVP, UK) software. All the amplified fragments, visualized as bands in UV light were determined and aligned according to their size (bp). Taking in account that ISSR are dominant markers, which don't allow the differentiation between homo- and hetero- zygotes, they were scored with 1 and 0 for presence and absence respectively.

The obtained results were statistically operated using the *Jaccard Index*/ Similarity Coefficient (Sc) [6]. According to the used primers and based on the molecular similarity index for each year and to report DNAs kinship the UPGMA Dendrogram was constructed (from Figure 1 to Figure 5).

3. Results and Discussions

3.1. The amount, quality and molecular pattern of alfalfa DNA

The horizontal gels of electrophoresis analytical-grade agarose in the running buffer (1X TAE) and a control DNA dye with appropriately sized DNA standards pointed out the difference among the samples.

The DNAs quality and availability to be analyzed was established by OD 260/280 ratio. In all years they ranged from 1.8 to 1.9 pointing out its high quality. Also the DNA quality is in correlation with the molecular weight of bands. In our case the high molecular weight varies from 1,540 bp to 1,000 bp for UBC 811 (4 primers) & UBC 810 and A2 (3 primers). The middle size fragments varied from 980 bp to 500 bp to 4 primers in equal frequency for UBC and A group. The light molecular fragments vary from 490 bp to 175 bp in case of 3 UBC primers and for A2. In terms of molecular fractions number, DNA of plants grown in Valea Cismelei was like to that of plants in Oltina (37.5% and 39.81% respectively). The pattern complexity of DNA from samples collected in CNN yard pointed out less fragments molecular (23.61%), i.e. it's uniformity was higher.

Table 3. The primers and their products (2013, 2014, 2015)

No.	Primers	Number of loci			No.	Primers	Number of loci		
		2013	2014	2015			2013	2014	2015
1	UBC810	1-6	1-24	1-24	10	UBC886	-	1-27	-
2	UBC811	1-17	1-28	1-27	11	A2	1-20	1-24	1-46
3	UBC816	1-13	-	1-27	12	A3	1-33	1-18	1-48
4	UBC820	1-18	-	1-27	13	A7	1-15	1-21	1-31
5	UBC841	1-25	-	-	14	A12	1-12	1-24	1-44
6	UBC853	-	-	-	15	A 21	-	-	1-28
7	UBC859	-	1-19	-	No. of Alleles		159	185	341
8	UBC864	-	-	1-39	No. of Primers		9	8	10
9	UBC884	-	-	-	Allele average /Pimer		17.7	23.1	34.1

Source: Own results.

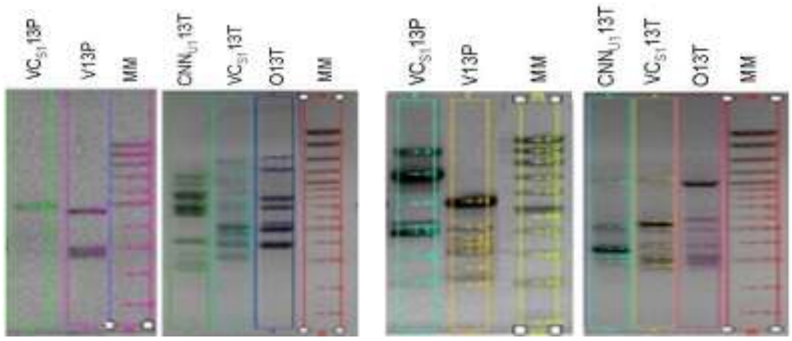
The primer's products varied yearly being in a large amount in 2015 and the smallest in 2013 (Table 3). The analysis of one and the same primer by year revealed obvious differences. Thus, the UBC 810 primer has the same values in 2014 and 2015, while UBC 811 revealed the maximum in 2014, followed by 2015 and closely was 2013. For the A2, A7, and A12 primers products were yearly more and more effective.

3.2.Season-dependence of DNA profile

At a quickly analysis of the electrophoresis products are seeing the differences between ecotypes but especially between framework of years and season. The autumn DNA profile is different from the spring especially of Valea Cismelei plants. The alfalfa samples displayed for each season a differentiated molecular pattern (Figure 1, Figure 2 and Figure 3).

In the 2013 spring DNAs of VC_S13P and of V13P pointed out only a few product with a small similarity between them. In autumn, for both primers UBC 810 and UBC 811 the molecular configuration were larger and almost identical (Figure 1).

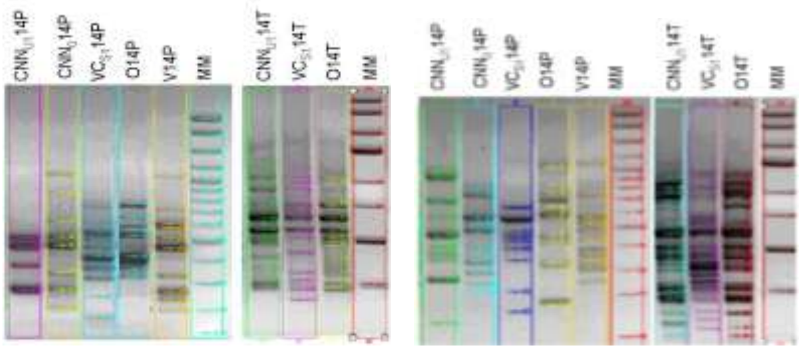
In the 2015 spring between CNN_{U1}15P, VC_S15P, VC_N15P, O15P and V15P the molecular profile of DNA were slightly differentiated while in the autumn they were almost identically (Figure 3). In their profile a lot of large bands were observed.



UBC 810 **UBC 811**

a b

Fig. 1. The spring (P) and autumn (T) DNA profile separately into molecular different weight bands (bp) by UBC810 and UBC811 primers (2013)
Source: Own results.



UBC 810 **UBC 811**

a b

Fig. 2. The spring (P) and autumn (T) DNA separated in bands with different molecular weight (bp) by UBC810 and UBC811 primers (2014)
Source: Own results.

The amplification products was poor in all years and almost to all DNA of spring plants (Table 4).

In comparison to spring DNA the spatial settlement of autumn DNA bands are different being higher in number and width and more complex. Broadbands ranged fromat 1 (CV_{S1}15P) to 3 (CNN_{U1}15P and O15P) in spring genotypes while in the autumn ones there were more ranging from 3 (VC_{S1}15T, VC_{N1}15T and O15T) to 4 (CNN_{U1}15T). The wide bands are in the area of average molecular weight indicating many alleles/locus. In comparison to spring DNA the number of molecular fragments of autumn DNAs was more complex having a higher number of fragments (59.72%) including 83.33% heavy fragments (1,600 bp-1,000 bp), middle 72.41% (1,000 bp-500 bp) and light 74.07% (490 bp-100 bp).

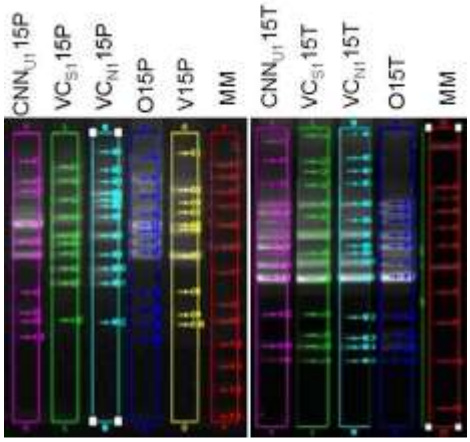


Fig. 3. The UBC 810 primer amplification products of DNA samples of the spring (P) and autumn plants (T; 2015)
Source: Own results.

Table 4. The percent of amplification products bands of different primers grouped by degree of expression of *Medicago sativa* genotypes collected in spring and autumn years 2013, 2014, 2015

Year	Ecosystem	No of primers	% of resulting products that were:		
			Higher in fall than spring (T>P)	*Equal in autumn and spring* (T=P)	Smaller autumn than spring (T<P)
2013	Valea Cişmelei	9	66.67	11.11	22.22
	Vlahi	9	77.77	22.23	0
2014	**Valea Cişmelei**	**8**	**75.00**	**0**	**25.00**
	CNN	**8**	**62.50**	**25.00**	**12.50**
	Oltina	**8**	**87.50**	**0**	**12.50**
2015	Cişmelei Valley	10	50.00	0	50.00
	CNN	10	30.00	40.00	30.00
	Oltina	10	40.00	20.00	40.00
General percent (%)			**59.73**	**15.27**	**25.00**
The areas under the direct influence of the CNN Plant					
Red (VC+CNN)		45	55.56	15.56	28.88
The areas free of the CNN Plant influence					
Green (Oltina+Vlahi)		27	66.67	14.81	18.52

Source: Own results.

The results obtained in the three years highlighted more electrophoretic products in the fall of 2013 and 2014 (Table 4).

In addition to other types of analysis, the electrophoretic products from 2015 were atypical. It should be noted that between the red and green areas the electrophoretic products were more distinctive for the DNA of autumn than the spring one being higher (55.56% and 66.67% respectively). The equal electrophoretic products for both spring and autumn seasons were of 15% and 14% for red and green areas.

At the plants collected in spring in the red zone, the electrophoretic products were more numerous than those of plants in the green zone (28.88%>18.52%).

3.3.The likenis of ecotypes

Based on the fingerprints the similarity coefficients were established and the dendrograms were designed.

The dendrograms from 2013 and 2014 are quite similar (Figure 4a and 4b). In 2015, due to the large number of samples, dendrograms were made apart for each primer. The choice of dendrograms from 2015 was done by correlation coefficients calculated. Significant correlation was between the group of primers A2-UBC 811-UBC 816 (0.358***, 0.788***>r0.1%), respective UBC 810-A3-A21 (0.606***, 0.545***>r0.1%=0.230). Farther will be discussed only these two dendrograms (Fig. 5a and 5b).

In 2013 the dendrogram contains 2 clades (Figure 4a). The CNN_{U1}13P genotype was willing separately from the two clades. In first clade are close connected VC_S13P respectively O13P and O13T genotypes belonging of red and green areas. The grouping in the same clade of the individuals from Oltina with those from Valea Cismelei shows the similarity between their molecular profiles and allows us to consider that the Cernavoda Plant does not induce harmful influences at the DNA level. In second clade are CNN_{U1}13T and VC13T. Their presence in clade 2 is normal whereas the areas are in the same environmental conditions, under the Cernavoda Plant influence. It can be seen that the similarity of the molecular profile of alfalfa is lower for the inter-populational genotypes compared to that of genotypes in the same location, being lower by 61.5%.

The allocation of ecotypes in the 2014 dendrogram (Figure 4b) is almost similar to the distribution in 2013 dendrogram. The CNN_{U1}14P is locate in the same first position as wll in 2013 starting from the first disjunction being separated from all other branches. $CNN_0$14P and V14P as well as CNN_{U1}14T and VC_S14T are situated in the second claster having a high similarity (Sc-0.6298 respectively Sc-0.6740) but not sufficient high to be consider different. VC14P is grouped in the third clade revealing appropriate molecular profile with O14P and O14T (Sc-0.6519 respectively Sc-0.5414; see Table 7).

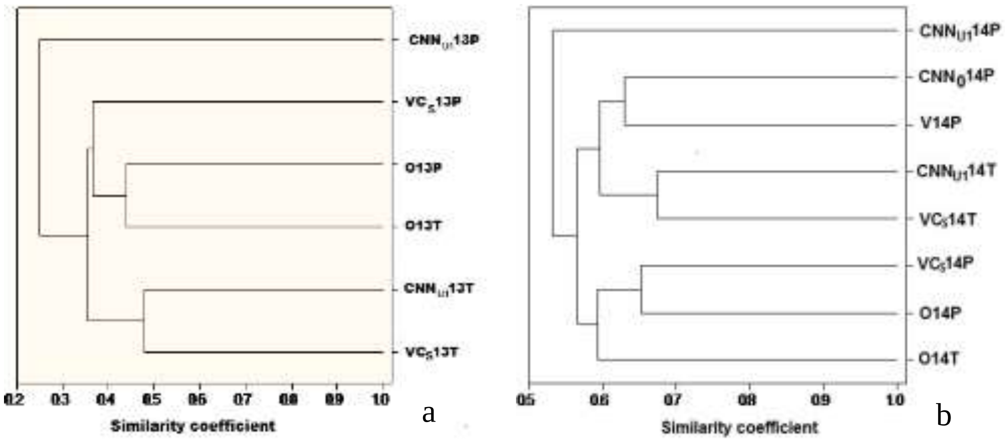


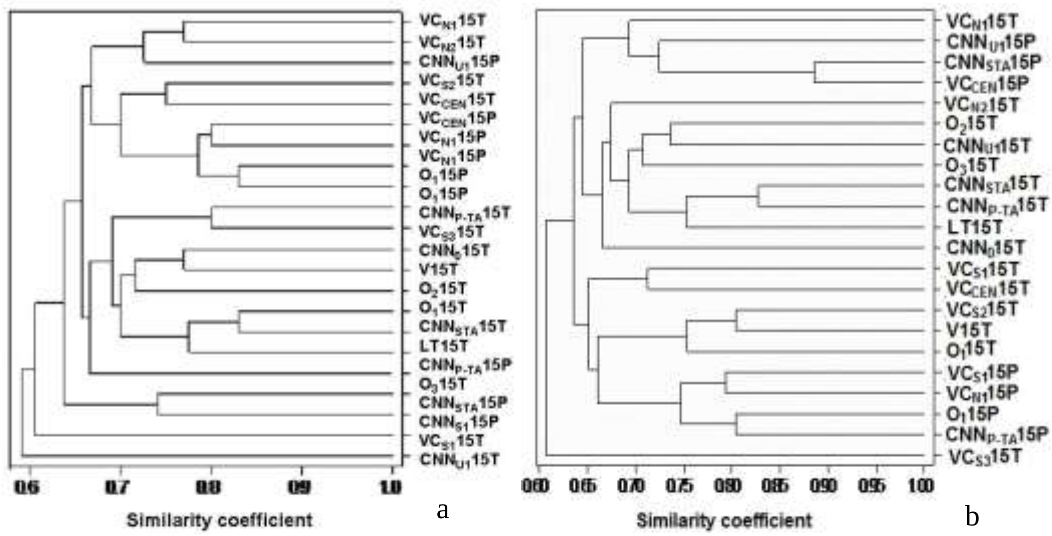
Fig. 4. UPGMA clustering of *Medicago sativa* populations using ISSR primers
(2013) (2014)
Source: Own results.

It should be noted that in 2014 also, the clades include genotypes originating from red areas CNN$_0$14P, CNN$_{U1}$14T and VC14T with those from green areas V14P, O14P and O14T, emphasizing and in this year their great similarity. The formation of mixed clusters indicates the great likeness between the DNA of the analyzed genotypes and in the same time indicates the unchanged molecular profile of those that grew in red areas. From our point of view, the 2013 and 2014 the Cernavoda Plant emissions do not produced any change in the gene pool of alfalfa plants.

The dendrogram constructed by primer A2-UBC811-UBC816, possesses 7 subclades (Figure 5a) in which are grouped individuals from red areas (four of they i.e. 57.14%); a clade comprises only genotypes from green areas (14.29%); two are 'mixed' having genotypes from green and red ecosystems (28.57%; CNN$_{P-TA}$15T with O$_1$15P and CNN$_{STA}$15T with LT15T; Sc-0.8300).

In an appart position are three genotypes that seems to be independent because they are not part of any clade. From the point of separation the CNN$_{U1}$15T and VC$_{S1}$15T detachs as the furthest from the rest of the clusters. The genotype O$_3$15T is separated from the clusters, being independent as the two previously mentioned. All the 3 genotypes have a apart disposition are not part of any clade and all comes from autumn plants. In the mixt clades are two completely different genotypes: O15P with CNN$_{P-TA}$15P (Sc 0.8300), CNN$_{STA}$15T with LT15T (Sc 0.8300).

Primer products UBC810-A3-A21generated a clear dendrogram but quite similar to the one obtained by the A2-UBC811-UBC816 (Figure 5b).



A2-UBC811-UBC816 UBC810-A3-A21

Fig. 5. UPGMA clustering of *Medicago sativa* populations
using A2-UBC811-UBC816 and UBC810-A3-A21 ISSR primers (2015)
Source: Own results.

And this has three genotypes that are not part of any clade. The VC_{S3}15T separates from the very beginning. The CNN_{0}15T and VC_{N2}15T branches have an arrangement like to the CNN_{U1}15T and VC_{S1}15T genotypes in the dendrogram generated by A2-UBC811-UBC816. In a similar position was no longer O15T. And this primer has only autumn genotypes.The seven subclades comprise 3 genotypes from the red zone (45.86%) and 4 of them are mixed (57.14%). The large proportion of mixed clades shows once again that in 2015 the DNAs in red and green ecosystems is very similar and indicates the absence of harmful emissions from CNN.

Despite the complexity of the 2015 dendrograms, it was possible to discern aspects that complement the data obtained in previous years.

Both dendrograms grouped on the criterion of similarity at A2-UBC811-UBC816 and UBC810-A3-A2 respectively comprise 7 clades; both have 3 independent genotypes that are not part of any clade; in both dendrograms in different amount poses mixed clades which include the molecular profile of the red and green ecosystems (28.57% and respectively 57.14%).

Dendrograms include cleavages that reflect the evolution of each genotype and the extent to which each has accumulated particularities of their living environment. They provide us with information about the kinship of their genetic background, in our case, between red and green ecotypes.

Mixed clades indicate a similar molecular profile of the nuclear DNA of individuals grown in green areas (Oltina and Vlahi) and those grown in supposedly "polluted" areas (CNN and VC). At the same time, it shows us that the emissions from the Nuclear Plant do not produce changes in the genetic background of alfalfa plants (a dicot species). Alike results were obtained in the case of molecular analysis with *Elymus repens* [(L.) Gould] a monocot specie (work in progress).

3.4. The genetic similarity coefficient

For a clear distinction of the similarity or vice versa to emphasize the variability between the DNAs of alfalfa individuals in red and green ecosystems, a scale was used that includes 5 classes: very small similarity, i.e. very high variability (0-20%), low similarity, i.e. high variability (21-40%), middle similarity or medium variability (41-60%), high similarity i.e. low variability (61-80) and very high similarity i.e. very low variability (81-99%).

Table 5. The genetic similarity coefficient between *M. sativa* populations using ISSR primers (2013)

No.	Population	1	2	3	4	5	6
1	$CNN_{U1}13P$	**1**	0.2407	0.2667	0.2203	0.2544	0.2583
2	VC_S13P	0.2407	**1**	0.4000	0.3167	0.3534	0.3306
3	O13P	0.2667	0.4000	**1**	0.3419	0.3220	0.4386
4	$CNN_{U1}13T$	0.2203	0.3167	0.3419	**1**	0.4779	0.3672
5	VC_S13T	0.2544	0.3534	0.3220	0.4779	**1**	0.4262
6	O13T	0.2583	0.3306	0.4386	0.3672	0.4262	**1**

Source: Own results.

The similarity between the $CNN_{U1}13P$-VC_S13P ecosystems and those from red and green area $CNN_{U1}13P$-O13P and VCs13P-O13P was small by 24.07%, 26.67% and 40.00%, respectively (see Table 5). The diversity of the DNA profile was high, in both places near (75.93%) and respectively far from the Cernavoda Nuclear Power Plant (73.33%). A middle variability of nuclear DNA was established between $CNN_{U1}13T$ and VC_S13T (52.21%) as well as for the DNA of spring and autumn plants of Oltina (56.14%). Overall, in 2013, for 80% of DNA profiles, there was a low similarity coefficient and only 20% were middle. The highest value of the Similarity coefficient (Sc 0.47779) when it was compared $CNN_{U1}13T$ with VC_S13T, pointing out a like growth medium (see Figure 4a last clade). The similarity of 42.62% for VC_S13T versus O13T is somewhat unpredictable. Valea Cismelei is in the red zone near the Plant, while Oltina is in the green zone outside the influence of CNN. Hypothetically, there should be little resemblance between the DNA of the two ecotypes.

Our results vere confirmed by the analysis of variance (Table 6) that shows a large and significant differences for all populations and seasons. With one exception the F test was small and insignificant ($CNN_{U1}13P$).

Table 6. Analysis of variance for *Medicago sativa* populations concerning the bands of the ISSR primers (2013)

No.	Populations	Between groups		Within groups		F Test
		SS	DF	SS	DF	
1	$CNN_{U1}13P$	0.03	1	40.08	179	0.14
2	VC_S13P	1.42	1	42.32	179	6.02*
3	O13P	2.93	1	40.63	179	12.90**
4	$CNN_{U1}13T$	16.31	1	28.70	179	101.75**
5	VC_S13T	25.04	1	19.90	179	225.19**
6	O13T	10.47	1	34.78	179	53.88**

Source: Own results.

Table 7. The genetic similarity coefficient between *M. sativa* populations using ISSR primers (2014)

No.	Population	1	2	3	4	5	6	7	8
1	$CNN_{U1}14P$	**1**	0.5304	0.5470	0.5746	0.5470	0.4917	0.5304	0.5083
2	$CNN_0 14P$	0.5304	**1**	0.5746	0.5691	0.6298	0.5635	0.5801	0.4917
3	VC_S14P	0.5470	0.5746	**1**	0.6519	0.6243	0.5470	0.5856	0.5414
4	O14P	0.5746	0.5691	0.6519	**1**	0.5525	0.5746	0.5580	0.6464
5	V14P	0.5470	0.6298	0.6243	0.5525	**1**	0.6022	0.6409	0.5525
6	$CNN_{U1}14T$	0.4917	0.5635	0.5470	0.5746	0.6022	**1**	0.6740	0.5525
7	VC_S14T	0.5304	0.5801	0.5856	0.5580	0.6409	0.6740	**1**	0.6133
8	O14T	0.5083	0.4917	0.5414	0.6464	0.5525	0.5525	0.6133	**1**

Source: Own results.

In 2014, 72.41% of the DNA profile showed an middle similarity and at 27.59% was high. Middle similarity coefficients were obtained for 2 mixed subclades $CNN_0 14P$-V14P (Sc 0.6298) and VC_S14P-O14P (Sc 0.6519).

