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ECONOMIC EFFICIENCY OF SUNFLOWER PRODUCTION DEPENDING ON TECHNOLOGY

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Abstract

The purpose of this paper is to present an analysis of the economic efficiency of sunflower production in the pedoclimatic conditions specific to the outskirts of the city of Timișoara different technological options in the period 2020-2022. The experiment was trifactorial (of the 4 x 3 x 3 type), with 3 factors: D – density; F – fertility; T – technology. Ten plants were chosen from each plot and a series of measurements were made. Based on the values obtained, descriptive statistical indices related to the different technological factors were calculated, namely: arithmetic mean, error of the mean and coefficient of variation. The results showed that the profit had a variation between 849 RON/ha in the case of plants grown at a density of 49,261 g.g./ha on unfertilized agrofund prepared by scarification + ploughing and 1,990 RON/ha for plants grown at a density of 59,524 g.g./ha on the agricultural land fertilized with N50P50K0 and prepared by ploughing. In 55% of cases, the technological variants produced a profit of over 1,500 RON/ha. The research related presented in this paper concerns useful information that will allow superior, high-quality, and sustainable productions under the conditions of the current climate changes.

Key words**:** *economic efficiency, production, technological factors, sunflower*

INTRODUCTION

In sunflower, which is a C3 type plant, the increase in CO_2 concentration is associated with an increase in the efficiency of the use of solar radiation, water, and soil nitrogen, thus producing a greater amount of biomass and seeds on the background of an increase in the rate of photosynthesis [16, 17, 18, 21, 19, 20, 31,32]. This beneficial effect of increasing CO^2 concentration is valid up to the level of about 750 ppm [29]. Recent studies have demonstrated that an increase in CO_2 concentration from 370 to 760 ppm causes certain changes such as an increase of about 60% in the net rate of photosynthesis, a reduction of stomatal conductance by 7%, a reduction in evapotranspiration by 0.074 l/m2/h, and an increase in water use efficiency from 4.36 to 10.56 mg CO_2/l H_2O [6, 9, 28].

As such, in the future, on the background of increasing CO_2 concentration, sunflower will be very efficient in converting CO_2 into carbohydrates and reducing water consumption on the background of increasing the rate of photosynthesis, biomass by 24-68%, and even production by 35-45 % [1, 25, 30, 32]. Regarding the chemical composition of the seeds, it was shown that an increase in CO_2 concentration from 370 to 550 ppm was associated with a reduction in protein content by 13% and an increase in carbohydrates by 13% and by 15% in oil content and unsaturated fatty acids, respectively [2, 4, 22, 25, 26, 27].

The beneficial effects of increasing CO_2 concentration are counterbalanced by the negative effects of increasing global temperature and reducing the level of precipitation, phenomena associated with current climate change [4, 5, 7].

In the conditions of the current climate change, it is necessary to create new hybrids with adaptability to thermal shocks and water stress, which allow sustainable productions. In this sense, it is possible to optimize breeding programs in the direction of increasing productivity under climate stress conditions, using the information from sunflower genome sequencing and the great diversity of the genus Helianthus as a source of genes for adaptive characters [11, 15, 20, 24].

To compensate the reduction of the vegetation period with the increase in global temperature, the early sowing of later hybrids with the ability to germinate at lower temperatures is necessary [12, 14].

The purpose of this paper is to present an analysis of the economic efficiency of sunflower production in a trifactorial experiment regarding density, fertility and technology in the pedoclimatic conditions specific to the outskirts of the city of Timișoara in the period 2020-2022.

MATERIALS AND METHODS

A series of information from the literature related to sunflower culture, applied technologies, and the effect of ecological and technological factors on production have been used.

The cultivated hybrid was NK Neoma and the production potential was realized based on a trifactorial experiment (of the 4 x 3 x 3 type), located in the outskirts of Timișoara. This experiment was organized in 3 replicas, each on six rows of 10 m in length. The economic efficiency of sunflower production was analysed for each technology: density, fertilization, and tillage, as follows: each technology: density, fertilization, and tillage, as shown in Table 1.

