

SUNFLOWER CROP SITUATION IN ROMANIA - COMPARATIVE STUDY OVER THE LAST DECADE

JURJESCU ANDREEA LIDIA¹, SALA FLORIN*^{1,2}

¹*Agricultural Research and Development Station Lovrin, Lovrin, 307250, Romania*

²*University of Life Sciences "King Mihai I" from Timisoara, Timișoara, 300645, Romania*

*Corresponding author's e-mail: florin_sala@usvt.ro

Abstract: *The situation of sunflower crop in Romania was studied in dynamics for the 2015 - 2023 period. The cultivated area (A, ha), yield (Y, kg/ha) and total production (TP, tons) were analyzed. The mean cultivated area during the study period was $\bar{A} = 1086400$ ha. In 2015, 2017 and 2018, negative differences were recorded ($p < 0.05$), and in 2019 a positive difference ($p < 0.001$). The mean yield was $\bar{Y} = 2294$ kg/ha. In 2015, 2020 and 2023 negative differences were recorded ($p < 0.05$). Positive differences were recorded in 2019 ($p < 0.05$) and in 2016, 2017 ($p < 0.01$). The mean total production was $\bar{TP} = 2494600$ tons. Negative differences from the average were recorded in 2023 ($p < 0.05$), in 2015 ($p < 0.01$). Positive differences were recorded in 2018 ($p < 0.05$) and in 2019 ($p < 0.001$). According to PCA, PC1 explained 68.203% of variance, and PC2 explained 31.75% of variance. Cluster analysis grouped the years of study based on similarity in relation to the analyzed elements (A, Y, TP; Coph.corr. = 0.879).*

Key words: *cluster, cultivated areas, dynamic analysis, sunflower, yield*

INTRODUCTION

In the category of oilseed plants and the vegetable oil system, sunflower occupies a particularly important place [2,18,16]. The sunflower is a multi-valued crop, with agronomic, economic, and social importance, a crop with real opportunities for the "Bio-Circular-Green" economy [4,2,1,20].

The area cultivated with sunflower, yield and marketing elements, have recorded different spatial and temporal variations in relation to ecological, economic and social factors [18,3]. Remote sensing techniques have been used to dynamically monitor sunflower cultivated areas, in relation to climatic conditions, cropping systems, and crop technologies [14,6]. Sunflower yield depends on the cultivated genotypes, environmental factors, crop technology and the interaction "genotype x environment x technology" [24,22,6,13].

Increasingly efficient genotypes have been created through sunflower breeding programs, with high potential for converting solar energy into biomass [10,21,5]. Environmental conditions have experienced extensive changes, especially in terms of thermal and water regimes, associated with climate change, and this has influenced the areas under cultivation and yields of sunflower crops [19,7,23]. Cultivation technologies have improved considerably in recent decades for sunflower cultivation [8,15]. Although sunflower has a high level of adaptation and tolerance to climatic conditions, cultivated areas, yield and total sunflower production have recorded wide variations in the world, in Europe and in Romania [17,18,24].

The aim of the study was to evaluate the dynamics of sunflower cultivation in Romania between 2015 and 2023, based on cultivated areas, yield and total seed production.

MATERIALS AND METHODS

Sunflower is a crop of great importance in Romania, intended for the production of seeds for domestic consumption and for export, for the production of oil and biodiesel [17]. Given the high interest in sunflower production, its importance for the domestic market, the EU market and emerging markets, variations in the agronomic, technological and economic elements of yield associated with sunflower cultivation have been recorded. Starting from the recorded fluctuations, this study analyzed the dynamics of sunflower cultivation in Romania, between 2015 and 2023. In relation to the purpose of the study, statistical data recorded by the Ministry of Agriculture and Rural Development were used [25]. Cultivated area (A, ha), yield (Y, kg/ha) and total production (TP, tons) were considered. Each element considered during the study period was analyzed, values recorded annually, compared to the average during the study period. Comparative analysis was used as a mathematical and statistical tool to evaluate differences and statistical reliability [11]. Multivariate analysis was used to explain the variance in the data set, and to identify the association of the years during the study period with the elements characterizing the sunflower crop. Cluster analysis was used to find out the level of similarity between the years during the study period, and subsequently a descending hierarchy of the years was made in relation to the value of the elements considered.