As in 2013, such a similarity was unexpected, because the DNA of the analyzed plants came from red and green areas, a priori considered to be influenced differently by the Cernavoda Nuclear Power Plant.

The similarity between the molecular profiles of the DNA in the two opposing ecosystems indicates the absence of harmful emissions that could come from CNN Plant. There were no changes in the nuclear DNA model of alfalfa plants grown from September 2013 to May 2014 in red or green ecosystems.

The analysis of the variance for 2014 (Table 8) exactly as in 2013 highlighted a single exception in which the difference was insignificant (CNN_{U1}). For 87.5% of the 2014 data, their veracity was confirmed.

Table 8. Analysis of variance for *Medicago* populations concerning the bands of the ISSR primers (2014)

No.	Genotype	Between groups		Within groups		F Test
		SS	DF	SS	DF	
1	CNN_{U1}14P	0.85	1	39.26	179	3.88
2	$CNN_0$14P	5.96	1	36.74	179	29.04**
3	VC_S14P	6.60	1	37.15	179	31.78**
4	O14P	6.93	1	36.63	179	33.88**
5	V14P	12.91	1	32.23	179	71.71**
6	CNN_{U1}14T	10.71	1	34.31	179	55.87**
7	VC_S14T	16.71	1	28.23	179	105.93**
8	O14T	5.61	1	39.64	179	25.35**

Source: Own results.

The primer A2-UBC811-UBC816 (Appendix 1 Table 1.), separated the nuclear DNAs from 22 samples in different classes of similarity: medium (12.02%) large (86.26%) and very large (1.72 %). The greatest similarity was highlighted between the DNA of plants in ecosystems: CNN_{STA}15T with LT15T the CNN_{P-TA}15P with $O_1$15P (83.00%) and VC_{S1}15P with $O_1$15P (80.00%). A wide diversity of alleles was observed at the VC_{S3}15T-$CNN_0$15T genotypes (80.00%).

The similarity coefficients of the BCU810-A3-A21 primers are very similar to those obtained at the A2-BCU811-BCU816 primers (Appendix 2 Table 1.). As expected, the greatest similarity was between the red zone genotypes CNN_{STA}15T-CNN_{P-TA}15T (82.76%), CNN_{STA}15P-VC_{CEN}15P (88.51%), CNN_{P-TA}15P-VC_S15P (80.46%). An unexpected high similarity was revealed by the UBC810-A3-A21 primers for genotypes from the red and green area (CNNP-TA15P-O15P; 80.46%). There are several differences between the two groups of primers that we consider useful to present. Thus, as extreme values, the small and very high similarity coefficients of the primer BCU810-A3-A21 are in proportion higher than those obtained at A2-BCU811-BCU816 (20.09%>12.02% and 2.16%>1.72%); while those with high values are less (77.75% <86.26%).

If for the ecotypes from Valea Cismelei a great similarity is natural (VCS115P-VCN115P = 80.00%), both being part of a large ecosystem under the imminent influence of the Power Plant. But the great similarity of over 80.00% for Valea Cismelei and CNN with Oltina and Lake Tibrin is unnatural. In this situation the similarity are 83.00% at CNN_{STA}15T-LT15T and CNN_{P-TA}15P-$O_1$15P and 80.00% at VC_{S3}15T-$O_3$15T. If the great similarity is debatable in the case of Lake Tibrin located at 5.51 km from CNN for Oltina located at 33.14 km, the interference of the Cernavoda Plant is excluded, because it is too far to be influenced by Power Plant emissions. The LT15T location is isolated and it is not known if there is a connection through groundwater or from the Danube.

Our data were attested by the analysis of the variance for both groups of primers being large and significant in the vast majority of combinations between and within the target groups (Appendix 1 Table 2 and Appendix 2 Table 2).

The inventory of the similarity coefficients of 2015 seasons, it is found that there are significant differences for the very high similarity for spring ecotypes (4.08%) while between genotypes collected in autumn there is a less uniformity being only 1.26% of them. This finding urges us to consider environmental conditions (TºC, mm, insolation, etc.) as a factor in revealing the molecular differences between ecotypes. The highest number of genotypes with high similarity (Sc>80%) was at the spring ecotypes (62.5%).

At the both primers, A2-UBC811-UBC816 and UBC810-A3-A21 the ADN similarity was high at the red and green areas ecotypes: $CNN_{T\text{-}TA}$15P-O15P (83.00% and 80.46%, respectively) and in VC_{S2}15T-V15T (80.46%).

Table 9. The similarity among alfalfa plants grown in CNN and Oltina ecosystems in two seasons by using primers A2-UBC 811-UBC 816 and UBC 810-A3-A21 (2015)

Ecosystems:		The percent of similarity			
Polluted/ Red	Clean/ Green	A2-UBC 811-UBC 816		UBC 810-A3-A21	
		Spring	Autumn	Spring	Autumn
CNN_{U1}	O_1	72.00	63.00	65.52	63.22
CNN_{STA}	O_1	65.00	65.00	62.07	68.97
$CNN_{P\text{-}TA}$	O_1	83.00	71.00	80.46	72.41
Average		**73.33**	**66.33**	**69.35**	**68.20**

Source: Own results.

The DNA of the alfalfa in the yard of the Cernavoda Power Plant should be different from that of the plants in Oltina, both ecotypes being grown up in differentiated environmental conditions. CNN is located in the red zone and Oltina in the green zone. The molecular profile should have been completely different. However, their similarity is very high (Table 9).

Such a resemblance can only be explained by similar long-term influence of like environmental conditions stress the absence of CNN modifying factors.

In terms of environmental conditions CNN and VC ecosystems are considered to be very like. Consequently, the DNA of alfalfa plants in the Valea Cismelei should be very similar to that of plants of the factory yard (Table 10).

In the 3 groups of genotypes the general similarity coefficient (ScG%) was high highlighting small differences between their DNAs. However, it is worth noting the greater similarity of the DNA from Oltina with that from CNN compared to that of the DNA from VC with CNN (69.30% >64.90%). It would have been natural to have a greater resemblance between similar ecosystems and on the contrary inferior to different ones. The difference of 5% is not big but still allows us to conclude that overall the 3 ecosystems do not differ too much from each other and that CNN Cernavoda does not negatively influence the area.

Table 10. The similarity molecular profile of alfalfa from CNN and VC ecosystems in spring and autumn revealed by A2-UBC 811-UBC 816 and UBC 810-A3-A21 primes (2015)

Ecosystems:		The percent of similarity			
Polluted/ Red	Clean/ Green	A2-UBC 811-UBC 816		UBC 810-A3-A21	
		Spring	Autumn	Spring	Autumn
CNN_{U1}	VC_{CEN}	65.00	56.00	66.67	66.67
CNN_{STA}	VC_{N1}	70.00	62.00	66.67	62.07
CNN_{P-TA}	VC_{S1}	64.00	56.00	80.46	63.22
Average (ScG%)		**66.33**	**58.00**	**71.27**	**63.99**

Source: Own results.

The ^3H content in the water collected in the spring campaign are much lower than those of autumn; the average was 6.5±0.44Bq/l respectively 22.1±0.97Bq/l [10]. The air samples for the spring campaign were below the detection limit. The exception is the exclusion zone, Valea Cismelei with 5.81±0.69 Bq/m^3. The measurements from October 2015 were slightly higher, keeping the same exception (8.34±0.73 Bq/m^3). The charge with ^3H of the environment cannot be incriminating as a harmful factor of the nuclear DNA. The high similarity of nuclear DNA indicates a similar environment in all ecosystems attested by the quantitative determinations of ^3H of water, air and soil.

In general, the literature in this field is limited. The evaluation of the two green and red ecosystems was made by analyzing the quantity and quality of DNA, of electrophoretic bands on gels, the dendrograms clades, variance analysis and similarity between the genotypes of 2013, 2014 and 2015. Each of them revealed more or less obviously the influence of Cernavoda Atomic Power Plant on alfalfa plants as well as on other species.

For Romania, the molecular investigations performed on alfalfa genotypes from the red and green areas of Cernavoda Nuclear Plant influence are singular. In the explored literature we did not find studies related to such aspects. Kamura and co-workers [4] approached the subject tangentially by describing the relatively low ratio of tritium activity (0.37) in the nucleic acid fraction of pea seedlings. They showed also the differentiation of tritium accumulation in biochemical constituents of the plant as well as the preferential incorporation in fats and proteins. Even alfalfa has been little studied from this point of view [11], although it is a plant used to highlight the environment stress [5].

The general analysis of the structure of the dendrograms in association with the similarity matrix indicates that both the sampling season and the place of origin had an influence on the genetic similarity between the *Medicago* genotypes.

We do not know if those comparative studies have been done to highlight the differences in molecular similarity between spring and autumn genotypes. It was useful to compare the molecular profile of DNA of alfalfa plants in spring and autumn, because new questions arose that should be answered. In the fall, DNA appears to be more complex and the number of allele copies to be higher. The DNA segments released by the proteins that protect them and the histone nucleus (dimers H2A-H2B and tetramers H3-H4) 2 are more susceptible to hybridization with the sequence of primers [13]. High summer temperatures predispose to the relaxation of the histone complex and DNA and thus the naked molecular profile ensures a more efficient hybridization of the primer [1].

Although RAPD and ISSR primers have the disadvantage of labeling homo- and hetero- zygous loci for our aim to emphasize the molecular diversity of individuals in alfalfa populations in green and red ecosystems, the random primers used have been appropriate.

So far, such a finding can only be explained by comparing our data with those reported by the ICSI Ramnicu Valcea research group [10] on the presence of ^{3}H in water, air and soil and its assessment in spontaneous grassy and woody vegetation of the Cernavoda Nuclear Power Plant ecosystems.

The similarity between the molecular profiles of DNA in the two opposing ecosystems indicates the absence of harmful factors that could have been emitted by CNN Plant.

Conclusions

(1) The molecular separation fractions of the 9, 8 and 10 ISSR and RAPD primes used in 3 consecutive years showed a number of 159, 185 and 297 active alleles in the spontaneous alfalfa genotypes in the red and green areas of Cernavoda;

(2) The comparative molecular analyses with RAPD or ISSR primers of spring and autumn plants pointed out a larger molecular diversity at the autumn plants.

(3) The autumn plants seems to be more convenient for that kind of investigations because the DNA profile is more complex, revealed information is more numerous and the monitoring costs would be lower.

(4) We conclude that the variability of the molecular profile of nuclear DNA is associated with environmental variability, especially in intervals spring-autumn rather than with the physical environment created of the emissions from the Cernavoda Power Plant.

(5) Based on the results obtained, we conclude that the emissions from the Cernavoda Power Plant do not produce any change in the genetic background of alfalfa plants.

(6) However, in order to clearly highlight the influence of ^{3}H on the DNA of organisms in the Cernavoda area, several fundamental studies need to be done.

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Authors' contributions

The manuscript was written through contributions of GB and SP; all authors have given approval to the final version of the manuscript; SP made the molecular analysis; the statistical work was performed by GB and SI; the other authors contributed to the data collection.

R E F E R E NC E S

[1] Butnaru, G., Chen, J., Goicoechea, P., Gustafson, J.P. In situ hybridization mapping of genes in Hordeum vulgare L. The Journal of heredity (USA), (1998).

[2] Doyle, J.J., Doyle, J.L. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochem Bull. 19: 11–15, (1987).

[3] Ferronsky, V.I., Polyacov, V.A. Isotopes of Earth’s Hydrosphere. Springer Verlag, p. 235, (2012).

[4] Kahma, K., Morsky, P., Hann1nen, V., Kuronen, P., Salonen, L., Miettinen, J.K. Incorporation of tritium from tritiated water into DNA and free amino acids of pea plant, 3rd IAEA Research Co-ordination Meeting on the Environmental Behaviour of Tritium, Helsinki, Finland, (1976).

[5] Mihacea, S. The physical map of the NOD region of alfaalfa. Timisoara *(*PhD thesis), (1993).

[6] Nei, M., Li, W-H. Mathematical model for studying genetic variation in terms of restriction endonucleases. Proc. Natl. Acad. Sct. USA Vol.76, No.10, pp.5269-5273, (1979)**.**

[7] Predeep Reddy, M., Sarla, M.N., Siddiq, E.A. Inter simple sequence repeat (ISSR) polymorphism and its application in plant breeding. Euphytica 128: 9–17, (2002).

[8] Radiation Information Network's Tritium Information Section. Idaho State University. In Molten Salt Reactors and Thorium Energy, Dolan, T.J. Editor, Elsevier, (2017).

[9] Sambrook, J.F., Russell, D.W. Molecular Cloning: A Laboratory Manual (3rd ed.). Cold Spring Harbor Laboratory Press (2001).

[10] Titescu, Gh., Varlam, C. Report on the environmental for Cernavoda NPP. ICSI Rm. Vâlcea, (2013-2016).

[11] Tritium in Some Typical Ecosystems. Vienna, Austria. IAEA. Technical Reports Series No. 207 Sti/Doc/10/207, (1981).

[12] Zhang, Q., Liu, T., Yang, L., De, M., Dahu, S., Monitoring and management of tritium from the nuclear power plant effluent. OP Conference Series: Earth and Environmental Science, Vol. 108, Issue 4, (2018).

[13] Zhang, B., Zheng, W., Papoian, G.A., Wolynes, P.G. Exploring the Free Energy Landscape of Nucleosomes. J. Am. Chem. Soc. 138. 26. pp. 8126–8133, (2016).

Appendix 1 **Table 1**

The genetic similarities coefficients between Medicago sativa populations using A2–UBC811–UBC816

No.	Population	1	2	3	4	5	6	7	8	9	10	11
		12	13	14	15	16	17	18	19	20	21	22
1	VC_{N1}15T	**1**	0.770	0.620	0.650	0.620	0.640	0.650	0.640	0.600	0.630	0.660
		0.540	0.620	0.680	0.570	0.730	0.700	0.580	0.630	0.670	0.650	0.600
2	VC_{N2}15T	0.770	**1**	0.710	0.680	0.670	0.610	0.640	0.690	0.650	0.720	0.630
		0.530	0.630	0.670	0.580	0.720	0.690	0.630	0.700	0.640	0.660	0.710
3	VC_{S1}15T	0.620	0.710	**1**	0.670	0.600	0.640	0.550	0.600	0.580	0.610	0.600
		0.480	0.580	0.560	0.530	0.630	0.620	0.580	0.610	0.610	0.570	0.640
4	VC_{S2}15T	0.650	0.680	0.670	**1**	0.690	0.750	0.640	0.630	0.590	0.660	0.590
		0.550	0.730	0.710	0.660	0.660	0.650	0.610	0.720	0.660	0.680	0.690
5	VC_{S3}15T	0.620	0.670	0.600	0.690	**1**	0.740	0.670	0.680	0.660	0.670	0.800
		0.640	0.720	0.680	0.690	0.690	0.620	0.620	0.710	0.630	0.650	0.640
6	VC_{CEN}15T	0.640	0.610	0.640	0.750	0.740	**1**	0.650	0.680	0.640	0.610	0.640
		0.560	0.660	0.680	0.690	0.670	0.660	0.660	0.730	0.730	0.690	0.700
7	V15T	0.650	0.640	0.550	0.640	0.670	0.650	**1**	0.730	0.770	0.620	0.710
		0.550	0.670	0.730	0.700	0.680	0.630	0.550	0.640	0.660	0.620	0.630
8	$O_1$15T	0.640	0.690	0.600	0.630	0.680	0.680	0.730	**1**	0.700	0.670	0.700
		0.620	0.680	0.740	0.710	0.690	0.620	0.600	0.670	0.630	0.630	0.600
9	$O_2$15T	0.600	0.650	0.580	0.590	0.660	0.640	0.770	0.700	**1**	0.670	0.700
		0.560	0.680	0.680	0.710	0.690	0.640	0.580	0.6500	0.670	0.630	0.660
10	$O_3$15T	0.630	0.720	0.610	0.660	0.670	0.610	0.620	0.670	0.670	**1**	0.690
		0.630	0.650	0.710	0.640	0.620	0.630	0.570	0.640	0.620	0.660	0.590
11	$CNN_0$15T	0.660	0.630	0.600	0.590	0.800	0.640	0.710	0.700	0.700	0.690	**1**
		0.660	0.680	0.720	0.670	0.710	0.620	0.600	0.6500	0.6500	0.630	0.600
12	$CNN_1$15T	0.540	0.530	0.480	0.550	0.640	0.560	0.550	0.620	0.560	0.630	0.660
		1	0.660	0.700	0.690	0.550	0.580	0.520	0.630	0.610	0.550	0.580
13	CNN_{STA}15T	0.620	0.630	0.580	0.730	0.720	0.660	0.670	0.680	0.680	0.650	0.680
		0.660	**1**	0.760	0.830	0.630	0.700	0.660	0.730	0.730	0.690	0.640
14	CNN_{P-TA}15T	0.680	0.670	0.560	0.710	0.680	0.680	0.730	0.740	0.680	0.710	0.720
		0.700	0.760	**1**	0.790	0.670	0.660	0.640	0.730	0.710	0.710	0.620
15	LT15T	0.570	0.580	0.530	0.660	0.690	0.690	0.700	0.710	0.710	0.640	0.670
		0.690	0.830	0.790	**1**	0.660	0.610	0.610	0.760	0.740	0.660	0.650
16	$CNN_1$15P	0.730	0.720	0.630	0.660	0.690	0.670	0.680	0.690	0.690	0.620	0.710
		0.550	0.630	0.670	0.660	**1**	0.730	0.650	0.720	0.700	0.720	0.710
17	CNN_{STA}15P	0.700	0.690	0.620	0.650	0.620	0.660	0.630	0.620	0.640	0.630	0.620
		0.580	0.700	0.660	0.610	0.730	**1**	0.740	0.670	0.690	0.650	0.660
18	VC_{CEN}15P	0.580	0.630	0.580	0.610	0.620	0.660	0.550	0.600	0.580	0.570	0.600
		0.520	0.660	0.640	0.610	0.650	0.740	**1**	0.690	0.590	0.670	0.620
19	VC_{S1}15P	0.630	0.700	0.610	0.720	0.710	0.730	0.640	0.670	0.650	0.640	0.650
		0.630	0.730	0.730	0.760	0.720	0.670	0.690	**1**	0.800	0.780	0.790
20	VC_{N1}15P	0.670	0.640	0.610	0.660	0.630	0.730	0.660	0.630	0.670	0.620	0.650
		0.610	0.730	0.710	0.740	0.700	0.690	0.590	0.800	**1**	0.780	0.790
21	O15P	0.650	0.660	0.570	0.680	0.650	0.690	0.620	0.630	0.630	0.660	0.630
		0.550	0.690	0.710	0.660	0.720	0.650	0.670	0.780	0.780	**1**	0.830
22	CNN_{P-TA}15P	0.600	0.710	0.640	0.690	0.640	0.700	0.630	0.600	0.660	0.590	0.600
		0.580	0.640	0.620	0.650	0.710	0.660	0.620	0.790	0.790	0.830	**1**

Appendix 1

Table 2

Analysis of variance for Medicago sativa populations concerning the bands of A2–UBC811–UBC816

No.	Population	Between groups		Within groups		F Test
		SS	DL	SS	DL	
1	$VC_{N1}15T$	3.121	1	18.639	98	16.41**
2	$VC_{N2}15T$	2.300	1	17.410	98	12.95**
3	$VC_{S1}15T$	0.708	1	22.332	98	3.11
4	$VC_{S1}15T$	2.300	1	17.410	98	12.95**
5	$VC_{S3}15T$	1.756	1	16.484	98	10.44**
6	$VC_{CEN}15T$	1.914	1	17.326	98	10.82**
7	V15T	5.100	1	16.290	98	30.68**
8	$O_1 15T$	2.533	1	16.707	98	14.86**
9	$O_2 15T$	4.767	1	16.993	98	27.49**
10	$O_3 15T$	3.392	1	17.998	98	18.47**
11	$CNN_0 15T$	2.723	1	17.438	98	15.30**
12	$CNN_1 15T$	1.103	1	21.938	98	4.93*
13	$CNN_{STA}15T$	3.033	1	15.207	98	19.55**
14	$CNN_{P\text{-}TA}15T$	5.601	1	12.639	98	43.43**
15	LT15T	3.516	1	15.234	98	22.62**
16	$CNN_1 15P$	2.402	1	14.188	98	16.60**
17	$CNN_{STA}15P$	2.723	1	17.438	98	15.30**
18	$VC_{CEN}15P$	0.000	1	20.160	98	0.00
19	$VC_{S1}15P$	0.478	1	10.832	98	4.33*
20	$VC_{N1}15P$	4.340	1	14.410	98	29.52**
21	O15P	1.284	1	15.306	98	8.22**
22	$CNN_{P\text{-}TA}15P$	1.120	1	16.040	98	6.84*

Appendix 2 **Table 1**

The genetic similarities coefficients between *Medicago sativa* L populations using UBC810–A3-A21 primers