RESEARCH RESULTS

Statistical evidence elements, specific to agricultural crops, were analyzed for sunflower during the period 2015 - 2023, from the annual reports in Romania. The values of cultivated area (A, ha), yield (Y, kg/ha) and total production (TP, tons) during the study period are presented in Table 1.

Table 1.
The dynamic situation of sunflower cultivation in Romania, period 2015 - 2023

Year	Area	Yield (mean value)	Total production
	(ha)	(Kg/ha)	(tons)
2015	1011527	1765	1785771
2016	1039823	1955	2032340
2017	998415	2917	2912743
2018	1006994	3041	3062690
2019	1282697	2783	3569150
2020	1142841	1858	2122865
2021	1123960	2530	2843531
2022	1093265	1927	2106573
2023	1077867	1870	2015621

Source: MADR data [25]

The mean value was calculated for each of the elements considered (A, Y, TP) in the characterization of the sunflower crop. The situation recorded each year for each element considered was analyzed, compared to the average value over the study period. The results obtained are presented in Table 2 for the cultivated area (A, ha), in Table 3 for the yield (Y, kg/ha), and in Table 4 for the total production (TP, tons).

In the case of the area cultivated with sunflower, the value in 2019 presented a statistically significant difference compared to the mean value of the study period ($p < 0.001$, ***). The area cultivated in 2015, 2017 and 2018 presented a negative difference compared to the mean value ($p < 0.05$, °). In the case of the other years, the differences did

not present statistical significance, Table 2.

Table 2.

Comparative analysis of sunflower cultivated areas in Romania, period 2015 - 2023

Anul	Given mean:	Sample mean:	95% conf. interval:	Difference	95% conf. interval:	t:	p (same mean):	Sig.
2015	1011527	1086400	(1.0171E06 1.1557E06)	-74850	(5525.7 1.4417E05)	2.490	0.038	o
2016	1039823			-46554	(-22770 1.1588E05)	1.549	0.160	ns
2017	998415			-87962	(18638 1.5729E05)	2.926	0.019	o
2018	1006994			-79383	(10059 1.4871E05)	2.641	0.030	o
2019	1282697			1.96E+05	(1.27E05 2.6564E05)	-6.530	0.000	***
2020	1142841			56464	(-12859 1.2579E05)	-1.878	0.097	ns
2021	1123960			37583	(-31740 1.0691E05)	-1.250	0.247	ns
2022	1093265			6888.4	(-62435 76212)	-0.229	0.825	ns
2023	1077867			-8509.6	(-60814 77833)	0.283	0.784	ns

Note: Given mean – annual mean value; Sample mean – multiannual mean value

Table 3.

Comparative analysis of sunflower crop yield in Romania, period 2015 - 2023

Anul	Given mean:	Sample mean:	95% conf. interval:	Difference	95% conf. interval:	t:	p (same mean):	Sig.
2015	1765	2294.00	(1896.4 2691.6)	-529	(131.42 926.58)	3.0682	0.015389	o
2016	1955			-339	(-58.58 736.58)	1.9662	0.084839	ns
2017	2917			623	(225.42 1020.6)	-3.6134	0.006848	**
2018	3041			747	(349.42 1144.6)	-4.3326	0.002503	**
2019	2783			489.00	(91.42 886.58)	-2.8362	0.021939	*
2020	1858			-436	(38.42 833.58)	2.5288	0.03532	o
2021	2530			236	(-161.58 633.58)	-1.3688	0.20826	ns
2022	1927			-367	(-30.58 764.58)	2.1286	0.065935	ns
2023	1870			-424	(26.42 821.58)	2.4592	0.039367	o

Note: Given mean – annual mean value; Sample mean – multiannual mean value

Table 4.