No.	Population	1	2	3	4	5	6	7	8	9	10
		12	13	14	15	16	17	18	19	20	21
1		**1**	0.5977	0.6322	0.6207	0.5862	0.6667	0.5632	0.6092	0.6437	0.6322
	VC$_{N1}$15T	0.6552	0.6207	0.6322	0.6552	0.6322	0.7356	0.7126	0.6782	0.6092	0.5862
2		0.5977	**1**	0.5977	0.6322	0.5517	0.5632	0.5747	0.6667	0.6552	0.6897
	VC$_{N2}$15T	0.6667	0.7011	0.6667	0.6667	0.6437	0.6782	0.7471	0.6667	0.6897	0.6207
3		0.6322	0.5977	**1**	0.5517	0.6552	0.7126	0.5862	0.7011	0.5977	0.6322
	VC$_{S1}$15T	0.6552	0.6667	0.6322	0.6552	0.6552	0.5747	0.5747	0.6092	0.6322	0.6322
4		0.6207	0.6322	0.5747	**1**	0.6207	0.6322	0.8046	0.7586	0.6552	0.6667
	VC$_{S2}$15T	0.6897	0.6782	0.7586	0.6207	0.6667	0.6322	0.6552	0.7126	0.6897	0.6437
5		0.5862	0.5517	0.6552	0.6207	**1**	0.6207	0.6552	0.6782	0.6437	0.5632
	VC$_{S3}$15T	0.5862	0.6667	0.6552	0.6552	0.6322	0.5057	0.5287	0.5632	0.5632	0.6322
6		0.6667	0.5632	0.7126	0.6322	0.6207	**1**	0.7126	0.7356	0.6322	0.6897
	VC $_{CEN}$15T	0.6667	0.6092	0.5977	0.6207	0.7126	0.6322	0.6092	0.6897	0.6437	0.6207
7		0.5632	0.5747	0.5862	0.8046	0.6552	0.7126	**1**	0.7471	0.6207	0.6782
	V15T	0.6322	0.6667	0.6552	0.5862	0.7011	0.5747	0.5747	0.6782	0.6322	0.6092
8		0.6092	0.6667	0.7011	0.7586	0.6782	0.7356	0.7471	**1**	0.6667	0.7011
	O$_1$15T	0.6322	0.6897	0.7241	0.6782	0.6552	0.5747	0.5747	0.6782	0.6782	0.6322
9		0.6437	0.6552	0.5977	0.6552	0.6437	0.6322	0.6207	0.6667	**1**	0.7126
	O$_2$15T	0.7356	0.7011	0.7126	0.6897	0.6667	0.5632	0.5862	0.5977	0.6667	0.5747
10		0.6322	0.6897	0.6322	0.6667	0.5632	0.6897	0.6782	0.7011	0.7126	**1**
	O$_3$15T	0.7011	0.7356	0.6552	0.7011	0.7241	0.6437	0.6437	0.6092	0.6092	0.5862
11		0.6207	0.6092	0.5977	0.5632	0.5977	0.5862	0.5977	0.5517	0.6782	0.6667
	CNN$_0$15T	0.6207	0.7011	0.7126	0.6667	0.6667	0.5862	0.6552	0.5287	0.5977	0.5517
12		0.6552	0.6667	0.6552	0.6897	0.5862	0.6667	0.6322	0.6322	0.7356	0.7011
	CNN$_1$15T	**1**	0.6667	0.6782	0.7011	0.6782	0.6207	0.6667	0.7011	0.7011	0.6322
13		0.6207	0.7011	0.6667	0.6782	0.6667	0.6092	0.6667	0.6897	0.7011	0.7356
	CNN$_{STA}$15T	0.6667	**1**	0.8276	0.7816	0.6437	0.6092	0.6552	0.6667	0.7126	0.6437
14		0.6322	0.6667	0.6322	0.7586	0.6552	0.5977	0.6552	0.7241	0.7126	0.6552
	CNN$_{P-TA}$15T	0.6782	0.8276	**1**	0.7241	0.6782	0.6667	0.6897	0.6322	0.7011	0.6092
15		0.6552	0.6667	0.6552	0.6207	0.6552	0.6207	0.5862	0.6782	0.6897	0.7011
	LT15T	0.7011	0.7816	0.7241	**1**	0.6322	0.6207	0.6207	0.6092	0.6552	0.5862
16		0.6322	0.6437	0.6552	0.6667	0.6322	0.7126	0.7011	0.6552	0.6667	0.7241
	CNN$_1$15P	0.6782	0.6437	0.6782	0.6322	**1**	0.7356	0.7126	0.6322	0.6322	0.6552
17		0.7356	0.6782	0.5747	0.6322	0.5057	0.6322	0.5747	0.5747	0.5632	0.6437
	CNN$_{STA}$15P	0.6207	0.6092	0.6667	0.6207	0.7356	**1**	0.8851	0.7126	0.6667	0.6207
18		0.7126	0.7471	0.5747	0.6552	0.5287	0.6092	0.5747	0.5747	0.5862	0.6437
	VC$_{CEN}$15P	0.6667	0.6552	0.6897	0.6207	0.7126	0.8851	**1**	0.6897	0.6667	0.6437
19		0.6782	0.6667	0.6092	0.7126	0.5632	0.6897	0.6782	0.6782	0.5977	0.6092
	VC$_{S1}$15P	0.7011	0.6667	0.6322	0.6092	0.6322	0.7126	0.6897	**1**	0.7931	0.7241
20		0.6092	0.6897	0.6322	0.6897	0.5632	0.6437	0.6322	0.6782	0.6667	0.6092
	VC$_{N1}$15P	0.7011	0.7126	0.7011	0.6552	0.6322	0.6667	0.6667	0.7931	**1**	0.7011
21		0.5862	0.6207	0.6322	0.6437	0.6322	0.6207	0.6092	0.6322	0.5747	0.5862
	O15P	0.6322	0.6437	0.6092	0.5862	0.6552	0.6207	0.6437	0.7241	0.7011	**1**
22		0.6667	0.6092	0.6437	0.6782	0.5747	0.7011	0.6437	0.6437	0.6092	0.6667
	CNN$_{P-TA}$15P	0.7356	0.5862	0.5977	0.5517	0.6897	0.6552	0.6782	0.8046	0.7586	0.8046

Appendix 2

Table 2

Analysis of variance for Medicago sativa populations concerning the bands of
UBC810–A3-A21 primers

No.	Population	Between groups		Within groups		F Test
		SS	DF	SS	DF	
1	$VC_{N1}15T$	3.903	1	14.327	85	23.16**
2		1.718	1	16.099	85	9.07**
3	$VC_{N2}15T$	1.249	1	17.739	85	5.99*
4		0.000	1	14.851	85	0.00
5	$VC_{S1}15T$	0.399	1	18.590	85	1.82
6		3.653	1	14.967	85	20.75**
7	$VC_{S2}15T$	1.006	1	17.224	85	4.97*
8		0.435	1	14.967	85	2.47
9	$VC_{S3}15T$	0.134	1	13.544	85	0.84
10		2.260	1	14.177	85	13.55**
11	$VC_{CEN}15T$	1.397	1	17.224	85	6.90*
12		0.454	1	12.604	85	3.06
13	V15T	0.524	1	14.327	85	3.11
14		0.005	1	11.742	85	0.04
15	$O_1 15T$	2.618	1	14.762	85	15.07**
16		3.050	1	13.387	85	19.37**
17	$O_2 15T$	5.748	1	12.872	85	37.96**
18		5.212	1	12.604	85	35.15**
19	$O_3 15T$	3.050	1	13.387	85	19.37**
20		1.313	1	14.090	85	7.92**
21	$CNN_0 15T$	1.006	1	17.224	85	4.97*
22		2.830	1	14.090	85	17.07**

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ASSESSMENTS ON THE PRODUCTIVITY OF GRASSLANDS LOCATED IN THE SUBCARPATHIC AREA OF OLTENIA, ACORDING TO THE MOISTURE REGIME EXPRESSED BY VEGETATION

Teodor MARUȘCA[1]

Abstract. *The Sub-Carpathian area of Oltenia is comprised between the Oltenia and Tismana Valleys, being located at the foot of the Parâng and Vâlcan Mountains and comprising Târgu Jiu - Câmpu Mare intracoline depression. The permanent grasslands found in this area comprise altitudes between 200-680 m altitude, generally on flat lands or slopes of up to 35 degrees, on soils with a pH of 5.2-6.8 and a high biodiversity, with an average of 152 plant species in a phytosociological association. From the geobotanical point of view, these grasslands are included mainly into 3 large classes: Molinio - Juncetea (mesohygrophile grasslands), Arrhenatheretea (mesophilic grasslands) and Festuco - Brometea (xerophile and xeromesophile grasslands), which expressed in decreasing order the humidity as a factor influencing their vegetation. Comparing the meso-hygrophile with the mesophile grasslands, we observe that the indices of pastoral value are almost identical for both grasslands, reaching values between 63.3-63.5 with the highest values in the association Festucetum pratensis (71) and the lowest in Agrostetum canini (52). On the xerophile and mesoxerophile grasslands the pastoral value is 33, almost half compared to the previous vegetation classes. The green mass production recorded by mesophile grasslands is on average 11.3 t/ha while the xerophile and xeromesophile ones reached green mass productions of 6.35 t/ha, a value lower with 44%. The loading with animals reached approx. 0.95 LU/ha on grasslands with better humidity and 0.53 LU/ha in areas with moisture deficit. The assessment of grassland productivity will be further used to establish the optimal grazing capacity, environmental production and biodiversity conservation.*

Keywords: permanent grasslands, production assessments, pastoral value, grazing capacity

1. Introduction

Grassland productivity has become a basic indicator for the preparation of pastoral arrangements [2, 3].

From a practical point of view, the methods used for determining or evaluating the productivity of grasslands are quite difficult to be applied in field conditions comprising protected areas [7]. Therefore, a new method for evaluating the productivity of grasslands was used in this study, a method based on the floristic survey and forage phytomass indices [4, 2].

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The present manuscript aims to assess the productivity of a grassland located in the Sub-Carpathian area of Oltenia, using these new methods.

2. Materials and methods

In order to perform the productivity assessments for the grassland studied in this research paper, we used the floristic surveys of these grasslands found in the paper "Grasslands from Sub-Carpathian area of Oltenia", Cap. 3.2 *Vegetation*, edited by Păun M., Popescu Gh. and Zaharia I., under the coordination of Pavel C. from the University from Craiova [6].

The main associations of grassland plants identified in the Oltenia Carpathian are framed in a Phytocoenology system as follows:

The vegetation of meso-hygrophile grasslands

Class *MOLINIO* - JUNCETEA, Br-Bl. 1949, 1951

Ord. *MOLINIETALIA*,, Koch 1926

Al . *Agrostion stoloniferae*, (Soó 1933)

1. As. *Agrostetum caninae* Harg. 1942
2. As. Agrostetum stoloniferae (Ujvarosi 1941)
3. As. *Alopecuretum pratensis*, Nowinski 1928
4. As. *Festucetum pratensis*, Soó 1938
5. As. *Poetum silvicolae oltenicum*, Buia, Păun, Safta et Pop 1959

The vegetation of mesophile grasslands

Class *ARRHENATHERETEA*, Br.-Bl. 1947

Ord. *ARRHENATHERETALIA*, Pawl. 1928

Al. *Arrhenatherion elatioris*, Br. – Bl. 1925, Pawl.1928

6. As. *Poetum pratensis*, Răv., Căzăc. et Turenschi 1956

Al. *Cynosurion cristati*, Br-Bl et Tx. 1943

7. As. *Festuco* - *Agrostetum*, Horv. 1951
8. As. *Agrostetum tenuis*, Szafer, Pawl., Kulcz. 1923
9. As. *Lolietum perennis*, Safta 1943

The vegetation of xerophile and xeromesophile grasslands

Clasa *FESTUCO – BROMETEA,* Br.-Bl. 1943
Ord. *BROMETALIA ERECTI*, Br.-Bl. 1936
Al. *Bromion*, Br-Bl 1925
10. As. *Ventenata dubia - Xeranthemum foetidum*, Borza 1950
Ord. *FESTUCETALIA VALESIACAE*
Al. ***Festucion rupicolae***, Soó 1964
11. As. *Botriochloetum ischaemi,* Krist 1937
12. As. *Medicagini - Festucetum valesiacae,*Wagner 1940
13. As. *Chrysopogonetum grylli oltenicum*, Buia, Păun, Safta et Pop 1959
Ord. *BRACHYPODIO - CHRYSOPOGONETALIA*, (H-ic 1958) Boșcaiu 1970
Al. *Danthonio - Brachipodion,* Boșcaiu 1970
14. As. *Festuco (rubrae) - Danthonietum,* Csűrős, Pop, Hodișan, Csűrős - Kapt. 1958

In addition to the stationary conditions (relief, altitude), the description of grassland associations also includes data related to soil reaction and some assessments on forage production.

Grouping the associations according to the vegetation classes that correspond also to humidity conditions have been very helpful in establishing grassland productivity.

Furthermore, we were able to determine more precisely the ecological and humidity indices for these associations are after [1], improved by [7] and [4]:

1 and 2 = very dry (xerophilous);
3 and 4 = dry (mesoxerophilous);
5 and 6 = moderate moisture (mesophilous);
7 and 8 = moisture (mesohigrophilous);
9 = moisture wet (hygrophilous);
10 = flooded (ultrahigrophilous).

The productivity assessments were performed according to the method proposed by [5], with an example provided also in the present Annals of the Romanian Academy of Scientists [2], therefore we won’t describe it again.

3. Results and Discussions

First we performed a synthesis of the seasonal conditions including the number of species (phytodiversity), components of each plant association of grassland (Table 1).

The grasslands found in the studied area are located at attitudes between 200-680 m, on a flat or sloping terrain with an inclination of up to 35 degrees.

The soil reaction is moderately acidic to neutral with a pH ranging between 5.2 and 6.8.

These grasslands are very rich in plant species, comprising an average of 152 taxa, with differences ranging from a minimum of 87 plant species found on the association *Alopecuretum pratensis*, and a maximum of 212 plant species found on the *Agrostetum tennuis* association.

Table 1) General data comprising the natural conditions and phytodiversity of the studied grasslands.

No.	*Phytosociologycal association*	*Altitude (m)*	*Relief*	*Soil reaction (pH)*	*No. of species*
The vegetation of the mesohigrophile grasslands					
1.	*Agrostetum caninae*	250-450	Flat	5.2-5.5	111
2.	*Agrostetum stoloniferae*	200-400	Flat	6.0-6.6	156
3.	*Alopecuretum pratensis*	200-350	Flat		87
4.	*Festucetum pratensis*	200-450	Flat		159
5.	*Poetum silvicolae oltenicum*	200-300	Flat		130
The vegetation of mesophile grasslands					
6.	*Poetum pratensis*	200-350	Flat	5.8-6.1	95
7.	*Festuco - Agrostetum*	250-680	Slope	5.2-5.8	148
8.	*Agrostetum tenuis*	200-600	Slope		212
9.	*Lolietum perennis*	200-600	Flat		125
The vegetation of xerophile and xeromesophile grasslands					
10.	*Ventenata dubia - Xeranthemum foetidum*	300-500	Slope		108
11.	*Botriochloetum ischaemi*	265-520	5 - 35^0	5.3-6.0	168
12.	*Medicagini - Festucetum valesiacae*	200-600	Slope		189
13.	*Chrysopogonetum grylli oltenicum*	200-450	Slope	5.4-5.6	164
14.	*Festuco (rubrae) - Danthonietum*	260-530	Slope	6.1-6.8	138
	AVERAGE	200-680	All	5.2-6.8	152

Source: Own results.

Our results concerning grassland productivity highlighted quite big differences among the studied grasslands associations considering the humidity factor (Table 2).

The mesohigrophile grasslands recorded ecological soil moisture indices with values ranging from 5.4 found in As. *Festucetum pratensis* up to 6.5 in As. *Alopecuretum pratensis*. The pastoral value recorded values between 52.2 in *Agrostetum canina* and 71 in *Festucetum pratensis*.

Forage green mass production (GM) recorded values ranging from 7.8 t/ha up to 14.22 t/ha for the same associations, which allow an optimal loading with animals between 0.65 and 1.18 units of livestock (LU) per hectare, in a 185-day grazing season.

The mesophile grasslands recorded ecological humidity indices ranging from 4.2 in *Agrostetum tenuis* up to 5.2 in *Poetum pratensis*.

The pastoral value (PV) reached values between 56.9 and 69.9 in the same associations as before.

Table 2) The indices for grasslands humidity and optimal loading with animals divided according to the phytosociologycal associations

No.	*Phytosociologycal association*	*Humidity factor (indices)*	*Pastoral value*		*GM (t/ha)*	*LU/ha*	*%*	*Evaluation*
			Ind.	*%*				
The vegetation of the mesohigrophile grasslands								
1.	*Agrostetum caninae*	6.0	52.2	99	7.80	0.65	81	Average
2.	*Agrostetum stoloniferae*	5.8	63.1	120	11.54	0.96	112	Mediocre
3.	*Alopecuretum pratensis*	6.5	67.8	129	13.01	1.08	135	Mediocre
4.	*Festucetum pratensis*	5.4	71.0	135	14.22	1.18	147	Good
5.	*Poetum silvicolae oltenicum*	0.1	63.4	121	11.08	0.92	115	Mediocre
The vegetation of mesophile grasslands								
6.	*Poetum pratensis*	5.2	69.9	133	12.23	1.02	127	Average
7.	*Festuco - Agrostetum*	4.6	59.6	114	9.98	0.83	104	Average
8.	*Agrostetum tenuis*	4.2	56.9	108	9.13	0.76	95	Mediocre
9.	*Lolietum perennis*	4.9	66.8	127	13.04	1.09	136	Average
The vegetation of xerophile and xeromesophile grasslands								
10.	*Ventenata dubia - Xeranthemum foetidum*	2.4	10.1	19	0.85	0.07	9	Degraded
11.	*Botriochloetum ischaemi*	3.1	18.0	34	1.77	0.15	19	Degraded
12.	*Medicagini - Festucetum valesiacae*	2.5	32.5	62	4.03	0.34	42	Very weak
13.	*Chrysopogonetum grylli oltenicum*	2.3	45.9	87	15.12	1.26	157	Good
14.	*Festuco (rubrae) - Danthonietum*	4.3	58.4	111	9.98	0.83	104	Average
	GENERAL AVERAGE	**4.5**	**52.5**	**100**	**9.56**	**0.80**	**100**	**Mediocre**

Source: Own results.

The lowest GM production of 9.13 t/ha was reached by the same association, namely *Agrostetum tenuis* while the highest GM production of 13.04 t/ha was recorded this time at *Lolietum perennis*, with a grazing capacity of 0.76 - 1.09 LU/ha.

The xerophile and mesoxerophile grasslands showed extremely low humidity indices from 2.3 found on *Crysopogonetum grylli oltenicum* to 4.3 in *Festuco (rubrae) Danthonietum*.

The pastoral value was 10 (degraded) for As. *Ventenata dubia - Xeranthemum foetidum* and higher than 58 (medium) in *Festuco (rubrae) Danthonietum*. Green mass production recorded values between 0.85 t/ha (degraded) and 15.12 t/ha in *Crysopogonetum grylli oltenicum* with an optimal loading with animals ranging between 0,07 LU/ha and 1.26 LU/ha.

On average, the soil moisture indices for the whole area were 4.5 for mesoxerophile to mesophile grasslands, 6.0 as the upper limit for mesophile to mesohygrophilic in the *Molinio - Juncetea* class and 2.9 as the lower limit for xerophile to mesoxerophile grasslands in *Festuco - Brometea* class (Table 3).

Table 3) The productivity and the average grazing capacity according to the humidity factor at the level of vegetation classes

Phytosociologycal classes (ecological group)	*Humidity factor (ind.)*	*Pastoral value (ind.)*	*GM production (t/ha)*	*Grazing capacity (LU/ha)*	*%*
MOLINIO - JUCETEA (mesohigrophilic)	6.0	63.5	11.53	0.96	120
ARRHENATERETEA (mesophilic)	4.7	63.3	11.10	0.93	116
FESTUCO - BROMETEA (xerophilic and xeromesophilic)	2.9	33.0	6.35	0.53	66
AVERAGE	**4.5**	**53.3**	**9.66**	**0.80**	**100**

Source: Own results.

Considering the average productivity, we found out that the mesohygrophile and mesophile grasslands reached very close values for pastoral value and of green mass production (63 PV and 11.1 - 11.5 t/ha GM).

The xerophile and xeromesophile grasslands included in *Festuco - Brometea* Class recorded a decrease with 34% in grazing capacity (0.53 LU/ha) compared to the average area grazing capacity (0.8 LU/ha), which could be explained by the lower soil moisture.

Our results highlighted the special influence of the soil moisture ecological factor on the productivity of the grasslands.

Conclusions

(1) The grasslands from Oltenia Sub Carpathians, spread on altitudes between 200-600 m showed a very high diversity comprising an average of over 150 plant species in the 14 phytosociologycal associations.

(2) The productivity of mesohigrophile and mesophile grasslands reached very closed values, with over 63 pastoral value and between 11.1-11,5 t/ha GM production.

(3) The productivity of xerophile and xeromesophile grasslands reached a lower pastoral value with 48% and lower green mass production with 34% compared to the other grasslands studied in this manuscript.

(4) The optimal grazing capacity is 0.95 LU/ha on grasslands with optimal soil moisture (mesophile) and 0.53 LU/ha on grasslands with moisture deficit (xerophile) in 185 days of grazing season.

(5) Soil humidity showed to have a determinant role in grassland productivity, being considered as an important indicator for the proper management of this agricultural system.

R E F E R E N C E S

[1] Kovacs, A. J., Biological, ecological and economical indicators of grasslands flora (Indicatorii biologici, ecologici şi economici ai florei pajiştilor), Redacţia de propagandă tehnică agricolă Publishing House, (1979).

[2] Marușca, T., Arsene, G.G., Taulescu, Elena, Assessment of permanent grassland productivity in Poiana Ruscă Mountains (Southwest Romanian Carpathians), Annals of the Academy of Romanian Scientists: Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 9(1):62 – 69, (2019a).

[3] Marușca, T., Taulescu, E., Roșca, V., Băjenaru, B., Memedemin, D., Contributions to the Evaluation of Grassland Productivity on the Măcinului Mountains National Park, Romanian Journal of Grassland and Forage Crops (RJGFC), Vol. 20, pp. 17 - 26, (2019b).

[4] Marușca, T., Praticulture in everybody's language (Praticultura pe înțelesul tuturor), Profesional-Agromedia SRL Publishing House, (2016).

[5] Marușca, T., Contributions to the evaluation of pasture productivity using the floristic releve, Romanian Journal of grassland and forage crops (RJGFC), Vol. 19, pp. 33- 47, (2019).

[6] Pavel, C. (coord.), Grasslands from the subCarpathian zone of Oltenia (Pajiștile din zona Subcarpatică a Olteniei), Scrisul Românesc Publishing House, (1973).

[7] Păcurar, F., Rotar, I., Study and interpretation methods of grassland vegetation (Metode de studiu și interpretare a vegetației pajiștilor), Risoprint Publishing House, (2014).