Comparative analysis of total sunflower production in Romania, period 2015 - 2023

Anul	Given mean:	Sample mean:	95% conf. interval:	Difference	95% conf. interval:	t:	p (same mean):	Sig.
2015	1785771	2494600	(2.0232E06 2.9659E06)	7.09E+05	(2.3746E05 1.1802E06)	3.4677	0.008471	oo
2016	2032340			4.62E+05	(-9107.8 9.336E05)	2.2614	0.053603	ns
2017	2912743			4.18E+05	(-53199 8.8951E05)	-2.0457	0.075005	ns
2018	3062690			5.68E+05	(96748 1.0395E06)	-2.7793	0.023951	*
2019	3569150			1.07E+06	(6.0321E05 1.5459E06)	-5.257	0.000767	***
2020	2122865			3.72E+05	(-99633 8.4308E05)	1.8186	0.10649	ns
2021	2843531			3.49E+05	(-1.2241E05 8.203E05)	-1.7071	0.12619	ns
2022	2106573			3.88E+05	(-83341 8.5937E05)	1.8983	0.094221	ns
2023	2015621			4.79E+05	(7611.2 9.5032E05)	2.3432	0.047178	o

Note: Given mean – annual mean value; Sample mean – multiannual mean value

In the case of sunflower crop yield (Y, kg/ha), the value in 2019 presented a difference from the mean value of the study period, with statistical safety at the $p < 0.05$ level (*). The yield values recorded in 2017 and 2018 showed positive differences

compared to the mean value for the study period at the $p < 0.01$ level (**). The yield values in 2015, 2020 and 2023 showed negative differences compared to the mean value for the study period, at the $p < 0.05$ level (^o). In the case of the other years, the differences did not show statistical safety, Table 3.

In the case of total production (TP, tons), the value recorded in 2018 presented a positive difference from the mean for the study period at the $p < 0.05$ level (*), and the total production recorded in 2019 presented a difference from the mean value for the study period at the $p < 0.001$ level (***). The total production in 2023 presented a negative difference compared to the mean value of the study period ($p < 0.05$, ^o), and the total production in 2015 presented a negative difference compared to the mean value for the study period at the $p < 0.01$ level (^{oo}).

The multivariate analysis led to the PCA diagram in Figure 1, in which the principal components explained the presence of variance, PC1 = 63.203% of the total variance, and PC2 = 31.75% of the total variance. The years 2017, 2018, 2019 and 2021, within the study period, were positioned differently associated with correlation with cultivated area (A, ha), with yield (Y, kg/ha) or with total production (TP, tons). The other years of the study period were positioned independently of the elements considered, as biplot.

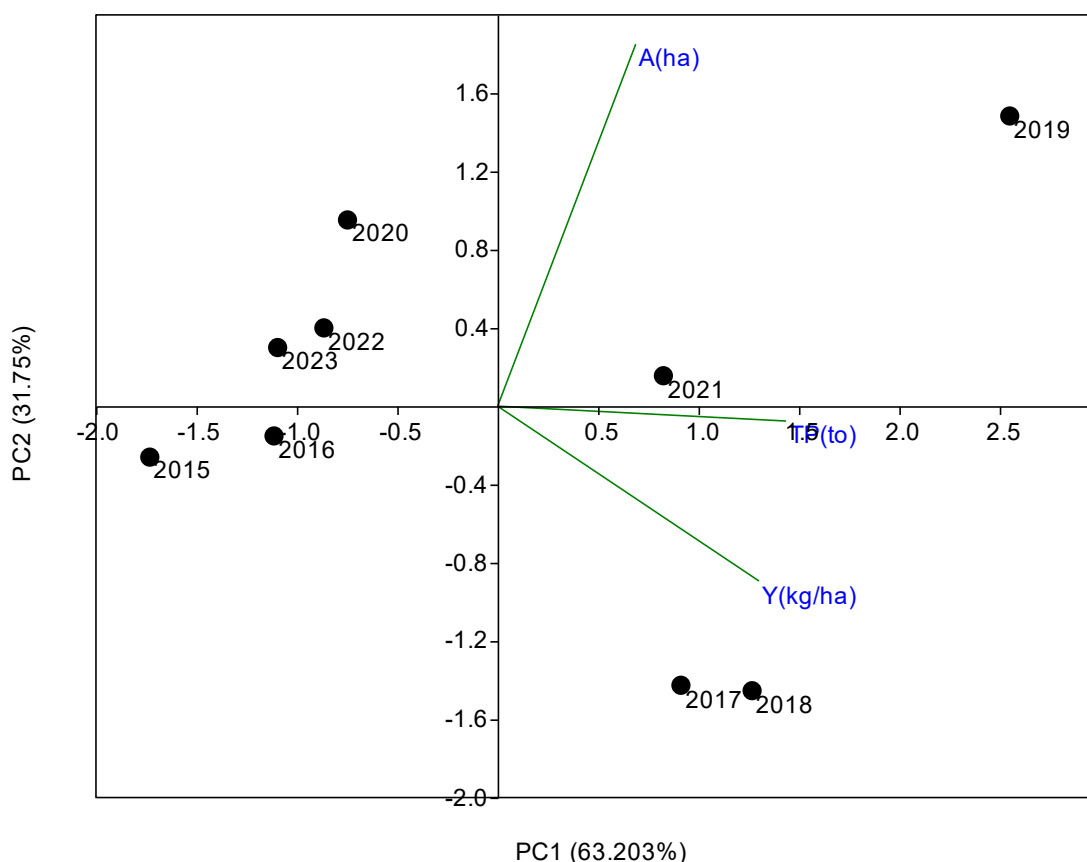


Figure 1. PCA diagram with the distribution of years over the study period in relation to the sunflower reference elements

The cluster analysis led to the dendrogram in Figure 2, in which the years of the study period were associated based on similarity, in relation to the values of the elements considered (Coph.corr. = 0.878). Two clusters resulted, with the years of study in different associations, with the SDI values presented in Table 5.

In cluster C1, the year 2019 was positioned independently, with high values of cultivated area and total production compared to the average for the study period ($p < 0.001$, ***), but also for yield ($p < 0.05$, *). In cluster C2, the independent position was occupied by the year 2015, which constantly occupied a position below the average value for each element analyzed.