CONTRIBUTIONS TO THE EVALUATION OF GRASSLAND FROM SOUTH BARAOLT MOUNTAINS IN TERMS OF PRODUCTIVITY

Teodor MARUȘCA[1], Marius DANCIU[2], Dan Marian GUREAN[3]

Abstract. *The permanent grasslands found in the Southern Baraolt Mountains are spread between 460-840 m altitude, from the Olt riverside up to the oak and beech floor, on flat lands up to 45 degrees. The vegetation belongs to 4 classes, 5 orders, 9 alliances and 17 associations, with an average of 77 phytotaxa. In the Olt riverside and its tributaries, grasslands are being harvested mainly for hay, having a pastoral value of 60 (average - good) and a green mass production of over 16,4 t/ha being evaluated as good. The highest production of over 27 t/ha was evaluated at the association Typhoidetum arundinacea and the lowest green mass production of 2 t/ha was recorded by the association Deschampsietum caespitosae. Very good production values of 19-20 t/ha were evaluated for Alopecuretum pratensis, Festucetum pratensis and Arrhenatheretum elatioris. The grasslands used for grazing recorded an average production of 7 t/ha, which allows a loading with animals of 0.63 LU/ha in 165 days grazing season. The highest production was evaluated at the association Lolio - Plantaginetum majoris (16.44 t/ha) with a loading with animals of 1.53 LU/ha and the lowest at Stipetum capillatae and Botriochloetum ischaemi that allow a loading with animals ten times smaller. The evaluation of the productivity of grasslands based on floristic surveys made by geobotanists could continue to be used for the preparation of pastoral arrangements and forage balance on large geographical areas or zootechnical units.*

Keywords: permanent grasslands, phytocoenosis, pastoral value, forage green mass production

1. Introduction

Grassland productivity has become an extremely important economic indicator used for the preparation of pastoral arrangements and their optimum management.

The optimal animal loading and the contribution of hayfields to the forage balance can be established based on the pastoral value and especially on the green mass production capitalizable by animals.

The most accurate method for determining grassland productivity includes fenced land, with mowing, weighing and laboratory analysis of grass harvested several times in a year, assessments performed for several years [2].

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This expensive method is more difficult to apply in isolated areas such as mountain areas or on pastures where animals are grazing.

Therefore, a more expeditious and sufficiently precise method for assessing grassland productivity was developed, a method based on floristic survey [4].

The application of this method generated good results so far and it is expected to be further used for the evaluation of grassland productivity based on floristic survey for both older and current geobotanical studies on grassland vegetation [5, 6, 7, 8, 9, 10].

In addition, a dynamic analysis concerning the evolution of productivity of a grassland located in a certain area can be made [3].

This paper is a continuation of the productivity assessment of grasslands found in the South of Baraolt Mountains, located in the Curvature Carpathians.

2. Materials and methods

In order to further evaluate the productivity of grasslands, the floristic surveys from the doctoral thesis “Geobotanical studies in the South of the Baraolt Mountains”, prepared by biologist Marius Danciu in 1974 under the guidance of Prof. Dr. doc. Ion Popescu Zeletin and Prof. dr. Doc. Iuliu Morariu were considered [1].

The vegetation of the permanent grasslands was classified in 4 classes, 5 orders, 9 alliances and 17 more important phytosociological associations, as follows:

Class ***PHRAGMITETEA AUSTRALIS***,Tűxen et Preising1942

Ord. *MAGNOCARICETALIA*, Pignatti 1953

Al.***Caricion rostratae***, Bal. - Tul. 1963

1. As. *Typhoidetum arundinaceae*, Eggler 1933
2. As. *Caricetum vulpinae*, Tx. 1947

Class ***MOLINIO - ARRHENATHERETEA***, Tűxen 1937

Ord. *MOLINIETALIA*, W.Koch1926

Al. ***Agrostion stoloniferae***, Soó1933

3. As. *Deschampsietum caespitosae*, Horvatic 1930
4. As. *Alopecuretum pratensis*, Soó1936
5. As. *Festucetum pratensis*, Soó 1928

Ord. *ARRHENATHERETALIA*, Pawl. 1928

Al. ***Arrhenatherion elatioris***, (Br.-Bl1925) W.Koch 1926

6. As. *Arrhenatheretum medio europaeum*, (Br.-Bl1919) Oberd. 1952

Al. ***Cynosurion***, Tx1947

7. As. *Festuco - Agrostietum*, Horv. 1951

Class ***FESTUCO – BROMETEA***, Br.- Bl. et Tx. 1943

Ord. *FESTUCETALIA VALESIACAE*, Br.-Bl. et Tx. 1943

Al. ***Seslerio - Festucion pallentis***, Klika 1931

8. As. *Caricetum humilis transsilvanicum*, Zólyomi 1939

9. As. *Festucetum rupicolae calcophyllum*, Csűrős 1959

Al. ***Festucion rupicolae***, Soó(1929) 1940

10. As. *Stipetum capillatae*, Huek 1931

Al. ***Cirsio-Brachipodion***, Hadač et Klika 1944

11. As. *Carici humilis-Brachipodietum pinnati transilvanicum*, Soó1942

12. As. *Botriochloetum ischaemi*, Krist. 1937

Class ***PLANTAGINETEA MAJORIS***,Tx. et Prsg.1950

Ord. *PLANTAGINETALIA MAJORIS*, Tx 1950

Al. ***Polygonion avicularis***, Br.- Bl. 1931

13. As. *Lolio – Plantaginetum majoris* (Linkola1921) Berger1930

14. As. *Sclerochloo - Polygonatum avicularis*,(Gams 1927) Soó1970

Al. ***Agropyro - Rumicion crispi*** Nordh 1940

15. As. *Lolio – Potentilletum anserinae* (Rapcs.1927) Knapp 1946

16. As. *Rorippo austriacae-Agropyretum repentis*, (Timár 1947)Tx.1950

17. As. *Rorippo silvestri-Agrostidetum stoloniferae*, Moor1958

The actual method of evaluating grassland productivity was extensively described by Marușca (2019) and exemplified in these Annals of the Romanian Academy of Scientists, Vol. 9, No.1 [6], therefore we won’t present it again.

3. Results and discussions

The description of the grassland vegetation is preceded by the characterization of the seasonal conditions where they were encountered (Table 1).

The grasslands found in the studied area are located at 460 - 840 m altitude, on flat or sloping land with different exposures and inclinations up to 45 degrees. The average vegetation cover is very good of 94%.

A total number of 186 surveys were performed comprising an average number of 77 cormophytes species, a minimum of 39 species belonging to the nitrophilic association *Sclerochloa - Polygonetum avicularis* and 124 species in the xerophilous association *Caricetum humilis transilvanicum*.

Table 1) General data comprising the natural conditions and phytodiversity of grassland associations found in South Baraolt Mountains

No. crt.	*Phytocoenosis (association)*	*Alt. (m)*	*Exposure*	*Ind. Degrees (^{0})*	*Coverage with vegetation (%)*	*No. of surveys*	*Species no.*
1.	*Typhoidetum arundinaceae*	460-480	Flat	0	100	14	60
2.	*Caricetum vulpinae*	465-535	Flat	0	95	11	56
3.	*Deschampsietum caespitosae*	470-500	Flat	0	97	15	89
4.	*Alopecuretum pratensis*	460-465	Flat	0	100	9	63
5.	*Festucetum pratensis*	535-660	Flat	0	100	17	110
6.	*Arrenatheretum medio europaeum*	470-620	Flat	0	100	11	120
7.	*Festuco-Agrostietum*	600-840	Flat, S, V, SV, NV, N	0-10	100	15	116
8.	*Caricetum humilis transsilvanicum*	520-640	S, SE, SV, E	20-45	83	19	124
9.	*Festucetum rupicolae calcophyllum*	540-640	S, E, SE	10-25	87	7	64
10.	*Stipetum capillatae*	480-590	S, SV	25-45	76	10	71
11.	*Carici humilis-Brachipodietum pinnati transilvanicum*	560-580	S	15-35	99	10	86

Continuation Table 1

No. crt.	*Phytocoenosis (association)*	*Alt. (m)*	*Exposure*	*Ind. Degrees (^{0})*	*Coverage with vegetation (%)*	*No. of surveys*	*Species no.*
12.	*Botriochloetum ischaemi*	510-670	S, SE, SV	15-30	95	10	114
13.	*Lolio – Plantaginetum majoris*	460-480	Flat	0	93	10	58
14.	*Sclerochloo - Polygonatum avicularis*	470-500	Flat	0	87	6	39
15.	*Lolio – Potentilletum anserinae*	470-480	Flat	0	98	7	45
16.	*Rorippo austriacae-Agropyretum repentis*	465	Flat	0	89	6	36
17.	*Rorippo silvestri-Agrostidetum stoloniferae*	460-465	Flat	0	100	9	60
	TOTAL-AVERAGE	**460-840**	**ALL**	**0-45**	**94**	**186**	**77**

Source: Own results.

These grasslands were used as hayfield in Lunca Oltului and other tributaries or near the localities and by grazing with animals in areas located far away from these sits.

The grasslands harvested for hay belong to the alliances *Caricion rostratae, Agrostion stoloniferae* and *Arrhenatherion elatioris* (Table 2).

On average, the participation of forage species in the vegetation cover is 76% with a minimum of 17% in the association *Deschampsietum caespitosae* and a maximum of 91% in *Arrhenatheretum elatioris* and *Typhoidetum arundinacea*, a proportion that has a great influence on the pastoral value of the degraded areas (13) as well as of the most productive grasslands (70 – 80).

The highest production, of over 27 t/ha green forage, was evaluated for *Typhoidetum arundinacea* and the lowest of only 2 t/ha for *Dechampsietum caespitosae*. The associations *Alopecuretum pratense*, *Festucetum pratense* and *Arrhenatheretum elatioris* with 19-20 t/ha, are also very valuable.

The largest area of grasslands belonging to 6 alliances and 11 plant associations is used for grazing with animals (Table 3).

Table 2) The productivity of hay meadows located in South Baraolt Mountains

No. Crt.	*Phytocoenosis (association)*	*Coverage with species (%)*		*Pastoral value*		*Green mass production*		*Evaluation*
		Harmfull	Forage	Ind.	%	t/ha	%	
	Al.***Caricion rostratae***							
1.	*Typhoidetum arundinaceae*	9	91	70.3	117	27.37	167	Excellent
2.	*Caricetum vulpinae*	16	79	37.0	62	10.61	65	Average

Continuation Table 2

No. Crt.	*Phytocoenosis (association)*	*Coverage with species (%)*		Pastoral value		Green mass production		Evaluation
		Harmfull	Forage	Ind.	%	t/ha	%	
	Al. ***Agrostion stoloniferae***							
3.	*Deschampsietum caespitosae*	80	17	13.2	22	2.00	12	Weak
4.	*Alopecuretum pratensis*	12	88	76.4	128	18.95	115	Good
5.	*Festucetum pratensis*	10	90	82.8	138	19.20	117	Good
	Al. ***Arrhenatherion elatioris***							
6.	*Arrenatheretum medio europaeum*	9	91	79.8	133	20.37	124	Very good
	AVERAGE	**23**	**76**	**59.9**	**100**	**16.42**	**100**	**Good**

Source: Own results.

Table 3) The productivity and optimal loading with animals in a 165 grazing days season of grasslands found in South Baraolt Mountains

No. Crt.	*Phytocoenosis (association)*	*Coverage with species (%)*		*Pastoral value*		*Green mass production*		*Loading with animals LU/ha*	*Evaluation*
		Harmful	Forage	Ind.	%	t/ha	%		
	Al. ***Cynosurion***								
1.	*Festuco - Agrostietum*	24	76	56.5	155	10.43	155	0.97	Average
	Al. ***Seslerio - Festucion pallentis***								
2.	*Caricetum humilis transsilvanicum*	34	49	22.5	62	1.25	19	0.12	Degraded
3.	*Festucetum rupicolae calcophyllum*	15	72	38.4	105	6.07	90	0.57	Weak
	Al. ***Festucion rupicolae***								
4.	*Stipetum capillatae*	68	8	4.6	13	0.70	10	0.07	Degraded

Continuation Table 3

No. Crt.	Phytocoenosis (association)	Coverage with species (%)		Pastoral value		Green mass production		Loading with animals LU/ha	Evaluation
		Harmful	Forage	Ind.	%	t/ha	%		
Al. ***Cirsio-Brachipodion***									
5.	*Carici humilis-Brachipodietum pinnati transilvanicum*	22	77	36.5	100	6.83	101	0.64	Weak
6.	*Botriochloetum ischaemi*	76	19	10.6	29	1.44	21	0.13	Degraded
Al. ***Polygonion avicularis***									
7.	*Lolio – Plantaginetum majoris*	3	90	78.2	215	16.44	244	1.53	Good
8.	*Sclerochloo - Polygonatum avicularis*	19	68	39.1	107	4.62	69	0.43	Weak
Al. ***Agropyro - Rumicion crispi***									
9.	*Lolio – Potentilletum anserinae*	86	12	8.6	24	0.60	9	0.06	Degraded
10.	*Rorippo austriacae-Agropyretum repentis*	22	77	38.9	107	10.66	158	0.99	Average
11.	*Rorippo silvestri-Agrostidetum stoloniferae*	7	93	66.1	182	14.95	222	1.39	Good
	AVERAGE	**34**	**58**	**36.4**	**100**	**6.73**	**100**	**0.63**	**Mediocre**

Source: Own results.

The meadows are generally more degraded compared to hay meadows, recording an average of only 58% participation of forage species in the vegetation cover, compared to hay meadows where a participation of 76% was reached.

The most degraded grasslands from economical point of view belong to the associations *Stipetum capillaris, Lolio-Potentilletum anserinae* and *Botriochloetum ischaemi* with 8-19% participation of forage species which results in a lower pastoral value indices of only 5-11.

The most valuable grasslands belong to the associations *Festuco-Agrostietum* and *Lolio- Plantaginetum majoris* with 76-90% participation of forage species and 56-78 for pastoral value.

Productions between 10 and 16 t/ha green forage mass was evaluated on the associations *Festuco - Agrostetum, Rorippo austriacae - Agropyretum repentis, Rorippo silvestri - Agrostetum stoloniferae and Lolio - Plantaginetum majoris* with an optimal grazing capacity between 1-1.5 LU/ha in a 165 days season.

The lowest green forage mass productions were reached on the associations *Lolio - Potentilletum anserinae, Stipetum capillatae, Caricetum humilis* and *Botriochloetum ischaemi* which showed an optimal loading with animals of only 0.06-0.13 LU/ha in the same grazing season.

The grasslands found in South Baraolt recorded, on average, a production of 6.73 t/ha green forage mass which support 0.63 LU/ha in a 165 days grazing season, being evaluated as mediocre from productivity point of view.

Conclusions

(1) The geobotanical studies performed on permanent grassland vegetation could be further used for evaluating grassland productivity assessments.

(2) The highest pastoral value of 70-80 was evaluated for the associations: *Festucetum pratensis, Arrhenatheretum elatioris, Alopecuretum pratense* and *Typhoidetum arundinacea* where we reached productions between 19-27 t/ha green forage mass, harvested as hay meadow.

(3) Grasslands used for grazing with animals reached a lower and variable green forage mass production which allow an optimal loading with animals of 0,06 LU/ha, being evaluated as degraded for the association *Lolio - Potentilletum anserinae* and up to 1.54 LU/ha on the association *Lolio - Plantaginetum majoris* which was evaluated as good.

(4) Data concerning the economical indices of productivity for grassland could be further used for the preparation of pastoral arrangements and for determining the forage balance required for animal growing.

R E F E R E N C E S

[1] Danciu, M., Geo-botanical studies in the South of the Baraolt Mountains, PhD. thesis, University from Bucharest, Faculty of Biology, (1974).

[2] Păcurar, F., Rotar, I., Study and interpretation methods of grasslands vegetation (Metode de studiu și interpretare a vegetației pajiștilor). Risoprint Publishing House, Cluj – Napoca, Romania, (2014).

[3] Marușca, T., Contributions to the evaluation of pasture productivity using the floristic releve, Romanian Journal of grassland and forage crops, Vol. 19, pp. 33- 47, (2019).

[4] Marușca, T., Ionescu, I., Taulescu, E., Simion, I., Malinas, A., Contributions to the evaluation of the productivity of permanent grassland from North Oltenia, Romanian Journal of Grassland and Forage Crops (RJGFC), No. 21, pp. 49 - 59, (2020a).

[5] Marușca, T., Arsene, G.G., Taulescu, E., Assessment of permanent grassland productivity in Poiana Ruscă Mountains (South-West Romanian Carpathians), Annals of the Academy of Romanian Scientists Series Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 9, No. 1, pp. 62-69, (2020b).

[6] Marușca, T., Oprea, A., Memedemin, D., Pop, O.G., Tibirnac, M.N., Maftei, D.I., Simion, I., Taulescu, E., Assessment of phytodiversity and productivity of steppic grasslands from ROSCI 0201 Podișul Nord-Dobrogean (Evaluarea fitodiversității și productivității pajiștilor stepice din ROSCI0201 Podișul Nord-Dobrogean, în relație cu unele caracteristici ale solului, "Gavrila Simion" Eco-museum Research Institute, Tulcea, Danube Delta Journal, Vol. VIII, pp. 63-82, (2020c).

[7] Marușca, T., Dihoru, Gh., Doniță, N., Memedemin, D., Pășcuț, C. Gh., Contributions to the evaluation of the productivity of permanent grasslands from the Babadag Plateau (Dobrogea), Annals of the University of Oradea, Fascicle: Environmental Protection, Vol. XXXV, pp.85-94, (2020d).

[8] Marușca, T., Nicolin, A.L., Contributions to the study of the impact of grassland phyto-coenoses in the upper and middle Timis river basin on forage and livestock production (Banat, Romania). University of Agricultural Sciences and Veterinary Medicine of Banat "King Michael I of Romania", Research Journal of Agricultural Science, Vol. 52, No. 1, pp. 159-166, (2020e).

[9] Marușca, T., Ularu, P., Gurean, D. M., Dragoș, M.M.M., Taulescu, E., Contributions to the grassland productivity evaluation in the Perșani Mountains, Journal of Montanology, No. 13, pp. 23-32, (2020f).

[10] Pășcuț, C. Gh., Marușca, T., Studies regarding the evolution of grassland productivity from Codru Moma Mountains (Western Carpathians), Annals of the Academy of Romanian Scientists Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 9, No. 2, (2020).

ROMANIA'S CONTRIBUTION TO THE EUROPEAN UNION'S AGRICULTURE IN THE PERIOD 2010-2020

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Abstract. *The purpose of this study was to analyze Romania's contribution to the EU agriculture using Eurostat data, fixed index, trend equations, determination coefficient, and descriptive statistics. For its high number of farms, Romania occupies the top position in the EU, but for only 3.6 ha utilized agricultural area per farm, the country is far away from 16.7 ha UAA the EU average. The standard output pushes Romania on the 8th position in the EU, but for only Euro 3,537 standard output per farm, it comes on the last position. In 2019, agricultural output reached Euro 18.9 Billion, reflecting a contribution of 4.2% to the EU output and that Romania was ranked the 8th in the EU. Due to its inbalanced crop/animal output ratio of 3.38, Romania's share in the EU crop output is 55.72%, while in animal output is only 2.2%. Romania is ranked the 8th in the EU for GVA 8.78 Billion and 4.56% contribution to the EU. Compared to 2010, in 2019, income from agriculture (Indicator A) was by 39.9% higher in Romania, being exceeded only by Italy which had +41.03%. About 4.1% of Romania's GDP comes from agriculture compared to Greece 3%, Spain 2.4%, Poland 2.2%, Italy 1.8%, Netherlands 1.6%, France 1.2%, Germany 0.6%, and United Kingdom 0.5%. Romania plays an important role in the EU agriculture and has to continue the implementation of CAP being focused on the sustainable development of this sector to obtain a higher economic performance under a more balance use of resources, preservation of the environment factors and being much better adapted to the challenges of climate change. Setting up associative forms of production, modernizing technical endowment, assuring a higher training level to the farmers, producing more gross value added along the product chain, Romania could increase its agricultural production value and its contribution to the EU agriculture.*

Keywords: farm structure**,** standard output, agricultural output, gross value added, Romania

1. Introduction

The performance in agriculture is given by interrelationships between the used production factors: agricultural land, technical endowment reflected by the fixed capital, technologies applied, human capital or labor force and financial capital [12]. Also, it is conditioned by farm structures and production systems [25].

Every country makes efforts to develop agriculture as it is one of the most important branch of the economy which is destined to assure food security of the population, to supply agricultural raw materials for processing industry, to sustain

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export, trade and payment balance, to offer jobs and income for farmers and rural population, for protecting environment and biodiversity [1, 18, 22].

Romania has a high agricultural potential and its entry into the EU since 2007 has been a crucial moment for achieving a higher performance in this field of activity, joining its efforts with other countries like France, Germany, Italy, Spain, United Kingdom, Netherlands, Poland and Greece for contributing to the sustainable development of agriculture according to the EU Common Agricultural Policy.