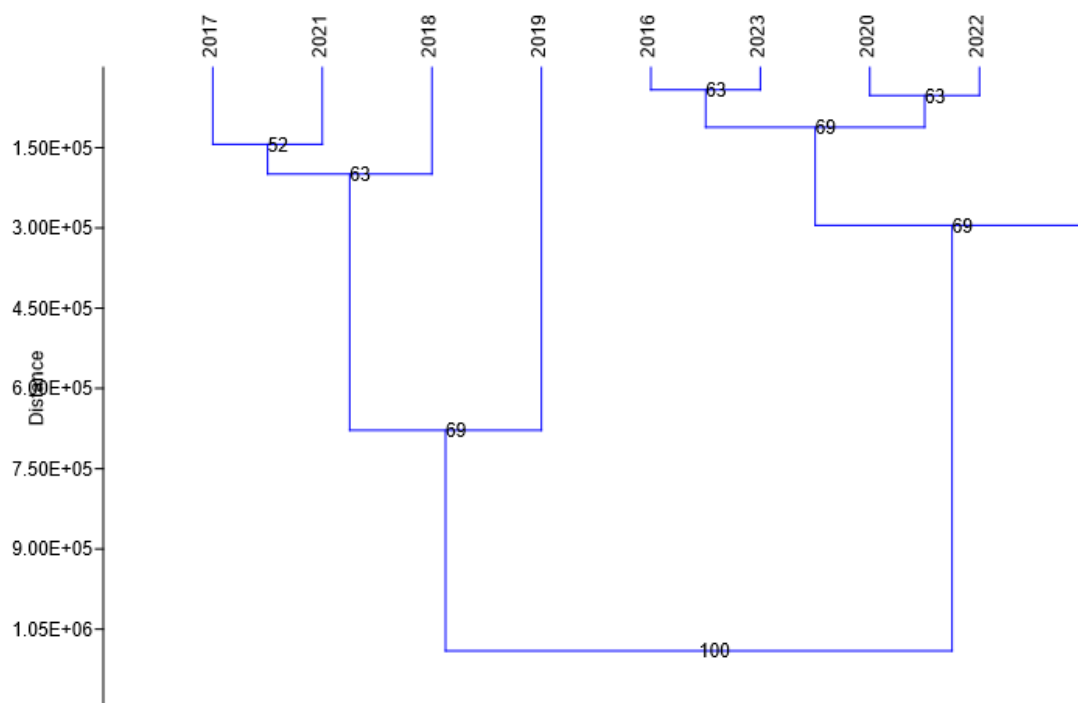


Figure 2. Cluster dendrogram for sunflower cultivation, under the study conditions

Table 5.

SDI values for the years of study in the evaluation of sunflower crop

	2015	2016	2017	2018	2019	2020	2021	2022	2023
2015	0	2.48E+05	1.13E+06	1.28E+06	1.80E+06	3.62E+05	1.06E+06	3.31E+05	2.39E+05
2016	2.48E+05	0	8.81E+05	1.03E+06	1.56E+06	1.37E+05	8.16E+05	91469	41556
2017	1.13E+06	8.81E+05	0	1.50E+05	7.15E+05	8.03E+05	1.43E+05	8.12E+05	9.01E+05
2018	1.28E+06	1.03E+06	1.50E+05	0	5.77E+05	9.50E+05	2.48E+05	9.60E+05	1.05E+06
2019	1.80E+06	1.56E+06	7.15E+05	5.77E+05	0	1.45E+06	7.43E+05	1.47E+06	1.57E+06
2020	3.62E+05	1.37E+05	8.03E+05	9.50E+05	1.45E+06	0	7.21E+05	52184	1.25E+05
2021	1.06E+06	8.16E+05	1.43E+05	2.48E+05	7.43E+05	7.21E+05	0	7.38E+05	8.29E+05
2022	3.31E+05	91469	8.12E+05	9.60E+05	1.47E+06	52184	7.38E+05	0	92246
2023	2.39E+05	41556	9.01E+05	1.05E+06	1.57E+06	1.25E+05	8.29E+05	92246	0

A ranking of the years was made based on the values of the elements analyzed during the study period (A, Y, TP). The diagrams in Figure 3 and Figure 4 resulted, in which the years were ranked in descending order (Figure 3), with the scattergram distribution (Figure 4) in relation to the three elements analyzed together.

Different techniques and models have been applied and used for the analysis and classification of agricultural areas, the study of crops and the estimation of sunflower yields in relation to environmental factors and technological inputs [12,9,23].

The yield and total production of sunflower in Romania, integrated into statistical data at EU and world level, in recent years, have represented elements of analysis in

relation to the agricultural products market [17], [18], [19].