To assess the development of agriculture of a country, there is a large range of indicators included in the economic accounts (EAA) which provide detailed information on income generated by agricultural production. As a satellite account of the European System of Accounts (ESA), the EAA provides information adapted to the specificity of the agricultural industry:

-*gross domestic product (GDP)* created in agriculture which allow to evaluate the sector contribution to the national economy and to assure a reference term for making comparisons among various countries regarding the development of their agriculture [15]; the level of GDP is deeply influenced by technical endowment (fixed assets volume and structure), and also by employment in agriculture [11, 16, 17, 19, 23, 24];

- *agricultural output at basic and producer prices* describes the value of goods and services achieved processes of production; detailed analysis is depicted about crop output, animal output and the value of services related to agriculture [5, 6, 7];

-*intermediate consumption in agriculture* regards the purchases made by farmers for raw and auxiliary materials needed in crop production (seeds, fertilizers, plant protection) and animal production (feeding stuffs, and veterinary expenses) and also the required services, repairs, maintenance etc.;

- *gross value added (GVA) created in agriculture* results from the difference between the value of agricultural output and the value of various input costs involved in the production process, adjusted for taxes and subsidies on products. It reflects how much value added is produced by every 1 euro spent on the cost of goods and services used in the production process (intermediate consumption) [8];

-*subsidies granted to the EU member states* according to their relative weight in the output value of the EU-28’s agricultural industry and even higher; their type and amount have changed over time as a result of successive reforms of the CAP (‘decoupling‘ subsidies from particular crops, single farm payments, subsidies on products, subsidies on production etc)

-*taxes* (income taxation, tax on property and wealth, Inheritance and gift tax, other taxes) [26];

-*labour input in agriculture* is provided first of all by the farmers and their family members, being known that the EU agriculture is characterized by family farming; secondly, the seasonality of the agricultural activities (for example, labour peaks at harvesting) imposes to hire workers for a relatively short period of time; thirdly, some farmers are occupied on a part-time basis as they have another important income source. For this reason, the volume of labour input in agriculture is expressed in terms of full-time labour equivalents, AWU (annual work units) [13, 14, 20, 21];

-*labour productivity* quantifies the result of work in agriculture in terms of "income", which is a key measure for determining the viability of the agricultural sector. Factor income in the EAA is the remuneration of all the used production factors (land, labour and capital). It reflects the net value added at factor cost, after adjusting gross value added for the consumption of fixed capital, and subsidies and taxes on production. Within agricultural accounts, labour productivity is expressed as an index, which reflects "the net value added by the equivalent of each full-time worker" in the agricultural industry. Therefore, it is computed on the basis of the real factor income per AWU [9]. This factor income is justified by the specificity of seasonal agricultural activities which result in more part-time activities than full-time.

In this context, the paper aimed to analyze the contribution of Romania to the EU's agriculture in the period 2010-2020, but also in 2020 according to the available data provided by Eurostat. The main indicators taken into consideration in this study were: number of the agricultural holdings, of which family farms; utilized agricultural area (UAA) and average UAA per farm, number of animal farms; standard output and standard output per farm; output of the agricultural industry, of which crop and animal output; gross value added (GVA) in agriculture; indicator A of the income from agricultural activity and the contribution of agriculture to GDP. Based on the level of the main indicators there were made comparison between Romania and the main agricultural EU-28 member states: France, Germany, Italy, Spain, United Kingdom, Netherlands, Poland and Greece in order to assess Romania's position and its contribution to the EU agriculture.

2. Materials and Methods

This research is based on Eurostat data base for the main indicators characterizing agriculture in Romania in comparison with other main agricultural EU-28 member states: France, Germany, Spain, Italy, United Kingdom, Netherlands, Poland, and Greece.

The period of analysis was in general 2010-2019 and in some cases 2010-2020 depending on the available data.

The indicators analyzed in this study were: number of farms, of which family farms; utilized agricultural area (UAA); average farm size in terms of UAA/farm; standard output and standard output per farm; agricultural production value; crop and animal production value; gross value added created in agriculture; indicator A of the income from agricultural activity; contribution of agriculture to GDP.

The main statistical procedures used in this research were:
- Fixed basis index, $I_{FB\%} = (x_n/x_1)$ x100 used for reflecting the increase/decrease of an analyzed indicator in the year 2019 or 2020 compared to 2010.
- Market share of Romania compared to the selected EU countries in the EU level for the analyzed indicators:
-Polynomial Regression equation, $Y = ax^2 + bx + c$ for reflecting the general tendency of the studied indicator over the time.
-The coefficient of determination, R^2, for showing the dependence of the variation of an indicator on the time variation.
-Descriptive statistics in terms of: mean, deviation standard, coefficient of variation, minimum and maximum value for agricultural output and gross value added in the period 2010-2020.
The obtained results were synthesized in tables and illustrated in graphics and the corresponding comments were made. The conclusions point out the main ideas resulting from this research.

3. Results and Discussions

3.1. Number of the agricultural holdings

Romania is the country with the most numerous farms and also with the most numerous small farms in the EU. In 2016, Romania had 3,422,000 agricultural holdings, coming on the top position in the EU-28. However, other countries like Poland, Italy and Spain have also many agricultural holdings: 1,410,000, 1,145,710, and respectively, 945,020. All these four countries keep 8,923,400 farms representing 66.15% of the total number of agricultural holdings in the EU-28 accounting for 10,465,000 at that time. Therefore, Romania had 32.6% of the total number of agricultural holdings in the EU-28 [3] (Fig. 1).

3.2.Family farming is dominant

In 2016, in the EU-28 there were 9,962,680 family farms representing 95.2% of the total number of agricultural holdings. Romania, Poland, Italy, Spain, followed by Greece, France, Hungary, Germany, United Kingdom and Netherlands, all together accounted for 86.17% of all the EU-28 family farms. Therefore, the EU agriculture is characterized by family farming (Fig.1).

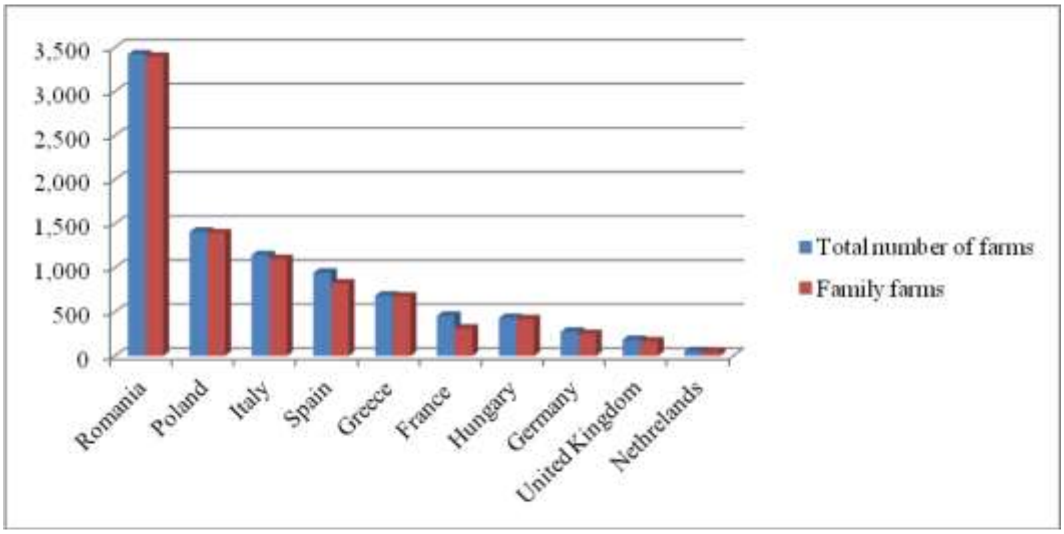

Fig.1. The number of farms, of which family farms existing in Romania and other selected EU-28 member states in 2016
Source: Own design based on the data from [3].

In Romania, 99.2% of the agricultural holdings are family farms, in general small sized-farms most of them being of a subsistence profile. In the selected countries mentioned above, the share of family farms is the following one: 98.7% in Poland and in Greece, 97.2% in Hungary, 96% in Italy, 90.9% in Germany, 90.8% in United Kingdom, 89.7% in Netherlands, 87.08% in Spain and 68.34% in France.

More than this, of the total number of farms existing in Romania 2,956,380 farms have households which consume over 50% of the final production, representing 86.39% of the total number of farms. In the other selected EU countries, the situation is the following one: 59.7% in Hungary, 25.3% in Italy, 18.3% in Poland, 16% in Greece, 3.5% in Spain, 1.5% in France and zero in United Kingdom, Germany and Netherlands.

3.3. Utilized agricultural area

Romania has 14.6 million ha agricultural land, but only 12,502,540 ha, that is 85.45% is utilized at present. More than this, 6,871 thousand ha belong to the family farms, meaning 54.95% of the utilized agricultural land (UAA). Therefore, the difference of 45% is worked by the agricultural commercial companies.
For the size of UAA, Romania is situated on the 7th position in the EU-28 after France, Spain, Germany, United Kingdom, Poland and Italy. In most of these countries, the share of the UAA in family farms is higher than in Romania as follows: 60.8% in Spain, 64.1% in Germany, 66.6% in Greece, 68% in United

Kingdom, 83% in Italy and 85.6% in Poland. France is the only exception where the UAA in family farms represent only 44.6% of the total UAA (Fig. 2).

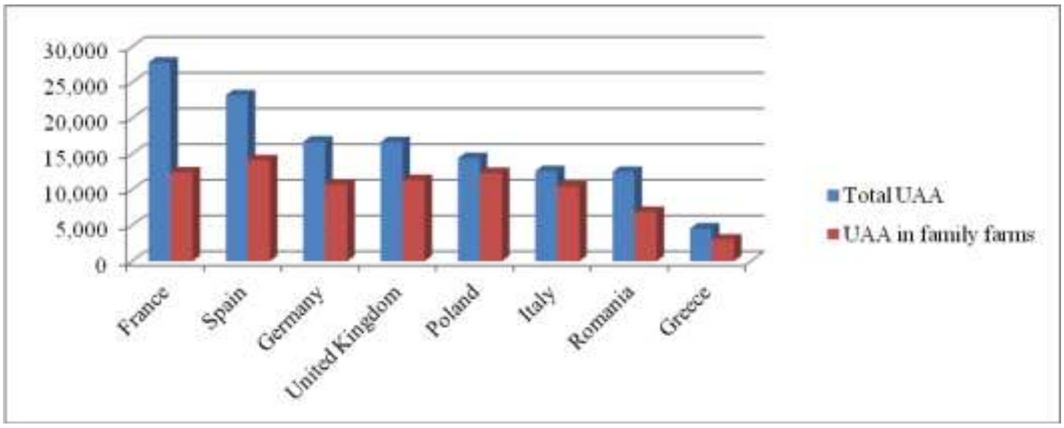

Fig. 2. The total utilized agricultural area, of which in family farms in Romania and other selected EU-28 member states
Source: Own design based on the data from [2, 3].

3.4. Average UAA per farm

Due to the high number of farms existing in Romania, the UAA per farm is one of the smallest in the EU, accounting for 3.6 ha and the UAA per family farm is only 2.02 ha.

However, compared to the EU-28 average UAA/farm of 16.7 ha, other selected EU countries have also a smaller UAA/holding like: Greece (6.64 ha), Poland (10.21 ha) and Italy (10.99 ha) (Table 1).

Table 1. The average UAA/farm in Romania and the selected EU countries (ha/farm)

	Average total UAA/Farm	Average UAA/ Family farms	Differences
EU-28	16.7	10.8	-5.9
Romania	3.6	2.02	-1.58
Poland	10.21	8.85	-1.35
Italy	10.99	9.51	-1.48
Spain	24.58	17.16	-7.42
Greece	6.64	4.48	-2.16
France	60.93	39.82	-21.11
Germany	60.53	42.70	-17.83
United Kingdom	90.65	67.97	-22.68

Source: Own calculation based on the data from [2, 3].

A higher UAA than the EU average is in United Kingdom (90.6 ha), Luxemburg (65 ha), France (60.9 ha), Germany (60.5 ha), Denmark (55 ha) and Spain (24.5

ha). It is obviously that in the family farms in all the EU countries, the UAA is smaller than the average UAA per total number of holdings.
The small UAA indicates a low production potential capacity and economic performance of the farm. the smallest average farm size is in Malta, Cyprus and Romania where it ranges between 1 and 3.6 ha (Table 1).

3.5. Number of farms with livestock

An important number of farms in the EU is raising animals: bovines, swine, sheep and goats, poultry, horses etc.
Romania is also in the top position from this point of view having 2,567,430 animal farms, having a share of 75% in the total number of farms. A high number of farms with livestock is in Poland (718,900, that is 50.9%). Also Hungary, France, Greece, Spain, Germany, Portugal, Italy, United Kingdom, Bulgaria and Ireland have a high number of farm animals (Fig.3).

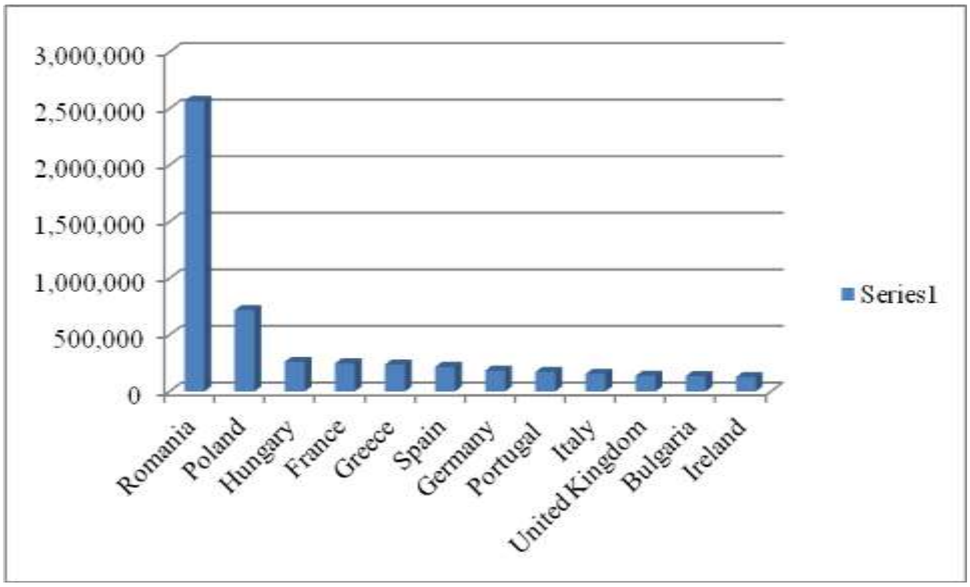

Fig. 3. The number of farms with livestock in Romania and other EU-28 countries
Source: Own design based on the data from [4].

The share of the number of farm animals in the total number of farms differs from a country to another reflecting the importance of animal farming in each member states' agriculture, the production performance, the applied technologies and the local favorable conditions for the development of animal husbandry.
The highest share of animal farms in the total farms is in Romania and United Kingdom (75%), Germany (66.8%), Hungary (60.8%), France (54.2%), and Poland (50.9%). A lower share of animal farms is in Italy (13.5%), Spain (22.9%) and Greece (34.8%).

3.6. Standard output

Standard output reflects the economic efficiency of agricultural activities in a farm and is the main synthetic indicator allowing comparisons in the agriculture of the EU member states.

Romania registered Euro 12,105 Million standard output (SO), coming on the 8th position in the EU after France, Italy, Germany, Spain, United Kingdom, Poland and Netherlands (Fig.4).

Therefore, Romania's performance in agriculture is five times lower than in France, 4.27 times smaller than in Italy, 4.06 times lower than in Germany, 3.16 times smaller than in Spain, 2.09 times than in United Kingdom, 2.06 times than in Poland and 1.9 times than in Netherlands.

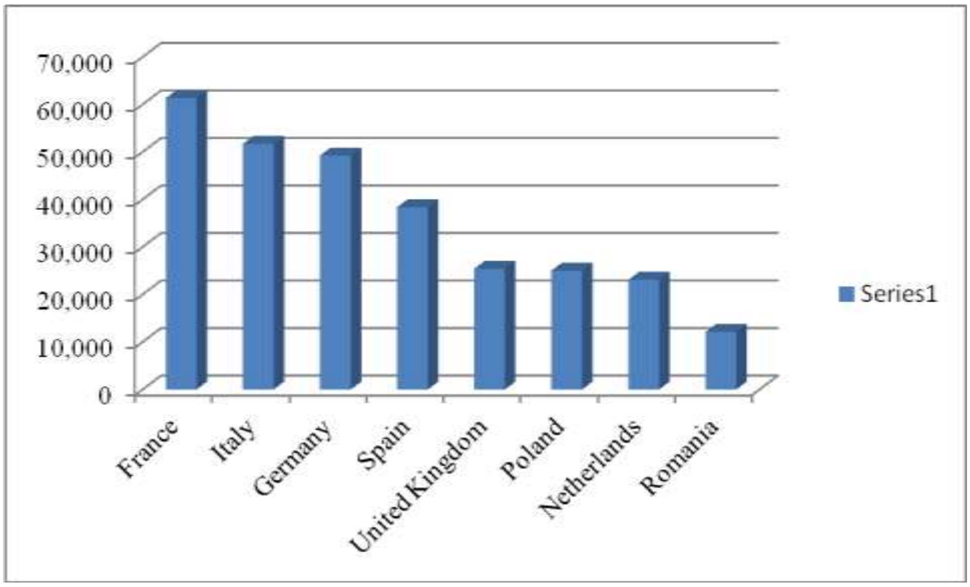

Fig. 4. Romania's standard output compared to SO in the selected EU-28 Countries (Euro Million)
Source: Own design based on the data from [2].

3.7. Standard output per farm

Taking into consideration the value of standard output and the number of farms, Romania registered a very low standard output per farm, accounting for only Euro 3,537, which reflects a low efficiency and average economic size of the agricultural holdings.

In the selected EU countries, the highest SO per farm was achieved in Netherlands and accounted for Euro 414,637, having in mind that this member state has a small number of farms of about 55,680. Also, a high SO per farm was carried out in the decreasing order by: Germany, United Kingdom, France, Italy, Spain, and Poland (Fig. 5).

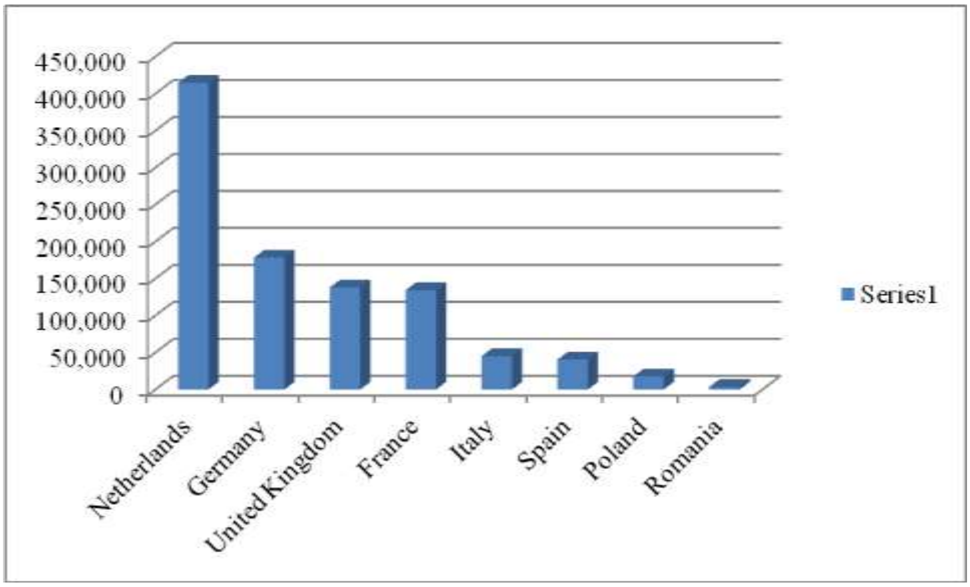

Fig. 5. Romania's standard output per farm compared to SO per farm in the selected EU-28 Countries (Euro per farm)
Source: Own calculation and design based on the data from [2].

3.8. Output of the agricultural industry

Romania carried out Euro 18.9 Billion agricultural output in 2019, by 23.5% more than in 2010 (Table 2).

Table 2.Output in the agricultural industry in Romania compared to other selected EU-28 countries in 2019 versus 2010 (Euro Billion)

	2019	2010	2019/2010 (%)	Market share in 2019 (%)
EU-28	448.5	372.0	120.5	100.00
1.France	77.0	68.1	113.0	17.16
2.Germany	58.5	49.8	117.4	13.04
3.Italy	57.8	48.0	120.4	12.88
4. Spain	51.6	40.3	128.0	11.50
5.United Kingdom	30.8	23.7	129.9	6.86
6.Netherlands	29.1	25.4	114.5	6.48
7.Poland	26.3	19.7	133.5	5.85
8. Romania	18.9	15.3	123.5	4.21
9. Greece	11.9	10.9	109.1	2.65

Source: Own calculation based on the data from [5].

This situated the country on the 8th position in the EU-28 after France, Germany, Italy, Spain, United Kingdom, Netherlands and Poland, being followed by Greece. Therefore, Romania contributed by 4.2% to the EU agricultural output in 2019 versus 4.1% in 2010.
These nine member states achieved Euro 361.9 Billion agricultural output in 2019, which accounted for 80.69% on the total EU-28 output produced in the agricultural industry (Table 2).

Crop output achieved in Romania accounted for Euro 13.26 Billion in 2019, being by 28.5% higher than in 2010. For this performance, Romania came on the 6th position in the EU-28, contributing by 5.72% to the EU crop output.
Romania is situated among the nine EU member states where crop output is the best developed: France, Italy, Spain, Germany, Netherlands, Romania, Poland, United Kingdom, Greece, which all together carried out Euro 191.59 Billion from crop farming contributing by 82.715 to the EU crop output (Table 3).

Table 3. Crop Output in Romania compared to other selected EU-28 countries in 2019 versus 2010 (Euro Billion)

	2019	2010	2019/2010 (%)	Market share in 2019 (%)
EU-28	231.64	196.88	117.6	100.00
1.France	43.35	39.16	110.6	18.71
2.Italy	31.40	26.56	118.2	13.55
3.Spain	29.99	25.03	119.8	12.94
4.Germany	27.89	24.86	112.1	12.04
5. Netherlands	14.38	12.63	113.5	6.20
6.Romania	13.26	10.32	128.5	5.72
7.Poland	11.67	10.00	116.7	5.03
8.United Kingdom	11.39	8.62	132.1	4.91
9.Greece	8.26	7.38	111.9	3.56

Source: Own calculation based on the data from [6].

Animal output in Romania is 3.38 times smaller than crop production, reflecting an inbalanced ratio between the two basic sectors of the agricultural industry.
In 2019, Romania carried out Euro 3.92 Billion animal output, that is 7.9% more than in 2010. The country contribution to the EU-28 animal output was very small, only 2.2% in 2019.
However, for its animal output, Romania came on the 8th position in the EU after Germany, France, Spain, United Kingdom, Italy, Poland and Netherlands, being followed by Greece. All these nine countries together achieved Euro 137.71 Billion output in animal sector and had a share of 77.46% in the EU-28 animal output (Table 4).

Table 4. Animal Output in Romania compared to other selected EU-28 countries in 2019 versus 2010 (Euro Billion)

	2019	2010	2019/2010 (%)	Market share in 2019 (%)
EU-28	177.76	144.60	122.90	100.00
1. Germany	27.35	22.68	120.50	15.38
2.France	26.57	23.15	114.70	14.94
3.Spain	19.91	13.79	144.37	11.20
4. United Kingdom	16.42	12.87	127.58	9.23
5. Italy	15.80	14.35	110.10	8.88
6. Poland	14.01	9.14	153.28	7.88
7.Netherlands	11.17	9.42	118.50	6.28
8. Romania	3.92	3.63	107.90	2.20
9.Greece	2.56	2.54	100.70	1.44

Source: Own calculation based on the data from [7].

Crop/Animal output ratio

Based on the absolute values of crop and animal production it was determined the ratio between crop and animal output in Romania and the selected EU countries. First of all, in almost the selected EU countries the crop output is higher than animal output, except Poland and United Kingdom where animal sector achieved a higher output than the crop sector.

In 2019, Romania had the highest crop/animal output ratio accounting for 3.38, being followed by Greece with 3.22. These two countries have an inbalance ratio between the two agricultural sectors.

The countries with a more balanced ratio are: Spain (1.50), Netherlands (1.55), France (1.63), Italy (1.98) and Germany (2.11).

In Poland animal output exceeds crop output and the ration crop./animal output was 0.83 while in United Kingdom is a similar situation this ration accounting for 0.69.

Table 5. Crop/animal output ration in Romania compared to the other EU selected countries in 2019 versus 2010

	EU-28	FR	ES	DE	IT	NL	RO	PL	UK	EL
2019	1.30	1.63	1.50	2.11	1.98	1.55	3.38	0.83	0.69	3.22
2010	1.36	1.69	1.81	1.09	1.85	1.34	2.84	1.09	0.66	2.90
Differ. 2019-2010	-0.06	-0.06	-0.31	+1.02	+0.13	+0.21	+0.54	-0.26	+0.03	+0.32

Source: Own calculation.

In the last decade, it is noticed a general increasing trend in almost all the selected EU countries, including Romania, except: France, Spain and Poland, which recorded a negative differences: (-0.06, -0.31, -0.26).
At the EU-28 level crop/animal output ratio was 1.30 in 2019 by -0.06 smaller than in 2010, and this shows that in other member states this ratio declined in the last year of the study (Table 5).

3.9. Comparison regarding the main descriptive statistics of the agricultural output in the period 2010-2020

In order to point out much better Romania's performance in agriculture compared to the selected EU countries, there were determined the main parameters of the descriptive statistics in terms of: mean, deviation standard, coefficient of variation, minimum and maximum value.
The results presented in Table 6 prove that Romania achieved Euro 16,794.64 Million agricultural output in average the interval 2010-2020, which situates the country on the 8th position in the EU-28. The minimum agricultural output was Euro 14,410.22 Million achieved in the year 2012, which was a year with a severe drought in Romania, and the maximum agricultural output was Euro 18,963,83 carried out in the year 2019. The year 2020 was also an unfavorable year for agriculture in Romania, and that is why agricultural output declined by 11.2% compared to the level attained in 2019.

Table 6. Descriptive statistics in terms of mean, standard deviation, variation coefficient, minimum and maximum value for agricultural output achieved in Romania compared to the selected EU-28 countries in the period 2010-2020 (Euro Million)

	Mean	Standard deviation	Coefficient of variation (%0	Minimum	Maximum
1. France	74,260.0	2,955.14	3.97	68,125.2	78,295.39
2. Germany	55,751.41	3,100.62	5.56	49,838.51	59,721.43
3. Italy	55,213.69	2,998.48	5.43	48,053.87	58,515.19
4. Spain	46,615.88	4,714.43	10.11	40,371.17	52,919.36
5. United Kingdom	29,352.82	2,415.98	8.23	23,745.75	32,598.37
6. Netherlands	27,527.05	1,164.01	4.22	25,474.96	29,138.34
7. Poland	23,776.43	2,129.30	8.95	19,750.51	27,177.73
8. Romania	16,794.69	1,481.74	8.82	14,410.22	18,963.83
9. Greece	11,205.16	483.55	4.31	10,610.38	11,880.09

Source: Own calculation based on the data from [6].

France occupies the top position in the EU-28 for its average agricultural output of Euro 74,260 Million in the last decade. On the 2nd position is Germany with Euro 55,751.41 Million, on the 3rd position came Italy with an average of Euro

55,213 Million, on the 4th position is situated Spain with Euro 46,615.88 Million, on the 5th position is United Kingdom with an average of Euro 29,352.82 Million, on the 6th position is Netherlands with an average of Euro 27,527.05 Million, on the 7th position is Poland with a mean agricultural output of Euro 23,726.43 Million, and on the 9th position is Greece which recorded a mean agricultural output of Euro 11,205.16 Million.

The variation coefficients had values ranging between 3.97% in France and 10.11% in Spain showing a reduced variation in the analyzed interval and confirming that the means are representative.

The highest agricultural output was Euro 78,295.39 Million registered in France in the year 2018, and the lowest agricultural output was Euro 10,610.38 Million recorded in Greece in the year 2011.

The EU's agricultural industry was an estimated EUR 411.8 billion in 2020, which includes the value of crops and animal production and also of agricultural services, as well as other goods and services related to agriculture. While crop production has a share of 52.8%, animal production of 38.6% and the remaining of 8.5% belongs to services.

Four countries: France, Germany, Italy and Spain produced more than 58.6% agricultural output, and another group of three countries: Netherlands, Poland and Romania achieved 17.6%, all these seven EU member states accounting for 76.2% of the EU agricultural output in the year 2020 [12].

3.10. Gross value added in agriculture

In 2019, Romania achieved Euro 8.78 Billion gross value added (GVA) in agriculture, by 33.23% more than in the year 2010. This meant 4.56% of the GVA carried out in the EU-28.

Romania came on the 8th position in the EU for GVA and had the highest growth rate in the interval 2010-2019 accounting for +33.23%, being situated after United Kingdom which registered a surplus of +47.88% in GVA in the same period.

The nine selected EU countries together produced Euro 162.89 Billion GVA in 2019, which accounted for 84.64% in the EU-28 GVA registered in the agricultural industry.

The results presented in Table 7 show that Romania is situated on the 8th position for the average GVA achieved in agriculture in the period 2010-2020, accounting for Euro 7,402.8 Million, with a minimum of Euro 6,209.14 Million recorded in the year 2012 when the severe drought had a deep impact and the maximum value of Euro 8,786.3 Million registered in the year 2019. In 2020, GVA accounted for Euro7,921.71 Million being by about 10% smaller than in the previous year.

The hierarchy of the selected EU-28 member states based on the average GVA created in agriculture during the period 2010-2010 is the following one: Italy,

France, Spain, Germany, United Kingdom, Netherlands, Poland, Romania and Greece.
The highest GVA was Euro 33,867.36 Million registered in Italy in the year 2018, and the lowest GVA was Euro 5,313.51 recorded in Greece in the year 2012 (Table 7).

Table 7. Descriptive statistics in terms of mean, standard deviation, variation coefficient, minimum and maximum value for GVA in Romania's agriculture compared to the selected EU-28 countries in the period 2010-2020 (Euro Million)

	Mean	Standard deviation	Coefficient of variation (%0	Minimum	Maximum
1. Italy	31,286.05	2,268.78	7.25	26,236.75	33,867.36
2. France	29,445.56	2,185.61	7.42	26,284.14	33,735.01
3. Spain	25,206.26	3,260.80	12.93	21,248.9	29,287.97
4. Germany	19,044.42	2,404.04	12.62	15,464.91	22,088.17
5. United Kingdom	10,586.69	1,176.20	11.11	7,810.99	11,944.57
6. Netherlands	10,213.63	938.77	9.19	8,475.61	11,743.67
7. Poland	9,238.46	1,032.86	11.18	7,858.6	11,045.32
8. Romania	7,402.8	860.99	11.63	6,209.14	8,786.3
9. Greece	5,770.25	317.28	5.49	5,313.51	6,144.42

Source: Own calculation based on the data from [8].

In 2020, the EU agriculture produced Euro 177 Billion GVA and for every 1 euro spent on the cost of goods and services used in the production process (intermediate consumption), the EU's agricultural industry created added value of EUR 0.75.
However, both agricultural production and GVA declined in 2020 compared to the year 2019 by -1.4% and, respectively, by -2.2% [10].

3.11. Indicator A of the income from agricultural activity

According to Eurostat, "Indicator A corresponds to the deflated (real) net value added at factor cost of agriculture, per total annual work unit. As deflator is used the implicit price index of GDP.
If we consider the year 2010 = 100, the decreasing order of the selected EU countries based on the growth rate achieved for the Indicator 1 of the income from agriculture was the following one in the year 2019: Italy +41.03%, Romania +39.97%, Poland +39.92%, Spain +27.94%, Germany +17.53%, France +15.99, United Kingdom +10.76, Greece +6.74% and Netherlands - 4.27% (Fig. 6).

In 2020, in the EU, there were 8.5 million full-time workers representing labor force input, of which 6.2 workers were non-salaried.

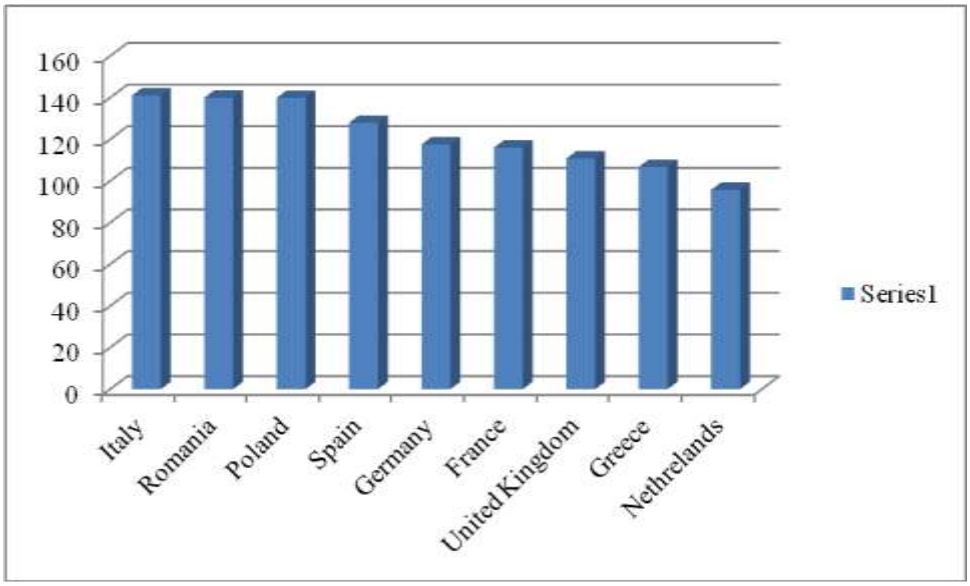

Fig. 6. Indicator A of the income from agriculture in Romania compared to the other EU selected countries in 2019 (2010 = 100)
Source: Own design based on the data from [9].

In 2020, it was continued the downward trend the labor force input being by -2.8 % less compared to 2019. The decline accounted for 5-6% in Romania, Slovakia, Lithuania, Portugal, Hungary, Bulgaria and Estonia, and slightly more than 8% in Spain.

In 2020, the EU's agricultural income expressed by real factor income per AWU fell slightly by -1.5 % compared to 2019.

In consequence, Factor income A declined by -4.2% in 2020 versus 2019. A slight decline was achieved in five EU largest seven agricultural producers: Italy (-4.9 %), the Netherlands (-5.1 %), France (-7.6 %), Romania (-13.8 %) and Germany (-14.6 %).

However, it is obviously, that the EU agricultural income per AWU was by 27.2 % higher in 2020 than the index level in 2010 [10].

3.12. Contribution of agriculture to GDP

In 2010, agriculture contributed by Euro 171.9 Billion to EU-27 GDP, that is by 1.3 % compared to 1.2 % in the year 2017 [10].

Regarding the contribution of agriculture to GDP in each analyzed country, the situation is the following one: Romania 4.1%, Greece 3%, Spain 2.4%, Poland 2.2%, Italy 1.8%, Netherlands 1.6%, France 1.2%, Germany 0.6%, United Kingdom 0.5% [1] (Fig. 1).

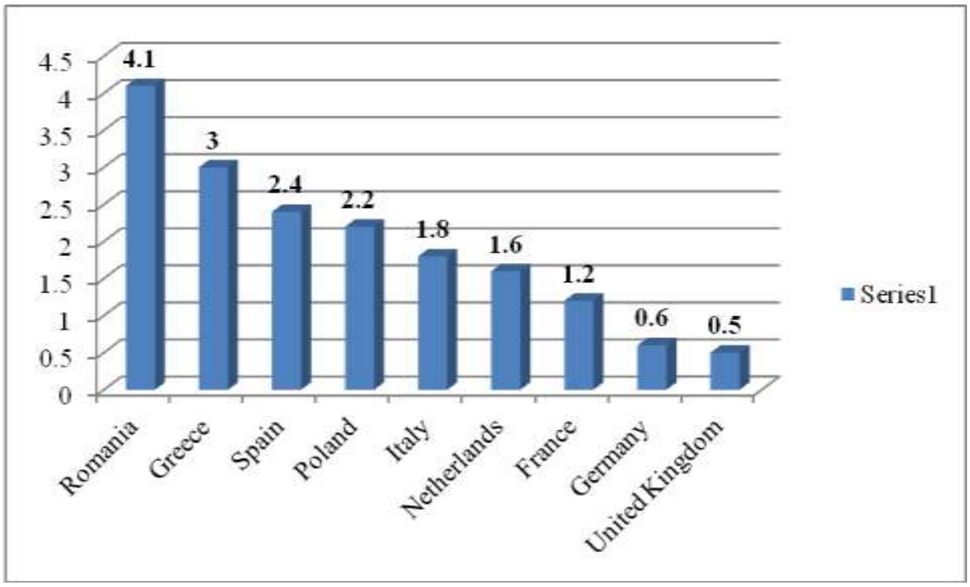

Fig. 7. Contribution of agriculture to GDP in Romania and the other selected EU countries (%)
Source: Own design based on the data from [1].

Conclusions

(1) Romania has proved to be among the most important EU countries dealing with agriculture during the period 2010-2020.

(2) Despite its highest number of small farms in the EU, dominated by family subsistence farms, it utilizes 12.5 million agricultural land, meaning 3.6 ha UAA per farm compared to 16.7 UAA the EU average. This puts Romania on one of the last positions in the EU next to Cyprus and Malta.

(3) For Euro 12,105 Million standard output, Romania comes on the 8th position in the EU after France, Italy, Germany, Spain, United Kingdom, Poland and Netherlands, but for only Euro 3,537 standard output per farm, Romania is situated on the last position in the EU.

(4) Carrying out Euro 18.9 Billion agricultural output in 2019, Romania contributed by 4.2% to the EU agricultural output and for this market share, it comes on the 8th position after France, Germany, Italy, Spain, United Kingdom, Netherlands, and Poland.

For crop output, it comes on the 6th position, contributing by 5.72% to the EU crop output, after France, Italy, Spain, Germany, and Netherlands. But for only Euro 3.92 Billion animal output, Romania has one of the smallest contribution of 2.2% to the EU and this because of the inbalanced crop/animal output ratio of 3.38.

(5) For Euro 8.78 Billion GVA in agriculture, Romania contributed by 4.56% to the EU GVA and was ranked the 8th among the selected member states.

(6) Compared to 2010, in 2019, income in terms of Indicator 1 from agriculture was by by 39.9% higher in Romania, being exceeded only by Italy which had +41.03%.

(7) The contribution of agriculture to Romania's GDP is enough high accounting for 4.1%, compared to Greece 3%, Spain 2.4%, Poland 2.2%, Italy 1.8%, Netherlands 1.6%, France 1.2%, Germany 0.6%, and United Kingdom 0.5%.

(8) Taking into account the situation regarding the development of agriculture and its contribution to the EU, for the next period of time, Romania has to continue the implementation of CAP being focused on the sustainable development of this sector to obtain a higher economic performance under a more balance use of resources, preservation of the environment factors and being much better adapted to the challenges of climate change.

(9) The development of agriculture depends on changes in farm structure based on setting up associative forms of production, on the assurance of a better technical endowment, a higher training level of the farmers, a higher level of farm inputs, a better production cost monitoring, on more gross value added along the product chain, on the increase of agricultural production value, standard output and the contribution of agriculture to the Romania's economic growth and participation in international trade.

R E F E R E N C E S

[1] European Union Country Statistical Fact Sheet, June 2020, https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/performance-agricultural-policy/agriculture-country/eu-country-factsheets_en, Accessed on May 5th, 2021.

[2] Eurostat, Farm indicators by agricultural area, type of farm, standard output, legal form and NUTS 2 regions, Last update 23.02.2021, https://ec.europa.eu/eurostat/databrowser/view/ef_m_farmleg/default/table?lang=en, Accessed on March 15, 2021.

[3] Eurostat Statistics Explained, 2019, Agriculture statistics - family farming in the EU, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agriculture_statistics_-_family_farming_in_the_EU, Accessed on April 25, 2021.

[4] Eurostat, Main livestock indicators by NUTS 2 regions, https://ec.europa.eu/eurostat/databrowser/view/ef_lsk_main/default/table?lang=en, Accessed on March 15, 2021

[5] Eurostat, Output of the agricultural industry - basic and producer prices, https://ec.europa.eu/eurostat/databrowser/view/tag00102/default/table?lang=en, Accessed on April 25, 2021.

[6] Eurostat, Crop output - basic and producer prices, https://ec.europa.eu/eurostat/databrowser/view/tag00054/default/table?lang=en, , Accessed on April 25, 2021.

[7] Eurostat, Animal output - basic and producer prices, https://ec.europa.eu/eurostat/databrowser/view/tag00055/default/table?lang=en, Accessed on April 25, 2021

[8] Eurostat, Gross value added of the agricultural industry - basic and producer prices, https://ec.europa.eu/eurostat/databrowser/view/tag00056/default/table?lang=en, Accessed on April 25, 2021.

[9] Eurostat, Indicator A of the income from agricultural activity, (2010 = 100), https://ec.europa.eu/eurostat/databrowser/view/tag00057/default/table?lang=en, Accessed on April 25, 2021.

[10] Eurostat, Performance of the agricultural sector, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Performance_of_the_agricultural_sector#Value_of_agricultural_output, Accessed on May 5th, 2021.

[11] Popescu, A., Research concerning the relationship between Gross Domestic Product, Fixed Assets and Employment using Cobb-Douglas Function, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.11(2):157-161 (2011).

[12] Popescu, A., Considerations on utilized agricultural land and farm structure in the European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.13(4): 221-226 (2013a).

[13] Popescu, A., Considerations on the main features of the agricultural population in the European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.13(4):213-220 (2013b).

[14] Popescu, A., Research on labour productivity in Romania's agriculture, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.15(2):271-280 (2015a).

[15] Popescu, A., Analysis of the dynamics of Gross Domestic Product and of its main factors of influence in Romania's agriculture, Proceedings of 25th IBIMA Conference Innovation Vision 2020: from Regional Development Sustainability to Global Economic Growth, Amsterdam, The Netherlands, May 7-8, 2015, pp.1379-1393 (2015b).

[16] Popescu, A., Research on the Relationship between GDP, Unemployment and Employment in the EU-28, Proceedings of 27th IBIMA Conference Innovation Management and Education Excellence Vision 2020: from Regional Development Sustainability to Global Economic Growth, Milan, Italy, May 405, 2016, pp. 686-695 (2016a).

[17] Popescu, A., Research on the Correlation between Economic Growth, Unemployment and Employment. A case study-Romania, Proceedings of 27th IBIMA Conference Innovation Management and Education Excellence Vision 2020: from Regional Development Sustainability to Global Economic Growth, Milan, Italy, May 405, 2016, pp. 696-706 (2016b).

[18] Popescu, A., The Intra-Industry Trade in Agro-Food Products - The Case of Romania, 29th IBIMA International Conference on Education Excellence and Innovation Management

through Vision 2020: from Regional Development Sustainability to Global Economic Growth, Vienna, May 4-5, 2017, IBIMA Conference Proceedings pp.1261-1278 (2017a).

[19] Popescu, A., Convergence of Regional Development in Romania in Terms of Gross Domestic Product, Proceedings of 29th IBIMA International Conference on Education Excellence and Innovation through Vision 2020: from Regional Development Sustainability to Global Economic Growth, Vienna, May 4-5, 2017, pp.1279-1293 (2017b**).**

[20] Popescu, A., Trends in Labour Productivity in Romania's Agriculture, Proceedings of 34th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, 13- 14 Nov.2019, Madrid, Spain, pp.9999-10016 (2019a).

[21] Popescu, A., Trends in Labour Productivity in the European Union's Agriculture, Proceedings of 34th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, 13-14 Nov.2019, Madrid, Spain, pp.9982-9998 (2019b).

[22] Popescu, A., Contribution of Agriculture to Romania's Gross Domestic Product, Proceedings of 36th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, November 4-5, 2020, Granada, Spain, pp.2207-2220 (2020).

[23] Popescu, A., David, L., The use of the Cobb-Douglas production function to analyze the relationship between GDP, Fixed assets and Employment in Romania's Agriculture, Proceedings of 25th IBIMA Conference Innovation Vision 2020: from Regional Development Sustainability to Global Economic Growth, Amsterdam, The Netherlands, May 7-8, 2015, pp. 1366-1378 (2015).

[24] Popescu A., David, L., The Relationship between GDP and its Resources in Romania's Economy, The 30th IBIMA International Conference, Madrid, November 8-9, 2017, IBIMA Conference Proceedings pp.449-468 (2017).