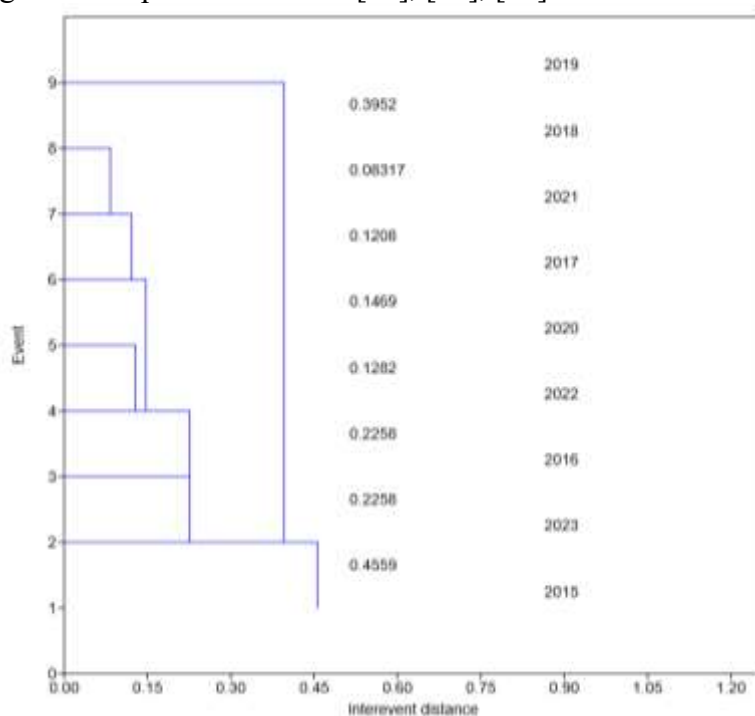


Figure 3. Ranking of years based on the characterization elements of the sunflower crop during the study period

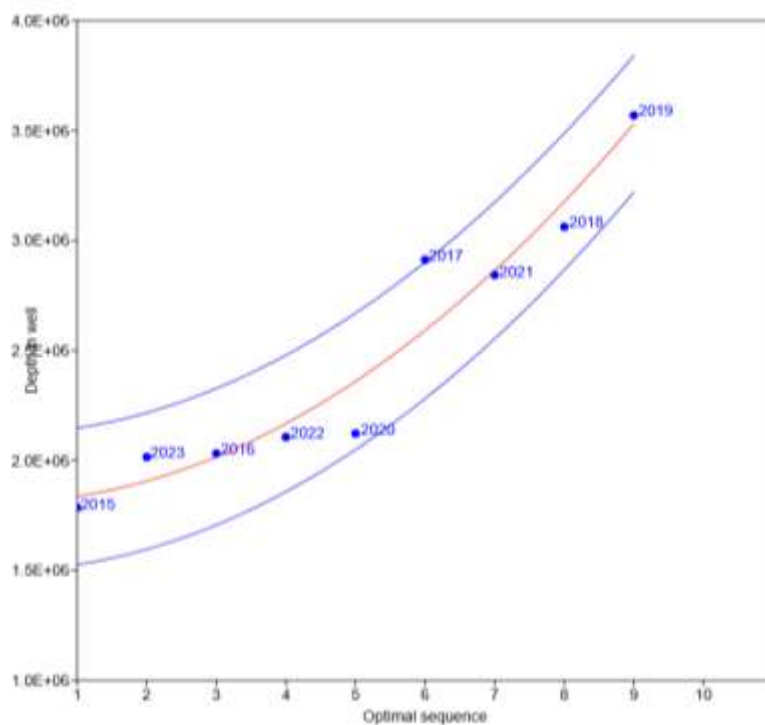


Figure 4. Scattergram distribution of years based on the characterization elements of the sunflower crop during the study period

The cultivated area, yield and total production were elements that described the variation in the dynamics of the sunflower crop under the study conditions, the years with favorability and advantages for sunflower were identified, and cluster groups and classifications were generated in conditions of statistical safety.

CONCLUSIONS

Differentiated variations in the cultivated area (A, ha), yield (Y, kg/ha) and total production (TP, tons) of sunflower were recorded in Romania, during the period 2015 - 2023. Compared to the mean value over the study period, for each element considered, positive and negative differences were recorded, with statistical certainty. The year 2019 was identified with positive differences compared to the calculated average, with statistical certainty for each element considered ($p < 0.05$ for yield; $p < 0.001$ for area and total production). The year 2018 was identified with positive differences, statistically assured, for total production ($p < 0.05$) and for yield ($p < 0.01$).

Multivariate analysis and cluster analysis explained the presence of variance, the association of years with the elements considered, as well as the grouping of years based on similarity. The ranking of the years over the study period was generated, and the year 2019 was highlighted with higher values of the elements considered in the evaluation of the sunflower crop.

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