[25] Postoiu, C., Busega, I., Romania's agriculture and its role în the convergence process, https://www.researchgate.net/publication/308898930_Romania's_agriculture_and_its_role_in_the_convergence_process, Accessed on May 5th, 2021 (2015).

[26] Van der Veen, H., van der Meulen, H., van Bommel, K., Doorneweert, B., Exploring agricultural taxation in Europe, https://edepot.wur.nl/23200, Accessed on May 15, 2021(2007).

THE DEVELOPMENT OF AGRICULTURAL PRODUCTION IN ROMANIA IN THE PERIOD 2010-2019 - A STATISTICAL APPROACH

Agatha POPESCU[1]

Abstract. *The study aimed to analyze the evolution of Romania's agricultural production in the period 2010-2019, based on the data provided by National Institute of Statistics and using the fixed index, trend equations, and determination coefficient. The main indicators taken in account were: GDP created in agriculture, agricultural production value and the contribution of vegetal and animal production, cultivated area and productions for the main crops, livestock and production for the main animal farm species, as well as output per inhabitant. In 2019, agriculture proved to continue to have an important contribution to GDP (4.3%), the production value reached Lei 89.9 Billion (+39.5% versus 2010), of which 69.9% is produced by the vegetal sector and only 28% by the animal sector. Agriculture is dominated by cereals, maize and wheat being on the top positions with a share of 63.7% in the cultivated area and 82.15% in the cereals production. Oils seeds cover 20.6% of the cultivated surface, and sunflower achieves 69% of the oils seeds output. The livestock of bovines, pigs and poultry declined, while the number of sheep and goats, and also the bee colonies increased. Meat production in terms of live weight at slaughter raised by 14.5%, and the contribution of the farm species to meat output is: poultry 44.9%, pigs 34.2%, sheep and goats 8.5%. Milk output declined by 15.3% and egg production by 10.2%, while honey and wool output increased by 13.7% and, respectively, by 16.4%. As a result, production per inhabitant increased in general, but a decline was registered in case of milk, eggs, vegetables and potatoes. In consequence, the requirements of agro-food products on the domestic market have to be covered by imports. For sustaining the continuous development of the agricultural production there are needed effective solutions to the problems Romania's agriculture is facing at present as mentioned in this study.*

Keywords: agriculture, vegetal production, animal production, development, Romania

1. Introduction

Agriculture is an important sector of the country economy assuring the raw materials for food industry and other processing industries, for assuring food security for population, products for export from the production surplus, income for agricultural producers and also contributes to the preservation of biodiversity, landscape and traditions conservation and environment protection [7, 43].

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The complexity of agriculture as being a branch of material production is given by the specificity of farm structure, technologies, production systems and processes run in the vegetal and animal sector and labor force, and the economic performance is determined by the manner in which the three production factors: agricultural land, fixed, working and financial capital and human capital are used in a balanced way under the impact of the climate factors and changes [4, 21, 49].

Romania has 3.42 million farms and agriculture is considered a family business as long as 99.9% are family farms. Of the total 12.5 million ha utilized agricultural land (UAA), 54.8% is worked by family farms and the remaining by commercial companies. Agriculture is dominated by small farms, the average farm size is 3.64 UAA, by 4.55 times smaller than the EU-28 average [6].
In terms of standard output (SO), the most complex indicator reflecting the economic efficiency in agriculture, Romania comes on the 8th position for Euro 3,537 SO per farm in the EU-28 after France, Italy, Germany, Spain, United Kingdom, Poland and Netherlands.

The performance in agriculture is given by the people dealing with agriculture regarding its number, age and gender structure, training level and managerial skills.
Romania is considered a rural country as long as 45.9% of the population lives in the rural areas and its main occupation is agriculture [48]. In 2019, in agriculture labor force accounted for 1,331 Agricultural Work Units (AWU), meaning by 8.8% less than in 2010. The declining trend is not specific only to Romania, it is a general feature in the EU countries, due to many factors such as: ageing and changes in age structure, and migration to urban areas. The seasonality of the activities and production in agriculture determines as a low number of employed persons in agriculture, part time jobs are specific to this economic sector. In 2020, a number of 154 AWU belonged to the employed people in agriculture, meaning by 26.7% less than in 2010. As a result, the share of employed people in total labor force in agriculture is only 11.5% [12, 20]. Also, labor productivity in agriculture is smaller than in other economic sectors taking into account the small sized farms which dominates Romanian agriculture [39, 40, 50].

In this context, the paper aimed to analyze the dynamics of the agricultural production in Romania during the last decade, more exactly in the interval 2010-2019, using the empirical data provided by National Institute of Statistics. The main purpose was to identify the trend in the level of the main indicators characterizing agriculture development: GDP created in agriculture, agricultural production value and the contribution of vegetal and animal production, cultivated area and productions for the main crops, livestock and production for the main animal farm species, as well as production obtained per inhabitant.

2. Materials and Methods

This research is based on the data provided by National Institute of Statistics for the main indicators characterizing agriculture in the last decade, more exactly, in the period 2010-2019.

The indicators analyzed in this study were: GDP obtained in agriculture, the share of GDP produced in agriculture in Romania's GDP, agricultural production value and the contribution of vegetal and animal sector to agriculture output, cultivated area and its structure by the main crops (cereals, oil seed plants, oleaginous plants, medicinal and aromatic plants), vegetal production for the main crops, livestock (bovines, swine, sheep and goats, poultry, bee colonies) and animal production (meat in terms of live weight at slaughter, milk, egg, honey, wool).
Also, at the end it was presented the production level per inhabitant.

From a methodological point of view, Fixed basis index, $I_{FB\%} = (y_n/y_1)$ x100 was used in order to show how much increased or declined the level of an analyzed indicator in the year 2019 compared to its level in 2010.
Regression equations of different types either linear or polynomial of the 2nd degree, $Y = bx + a$, and, respectively, $Y = ax^2 + bx + c$ were used for explaining the trend line of the analyzed indicators over the time.
Also, the coefficient of determination, R^2, was used for reflecting in which measure the variation of an indicator was influenced by the time variation.

The results were illustrated in charts and tables, and were accompanied by the corresponding comments. The main ideas resulting from this research work have been drawn at the end of the statistical research and included in the conclusions.

3. Results and Discussions

3.1. Dynamics of Gross Domestic Product in agriculture

One of the forms in which agriculture development is quantified and represent its contribution to the economic growth is reflected by the evolution of the gross domestic product created in this sector of the national economy [7, 8, 21]. During the analyzed decade, GDP created in Romania's agriculture increased from Lei 26.4 Billion in 2010 to Lei 41.2 Billion in the year 2019, meaning a surplus of +56%. The general increasing trend was marked by a few inflexions in the years when agricultural production was deeply affected by climate factors especially by drought in 2010, 2012 and 2015 (Fig. 1).
If in 2010, the share of the GDP created in agriculture in Romania's GDP accounted for 4.9%, in 2019 its weight declined to 4.3%. It is a normal trend explained by the high growth rate in other sectors of the economy, and even

though the agricultural GDP raised, its growth rate is lower than the average growth rate in the national economy.

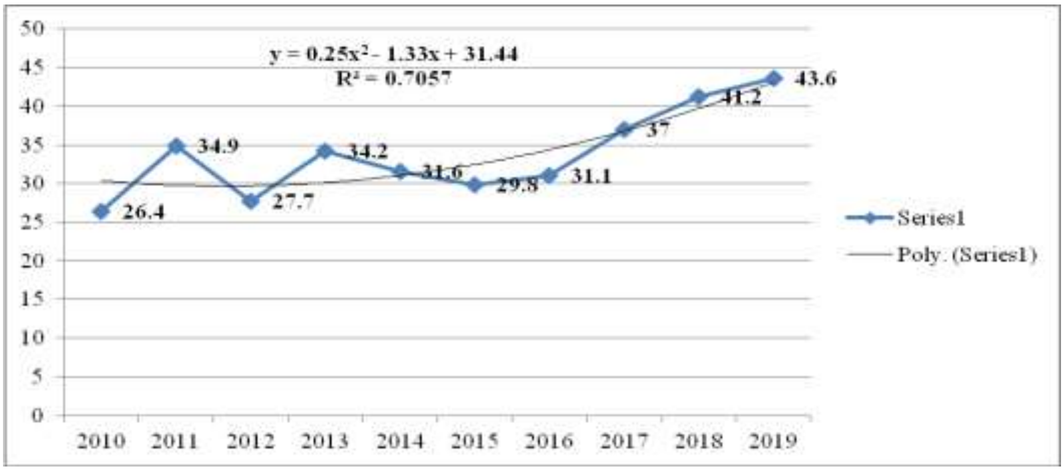

Fig. 1. Dynamics of GDP in Romania's agriculture in the period 2010-2019 (Lei Billion)
Source: Own design and processing based on NIS Data, 2021 [11].

3.2. The value of agricultural production

The value of agricultural production is one of the main indicators of the national accounts in the field whose dynamics reflects the development of agriculture [1, 3].

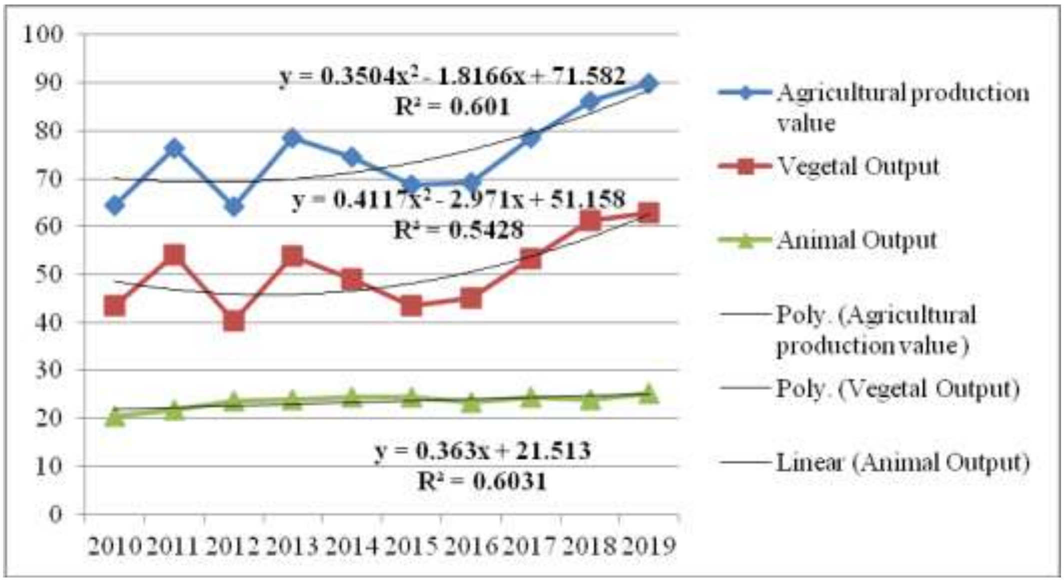

Fig. 2. Dynamics of Romania's agricultural output by the two main sectors in the period 2010-2019 (Lei Billion)
Source: Own design and processing based on NIS Data, 2021 [11].

Regarding the total agricultural output, Romania registered a relatively general ascending trend from Lei 64.4 Billion in 2010 to Lei 89.9 Billion in 2019, meaning +39.5%. In the vegetal sector, the growth rate on the whole period was +44.5%, as the production value raised from Lei 43.5 Billion in the first year of the analysis to Lei 62.9 Billion in the last one. Compared to the vegetal sector, the animal sector registered only +23.5% growth rate in the analyzed decade, its production value increasing from Lei 20.4 Billion in 2010 to Lei 25.2 Billion in 2019 (Fig. 2).

Taking into account the absolute values, the share of the two main sectors of agriculture has changes over the time, but it proved that the vegetal sector has the highest contribution to agricultural output: 67.5% in 2010 and 69.9% in 2019, while the animal sector diminished its weight from 31.6% in 2010 to 28% in 2019. Therefore, in Romania, the main feature of agricultural output is the unbalanced contribution of the main sectors, the vegetal sector producing 2.5 times more production value than the animal one.

3.3. Development of the vegetal sector

The development of the vegetal sector was deeply influenced by farms structure, crop structure in close relation to their suitability to the local soil and climate conditions, the varieties and hybrids production potential, resistance to drought, pests and diseases, technologies applied, farmers' training level and managerial skills.

Production level was also determined by the cultivated area which has been extended year by year reaching 8,737 thousand ha in 2019, when it was by 24.7% higher than in 2010.

The main groups of crops cultivated in Romania are: cereals (maize, wheat, barley, oats, sorghum etc) [35, 44, 46], oil seeds crops (sunflower, rape, soy bean) [16, 36, 42, 45, 47], the leguminous plants (beans, peas etc), vegetables (tomatoes, cucumbers, egg plants, green peppers, carrots etc) [19, 29] and medicinal and aromatic plants.

However, the main attention is paid to cereals, oil seeds and also to vegetables which have to cover the needs of the domestic market and also to contribute to Romania's export with agricultural products.

Cultivated area by main crops

In 2019, the cereals were cultivated on 5,560 thousand ha, by 10.4% more than in 2010, the extended areas were mainly for maize and wheat and also for sorghum. Cereals cover 63.7% of the cultivated area being on the top position.

Oil seed plants come on the 2nd position with a share of 20.6% in the cultivated area in 2019, meaning 1,801 thousand ha and vegetables are on the 3rd position with a share of only 2.6% in the cropped surface.
However, if the cereals, oil seed crops and leguminous plants are cultivated on higher areas in 2019 compared to 2010, the surface cultivated with vegetables declined in the last decade by 13.33% and the one cultivated with medicinal and aromatic plants decreased by about 89.4% (Table 1).

Table 1. Cultivated area by main crops in Romania in 2019 versus 2010 (Thousand ha)

	Cultivated area- Total	of which:				
		Cereals	Oil seed crops	Vegetables	Leguminous plants	Medicinal and aromatic plants
2010	7,807	5,040.6	1,410	262.7	37.6	15.9
2019	8,737.3	5,569	1,801	227.7	115.9	1.7
2019/2010 %	124.7	110.4	127.7	86.67	308.2	10.6
Share in the cultivated area in 2019 (%)	100.0	63.7	20.6	2.6	1.3	0.01

Source: Own calculation based on the data from NIS, 2021 [11].

Therefore, in Romania's agriculture, cereals and oil seed plants have a share of 84.3% in the total cultivated area, being the dominant crops (Fig. 3).

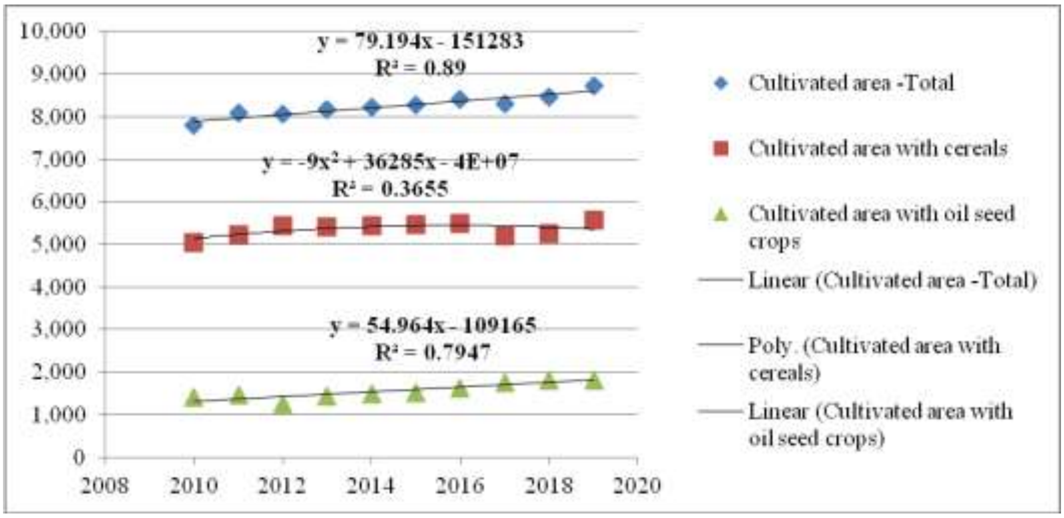

Fig. 3. Dynamics of the cultivated area: total, cereals and oil seed crops, 2010-2019 (Thousand ha)
Source: Own design and processing based on NIS Data, 2021 [11].

Vegetal production by main crops

Cereals production increased by 81.9% reaching 30,412 thousand tons in 2019. The main cereal is maize whose production accounted for 17,432 thousand tons, representing 57.3% of the total cereal output. Maize production was by 92.7% higher in 2019 compared to 2010.

On the 2nd position is wheat which produced 10,297 thousand tons grains in 2019 by 77.16% more than in 2010. its share in the cereal production is 33.85%.
Also, barley and two row barley produced 1,880 thousand tons, by 43.4% more than in 2010,a d the contribution of this crop to the total cereal production is 6.18%.

Sorghum registered almost a triple production in 2019, accounting for 320.8 thousand tons, compared to 2010, its weight in the cereal output accounting for 1.05% [9, 10].

Regarding oil seed crops, their total output in 2019 accounted for 4.792.4 thousand tons including only three crops: sunflower, rape and soybean. The highest share belongs to sunflower, 69% due to its importance in oil industry and also for export. Its seed production reached 3,569 thousand tons being by 182.5% higher than in 2010. Rape produced 798 thousand tons, 5.74 times more in 2019 than in 2010, while soybean reached 425.4 thousand tons being 2.8 times higher than in the first year of the studied period.

Vegetable production registered a decline in connection with the reduced cultivated area and high input costs. In 2019, there were produced 3,530 thousand tones vegetables by 8.65% less than in 2010 [29].

Potatoes, which are a basic food in the population consumption, produced an output of 2,627 thousand tons being by 20% smaller in 2019 compared to 2010.

Also, in horticulture there were many problems related to the ageing of the plantations, the need of investments in new plantations, the damages produced by extreme weather phenomena during flowering which affected production, storage etc. [28].

Table 2. Agricultural production by main crops in Romania in 2019 versus 2010 (Thousand tons)

	Cereals production	of which:				Oil seed production	of which:			Vegetables	Potatoes
		Maize	Wheat	Barley	Sorghum		Sunflower	Rape	Soybean		
2010	16,713	9,042	5,812	1,311	18.7	2,377.6	1,263	139	150	3,864	3,284
2019	30,412	17,432	10,297	1,880	60.0	4,792.4	3,569	798	798	3,530	2,627
2019/ 2010 %	181.9	184.7	177.1	143.4	320.8	201.5	282.5	574.0	532.0	91.3	79.9

Source: Own calculation based on the data from NIS, 2021 [11].

This was caused by the high production costs, climate change and the cheaper import from Poland which invaded the market and affected local producers [5]. In this situation, the internal production could not satisfy consumption needs and imports were claimed to complete the offer (Table 2).

3.4. Development of animal sector

Livestock dynamics

The number of farm animals registered a general decline regarding bovine species, pigs, poultry and horses and an increase in sheep and goats and also in bee colonies [9, 10].

Cattle livestock accounted for 1,923 thousand heads in 2019, being by 3.9% smaller than in 2010. The number of swines diminished by -29.37% so that in 2019 in the country there were only 3,834 thousand pigs compared to 2010. The decline in pig livestock reflects the crisis of this species, despite that pork is traditional in the Romanians' consumption, but pig breeders have been and still are deeply affected by the African fever, high input costs, the lack of piglets in the market, and the cheaper pork imports [22, 25, 41].

In case of sheep and goats, their number raised by 23.07% and, respectively 28.5%, accounting for 10,359 thousand sheep and 1,595 thousand goats in 2019. This reflected the continuous tradition in raising sheep for milk, cheese and wool and the fact that live sheep are exported to the Arab countries and also the increased importance of goats for their special milk quality [18, 33].

Poultry livestock decreased by 6.78%, accounting for 75,365 thousand heads in 2019. The decline affected especially the laying hens due to the imported eggs and in a lower measure broilers fattening, because Romania is an exporter of poultry meat of high quality. Horses lost 33.6% of its livestock, remaining just 406 thousand heads in 2019 in the rural households.

Bee families increased their number to 1,843 thousand colonies in 2019, being by 44.5% more than in 2010 due to their importance for producing honey and other bee products, for intensifying the export of high quality honey, for their role in crop and wild flora pollination, and for maintaining the landscape and biodiversity [13, 17, 26, 27, 32, 38] (Table 3).

Table 3. Dynamics of the livestock by species in 2019 versus 2010 (Thousand)

	Bovines	Pigs	Sheep	Goats	Horses	Poultry	Bee families
2010	2,011	5,428	8,417	1,241	610.8	80,844	1,275
2019	1,923	3,834	10,359	1,595	406	75,365	1,843
2019/2010 %	96.1	70.6	123.0	128.5	66.4	93.22	144.5

Source: Own calculation based on the data from NIS, 2021 [11].

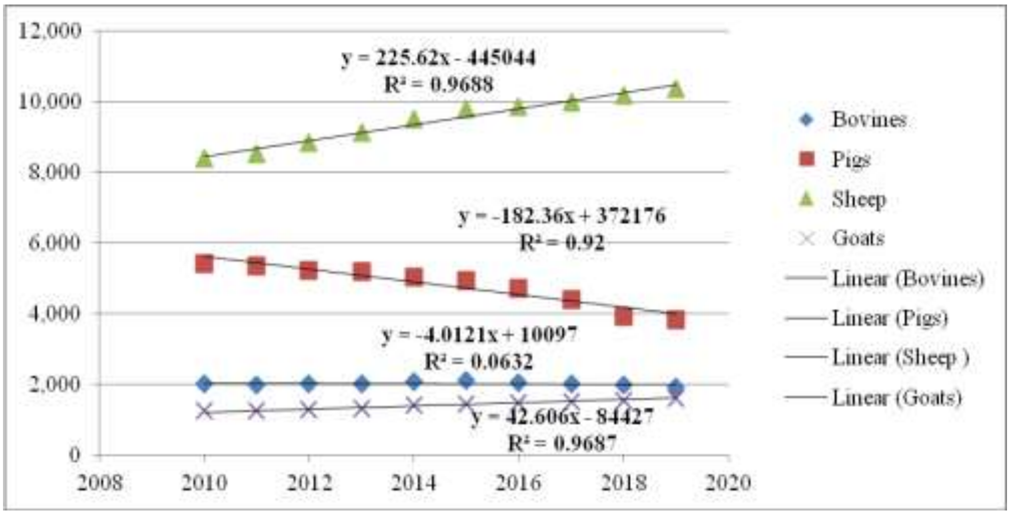

Fig. 4. Dynamics of livestock: bovines, pigs, sheep and goats, 2010-2019 (Thousand heads)
Source: Own design and processing based on NIS Data, 2021 [11].

Animal production

The decline in animal livestock at a several species had a negative impact on production level.

Meat production in terms of animal live weight at slaughter registered 1,495 thousand tons in 2019, being by + 14.5% higher than in 2010, while the total live weight at slaughter for bovines declined by 12.85, for swine by 7.3%, but for poultry and sheep and goats raised by 50.6% and, respectively, by 27.8% in the analyzed decade [30, 41].

Therefore, in the total live weight at slaughter in 2019, which accounted for 1,495 thousand tons, the contribution of various species was: 11.92% for bovines, 34.27% for swine, 44.96% for poultry and 8.5% for sheep and goats (Table 4 and Fig. 5).

Table 4. Dynamics of meat production in terms of live weight at slaughter by species in 2019 versus 2010 (Thousand tons)

	Live weight at slaughter	of which:			
		Bovine	Pigs	Sheep and goats	Poultry
2010	1,305	205.3	552.7	99.5	446.4
2019	1,495	179.2	512.4	127.2	672.3
2019/2010 (%)	114.5	87.2	92.7	127.8	150.6
Share in total live weight in 2019 (%)	100.0	12.0	34.3	8.6	45.1

Source: Own calculation based on the data from NIS, 2021 [11].

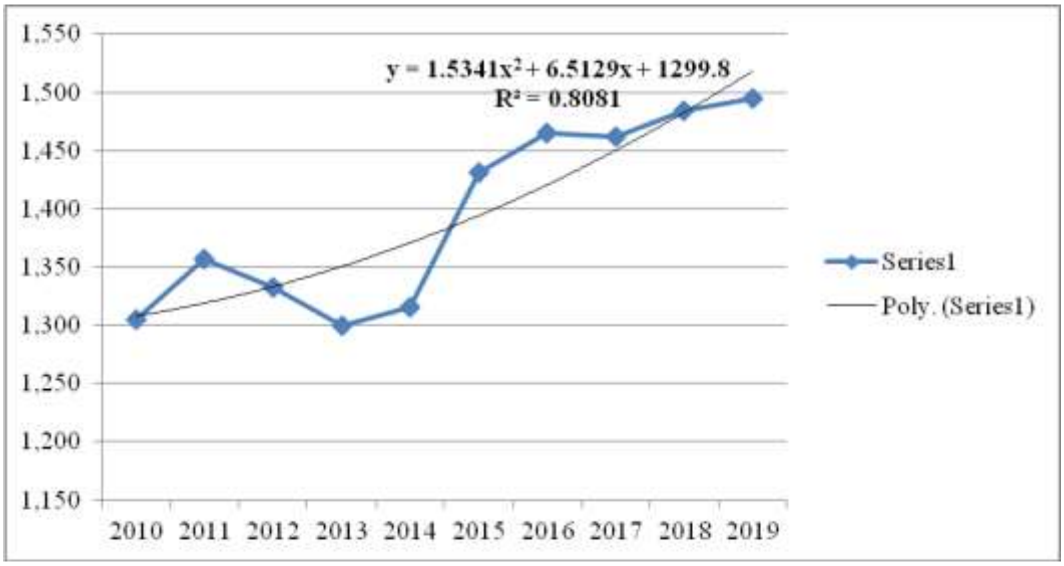

Fig. 5. Dynamics of meat production in terms of animal live weight at slaughter, 2010-2019 (Thousand Tons)
Source: Own design and processing based on NIS Data, 2021 [11].

Milk production declined in the analyzed period by 6% from 44,799 thousand hl in 2010 to 42,113 thousand hl in 2019. This was due to the decrease of the number of dairy cows and heifers and female buffaloes and had a negative impact on milk offer for processing industry. Therefore, consumption of milk and dairy products had to be covered by imports [31, 34].

Analyzing milk production by species, cow and buffalos milk output decreased by 7.35 from 38,494 thousand hl in 2010 to 35,706 thousand hl in 2019. As a result, the contribution of the cows and buffalos to total milk production declined from 85.9% in 2010 to 84.7% in 2019.

At the same time, milk production from sheep and goats increased by 1.6%, accounting for 6,407 thousand hl in 2019. As a result, its share in total milk output went up from 14.07% in 2010 to 15.21% in 2019.

Egg production recorded a decline as a result of the decrease in the number of laying hens. In 2019, egg production accounted for 5,564 million pieces, by 10.25% less than in 2010 [37].

Honey production was sustained by subsidies from the EU which encouraged beekeepers to raise more bee families. In 2019, Romania achieved 25,269 tons honey by +13.7% more than in 2010. The high quality of the Romanian honey stimulate its export especially to the countries from the Western Europe [15, 32, 34, 38].

Wool production registered a surplus of +16.4% in the last decade sa the livestock of sheep increased. In 2019, Romania achieved 23,824 tons wool but it could be not industrially processed only in an artisanal manner by various sheep breeders (Table 5).

Table 5. Dynamics of milk, egg, honey and wool production in Romania, in 2019 versus 2010

	Milk production (Thousand hl)	of which:		Eggs Million pieces	Honey Tons	Wool Tons
		Cow and buffalos milk				
2010	44,799	38,494	6,305	6,199	22,222	20,457
2019	42,113	35,706	6,407	5,564	25,269	23,824
2019/2010 %	94.0	92.7	101.6	89.75	113.7	116.4

Source: Own calculation based on the data from NIS, 2021 [11].

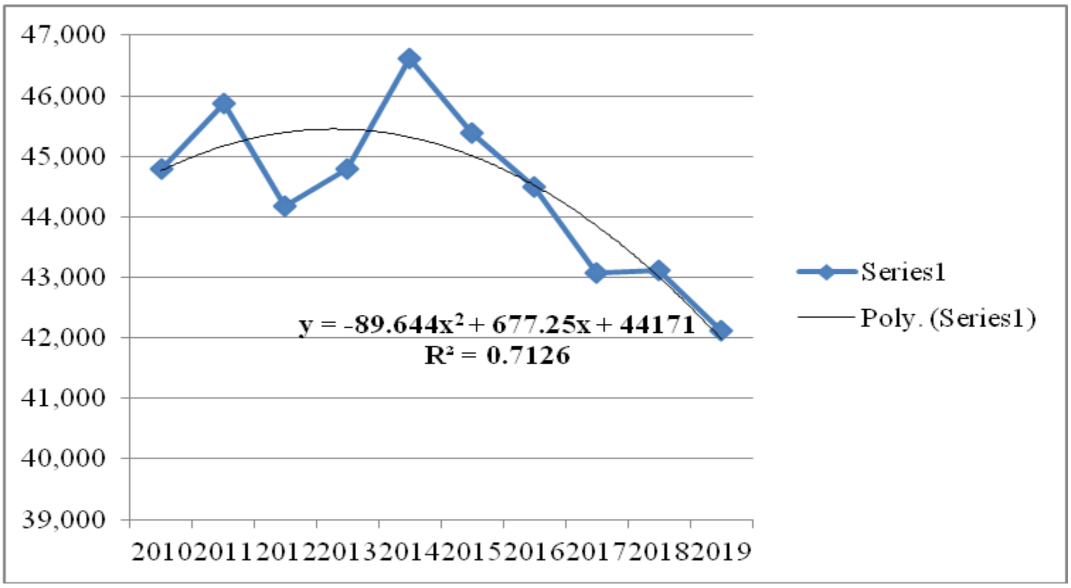

Fig. 6. Dynamics of total milk production, 2010-2019 (Thousand hl)
Source: Own design and processing based on NIS Data, 2021 [11].

3.5. Production per inhabitant

The changes in vegetal and animal production and also in the number of population in the last decade in Romania has resulted in a different level of production per inhabitant from a year to another [11].

Taking into consideration the main agricultural products, in the interval 2010-2019, production per inhabitant increased 2 times in case of maize grains, 1.85 times for wheat, 2.95 times for sunflower seeds, 1.1 times for fruit, 1.2 times for meat. Also, production per inhabitant declined by 6.4% in case of potatoes, by

4.51% for vegetables, by 1.82% in case of milk and by 6.21% in case of eggs (Table 6).

Table 6. Dynamics of production per inhabitant in Romania, in 2019 versus 2010

	Maize kg	Wheat kg	Sunflower seeds kg	Potatoes kg	Vegetables kg	Fruit kg	Meat kg	Milk liters	Eggs Pieces
2010	446.6	287	62.4	162.2	190.8	70.1	64.5	242.7	306
2019	899.9	531.6	184.3	135.6	182.2	76.8	77.2	238.3	287
2019/ 2010 (%)	201.5	185.2	295.3	83.6	95.4	110.1	119.6	98.1	93.7

Source: Own calculation based on the data from NIS, 2021 [11].

3.6. The main problems which have to be solved in Romania's agriculture to increase agricultural production

The main challenges Romania's agriculture is facing at present are the following ones:
- the impact of climate change on the agricultural production; the extreme weather phenomena and especially the long and severe droughts have affected production and many farmers were in danger to fail; for escaping from their critical financial situation, some farmers sold a part of their assets (land and equipments) in order to pay their debts, employees and to survive, especially in the South Eastern part of the country;
- the decline in the number of the companies operating in agriculture due to the pressure of the climate change negative impact [23];
- the lack of investments in agriculture, mainly in irrigation systems and especially in the South and South East of Romania which are the most affected regions by droughts;
- the lack of land reclamation measures such as drainage works and against soil erosion;
- farm structure dominated by small farms, which have to joint their forces in order to be able to apply modern technologies and get a higher productivity and economic efficiency;
- the low endowment in agriculture, where over 90 % of small farms have no tractor;
- the gap between the production performance in the vegetal sector compared to the animal sector, in term of contribution to the agricultural output;
- the high prices for farm inputs which increase production costs and the low acquisition price offered to the agricultural producers at the farm gate, which have a deep impact on gross margin and net income of the farmers [14, 24];

- the insufficient subsidies, aids and compensations offered to the farmers [2];
- the aging of labor force, improperly age structure of the population working in agriculture, migration, the small number of young farmers and low training level of the farm workers and managers;
- the use on a large scale of uncertified seeds, especially by the small farmers, the lack of support offered for seed treatments in order to assure plant protection;
-the lack of a viable credit system which could financially support the farmer mangers under advantageous conditions.

Conclusions

(1) The study proved that despite the big problems Romania's agriculture is facing, agricultural production increased and was impelled by the country's accession to the EU, which has been a pressure factor for the fast reform in the Romanian agriculture.
However, the multitude of small holdings and their problems related to technical endowment, labor force and financial capital has led to a slow development compared to other countries with high developed agriculture in the EU.

(2) Despite all the challenges in Romania's agriculture, agriculture remains an important branch in the national economy giving its contribution to food security, industry and export development, and 4.3% to GDP.

(3) Romania's agriculture is dominated by the vegetal sector which contributes by 69.9% to the total agricultural output accounting for Lei 89.9 Billion in 2019.
Cereals are the main crops accounting for 63.7% in the cultivated area country and their contribution to agricultural production is 21% and 32% in vegetal production. Maize and wheat have the highest share in the cereal production: 57.3% and, respectively, 33.8%.
(4) Also, the oil seed plants come on the second position occupying 20.6% of the cultivated surface, being important for oil industry and export and as a valuable resource for producing renewable energy. Sunflower has 69% weight in oil seeds output.
(5) Vegetables cover the internal market and offer a surplus for export, but also import is required in the extra season to cover the needs of the domestic market.
Fruit sector is in decline and the climate change affected production during the last decade, and this claimed as important amounts of fruit to be imported to enlarge the offer.
(6) Animal sector is in a deep decline, contributing with only 28% to the agricultural production value, determining a huge discrepancy compared to vegetal sector compared to other EU countries. The decline in bovine, pigs, and poultry livestock and the growth in sheep and goats number and bee colonies had a deep influence on production, export, import and agro-food trade balance.

(7) The contribution of the species to the live weight at slaughter is 44.9% poultry, 34.% pigs, 8.5 % sheep and goats. Milk output declined by 15.3% and egg production by 10.25, while honey production increased by 13.7% and wool by 16.4%.

(8) Imports of food of animal origin, fruit and even vegetables are higher and higher to cover the consumption requirements on the domestic market.

(9) The agricultural potential of Romania has to be much better valorized for increasing agricultural production. The solutions which have to be found to the challenges determined by the main problems of the Romanian agriculture as presented above could be welcome to boost agriculture production development.

R E F E R E N C E S

[1] Anghelache, C., Structural analysis of Romanian agriculture, Romanian Statistical Review, Supplement No. 2, 11-18 (2018).

[2] Bosch, R.A., The Economics of Agricultural Subsidies, Wageningen, https://edepot.wur.nl/45800, Accessed on May 5, 2021 (1985).

[3] Brata, A.M., SWOT analysis on Romanian agriculture in the transition period to market economy, Natural Resources and Sustainable Development, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2700100, Accessed on May 10, 2021 (2013).

[4] Campos, M., Jaklic, T., Juvancic, L., Factors affecting farm productivity in Bulgaria, Hungary, Poland, Romania and Slovenia after the EU-accession and likely structural impacts, No 95315, 118th Seminar, European Association of Agricultural Economists, August 25-27, 2010. Ljubljana, Slovenia (2010).

[5] De Cicco, A., Jeanty, J.C., The EU potato sector - statistics on production, prices and trade, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The_EU_potato_sector_-_statistics_on_production,_prices_and_trade, Accessed on May 10, 2021 (2019).

[6] Eurostat, Farm indicators by agricultural area, type of farm, standard output, legal form and NUTS 2 regions, Last update 23.02.2021, https://ec.europa.eu/eurostat/databrowser/view/ef_m_farmleg/default/table?lang=en, Accessed on March 15, 2021.

[7] Glogovețan, O.E., The place and role of agriculture in Romania's economy, Dacia Publishing House, Cluj-Napoca, pp.35 (2010).

[8] Ionescu, C.A., Paschia, L., Coman, M.D., Romanian Agriculture and Sustainable Development, Lumen Proceedings, Vol 7 No 1, 11th LUMEN International Scientific Conference Communicative Action & Transdisciplinarity in the Ethical Society, CATES, 23-24 November 2018, Targoviste, Romania **(**2019).

[9] MARD, National Program for Rural Development 2014-2020, Ministry of Agriculture and Rural Development (2014).

[10] MARD, Romania's Agriculture, https://www.madr.ro/docs/agricultura/agricultura-romaniei-2015.pdf, Accessed on May 10, 2021(2015).

[11] National Institute of Statistics, Tempo online data base, www.insse.ro, Accessed on April 25, 2021.

[12] Nica, M., Study on Labour Force in Romanian agriculture, International Journal of Sustainable Economies Management (IJSEM), 7(2):9 pp. (2018).

[13] Pirvutoiu, I., Popescu, A., Analysis of Romania's honey market, Scientific Papers Animal Science and Biotechnologies, 44(2):500-503 (2011).

[14] Popescu, A., Gross margin a barometer of profitability in agriculture, International Symposium "Durable Agriculture–the agriculture of the future ", Craiova, pp.23-24 (2006).

[15] Popescu, A., Home and foreign trade, Dominor Rawex Coms Publishing House, 176-244 (2010).

[16] Popescu, A., Research regarding oil seeds crops development in Romania in the EU context, Економика пољопривреде,Agricultural Economics, Vol.59 (1), (2012a).

[17] Popescu, A., Research on beekeepers income estimation based on honey production, Bulletin UASVM Animal Science and Biotechnologies, Vol.69(1-2) (2012b).

[18] Popescu, A., Study regarding the trends in the world and European goat milk production, Lucrări Ştiinţifice-Seria Zootehnie, Vol.59, 127-132 (2013a).

[19] Popescu, A., Considerations on Romania's vegetable market, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.13(4):227-233 (2013b).

[20] Popescu, A., Considerations on the Rural population as a resource of labor force in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 13(3):229-236 (2013c).

[21] Popescu, A., Analysis of the dynamics of Gross Domestic Product and of its main factors of influence in Romania's agriculture, Proceedings of 25th IBIMA Conference Innovation Vision 2020: from Regional Development Sustainability to Global Economic Growth, Amsterdam, The Netherlands, May 7-8, 2015, pp.1379-1393 (2015a).

[22] Popescu, A., Research on the Pork Production Trends in the EU-28, the CEECs and Romania, Proceedings of 25th IBIMA Conference Innovation Vision 2020: from Regional Development Sustainability to Global Economic Growth, Amsterdam, The Netherlands, May 7-8, 2015, pp.1407-1422 (2015b).

[23] Popescu, A., Research on the Bankruptcy Risk Prediction in Romania's Agriculture - A Case Study on the Companies Producing Cereals, Proceedings of 26th IBIMA Conference Innovation Management and Sustainable Economic Competitive Advantage: From Regional Development to Global Growth, Madrid, Spain, November 11-12, 2015, pp.2196-2204 (2015c).

[24] Popescu, A., Regression and Elasticity of Maize Price and Production in Romania, Proceedings of 26th IBIMA Conference Innovation Management and Sustainable Economic Competitive Advantage: From Regional Development to Global Growth, Madrid, Spain, November 11-12, 2015, pp.2205-2213 (2015d).

[25] Popescu, A., Research on concentration of pork production in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 16(1): 405-410 (2016a).

[26] Popescu, A., The effect of Honey Production on Beekeepers' Income. A Study Case in South Muntenia Development Region of Romania, Proceedings of 28th IBIMA Conference Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth, Sevilla, Spain, November 9-10, 2016, pp. 919-934 (2016b).

[27] Popescu, A., Regression and Elasticity of the Average Delivery Price and Production of Honey in Romania, Proceedings of 28th IBIMA Conference Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth, Sevilla, Spain, November 9-10, 2016, pp. 935-944 (2016c).

[28] Popescu, A., Some considerations on the dynamics of fruit and apple production and consumption in Romania in the period 2007-2014, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.16(3):267-276 (2016d).

[29] Popescu, A., Some considerations on vegetables and tomatoes production and consumption in Romania in the period 2007-2014, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.16(3):277-284 (2016e).

[30] Popescu, A., Considerations on beef production, consumption and trade balance in Romania (2007-2015), Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.16(4):267-277 (2016f).

[31] Popescu, A., Trends in milk market and milk crisis impact in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 17(2): 281-289 (2017a).

[32] Popescu, A., Bee honey production in Romania, 2007-2015 and 2016-2020 forecast, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol.17(1):339-349 (2017b).

[33] Popescu, A., Analysis of sheep and goats livestock and milk and meat production in Romania, 2007-2016, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development,Vol.17(4):267-280 (2017c).

[34] Popescu, A., The Intra-Industry Trade in Agro-Food Products - The Case of Romania, Proceedings of 29th IBIMA International Conference on Education Excellence and Innovation Management through Vision 2020: from Regional Development Sustainability to Global Economic Growth, Vienna, May 4-5, 2017, pp.1261-1278 (2017d).

[35] Popescu, A., Maize and wheat - top agricultural products produced, exported and imported by Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 18(3):339-352 (2018a).

[36] Popescu, A., Romania's sunflower seeds production, export and import- Analysis of the 2007-2017 period and forecast for 2018-2022 horizon, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol.18(4):261-270 (2018b).

[37] Popescu, A., Aspects and trends in the European Union and Romania's egg market, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development,Vol.18(1):357-370 (2018c).

[38] Popescu, A., Honey production and trade before and after Romania's accession into the European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18(4),229-248 (2018d).

[39] Popescu, A., Trends in Labour Productivity in Romania's Agriculture, Proceedings of 34th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, 13- 14 Nov.2019, Madrid, Spain, pp.9999-10016 (2019a).

[40] Popescu, A., Trends in Labour Productivity in the European Union's Agriculture, Proceedings of 34th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, 13-14 Nov.2019, Madrid, Spain, pp.9982-9998 (2019b).

[41] Popescu, A., Pork market crisis in Romania: pig livestock, pork production, consumption, import, export, trade balance and price, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.20(1):461-474 (2020a).

[42] Popescu, A., Soybean Production - Actual Statement and 2020-2024 Forecast in Romania, Proceedings of 36th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, November 4-5, 2020, Granada, Spain, pp.2196-2206 (2020b).

[43] Popescu, A., Contribution of Agriculture to Romania's Gross Domestic Product, Proceedings of 36th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, November 4-5, 2020, Granada, Spain, pp.2207-2220 (2020c).

[44] Popescu, A., Sorghum production in Romania in the period 2010-2019-trends and determinant factors, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.20(3):455-465 (2020d).

[45] Popescu, A., Oil seeds crops: sunflower, rape and soybean cultivated surface and production in Romania in the period 2010-2019 and the forecast for 2020-2024 horizon, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.20(3):467-477 (2020e).

[46] Popescu, A., Condei, R., Some considerations on the prospects of sorghum crop, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 14(3):295-304 (2014).

[47] Popescu, A., Criste, R., Using full fat soybean in broiler diets and its effect on the production and economic efficiency of fattening, Journal of Central European Agriculture, Vol.4(2):167-174 (2003).

[48] Postoiu, C., Busega, I., Romania's agriculture and its role în the convergence process, https://www.researchgate.net/publication/308898930_Romania's_agriculture_and_its_role_in_the_convergence_process, Accessed on May 5th, 2021 (2015).

[49] Quamrul, A., Michalopoulos, S., Climatic Fluctuations and the Diffusion of Agriculture, The Review of Economics and Statistics, MIT Press, 97(3), 589-609 (2015).

[50] Schultz, T.W., Transforming Traditional Agriculture, New Haven, CT: Yale University Press (1964).