Table 1. The characteristics of the experiment regarding density, fertilization and tillage

D. Density	F. Fertilisation	T. Technology
D_1 – 4,9261 g.g./ha;	F_1 – $N_0P_0K_0$;	T_1 – Ploughing;
D_2 – 5,3908 g.g./ha;	F_2 – $N_{50}P_{50}K_0$;	T_2 – Scarification;
D_3 – 5,9524 g.g./ha;	F_3 – $N_{50}P_{50}K_{50}$;	T_3 – Scarification+Ploughing.
D_4 – 6,6756 g.g./ha.		

Source: Own experiments.

Studies were carried out during 2020-2022.

Each plot, or replica, had different thicknesses, from 21.4 cm to 29 cm between plants in a row and 70 cm between rows. Ten plants were randomly selected from each plot and a series of measurements were taken. Based on the values obtained, descriptive statistical indices related to the different technological factors were calculated: arithmetic mean, error of the mean, and coefficient of variation.

The evaluation of the stability of the production and some of its morphological components for different technological variants was carried out by means of some parameters following to the linear regression analysis according to the Eberhart-Russell mathematical model in which: [3, 7, 8, 10].

$$F_{ij} = \mu + g_i + b_i t_j + \delta_{ij} + e_{ij} \quad \text{.....(1)}$$

where:

F_{ij} – average of variant i in year j; μ – general average: g_i – the effect of variants i; t_j – the effect (index) of year j; b_i – linear regression coefficient between F_{ij} and t_j; δ_{ij} – F_{ij} deviations from the regression line; e_{ijk} – the error associated with variant i in year j.

To calculate the profit rate, depending on the total cost, the following formula was used [13]:

$$R_{Pr/CT} = \frac{Pr}{CT} * 100 \quad \text{.....(2)}$$

where:

R Pr/CT – profit rate depending on the total cost, Pr – profit, CT – total cost.

The regression coefficient b_i which indicates the value by which the average of a technological variant changes when the average of a certain year increases or decreases by one unit. For option *i* the regression coefficient is [3]:

$$b_i = \sum F_{ij} t_j / \sum t_j^2 \quad \text{.....(3)}$$

Variance of regression deviations:

$$s_\delta^2 = \frac{1}{n-2}\left[\left(\sum F_{ij}^2 - \frac{(\sum F_{ij})^2}{n}\right) - \frac{(\sum F_{ij} t_j)^2}{\sum t_j^2}\right] - \frac{\sigma_E^2}{r} \quad \text{...(4)}$$

where:

n – number of years; *r* – number of repetitions; σ_E^2 - error variance.

The data on meteorological parameters for the period 2020-2022 for the town of Timișoara are provided by the Meteorological Station in Timisoara.

RESULTS AND DISCUSSIONS

Thermal and pluviometric regime

Most of the basic meteorological parameters (according to the Banat-Crișana Regional Meteorological Centre), which were

considered, were: thermal regime, pluviometric regime, and wind regime.

From the point of view of the rainfalls regime (Figures 1 and 2) during the analysed period, the least precipitation was recorded in the spring of 2020, the year in which, in April, there were only 7 l/m^2, and in May 29 l/m^2, which led to certain decreases in sunflower production.

In the year 2020, the total amount of precipitation was 540 l/m^2, while the year 2022 stood out with a value of 470 l/m^2. The fall of 2020 was rainy, in the last four months an amount of 250 l/m^2 was recorded. The highest amount of precipitation was in September, 121.6 l/m^2, and the lowest rainfall was in March, 3.9 l/m^2 and in June, 18.4 l/m^2. For the analysed interval, it can be observed that, in the month of July, the average values exceeded 22ºC, the highest value being recorded in 2021, which was 25.7ºC.

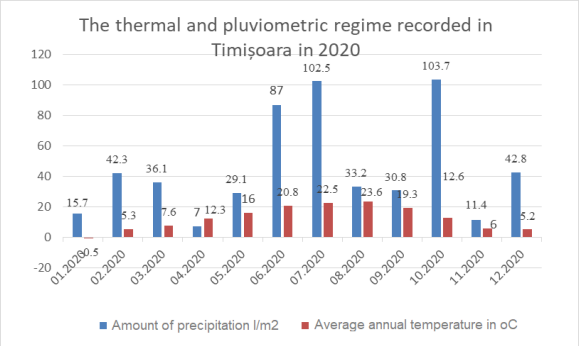

Fig. 1. Thermal and pluviometric regime recorded in Timișoara in 2020
Source: Meteorological Station in Timisoara [23].

Spring came a bit earlier and warmer than in other areas of the country. Temperature oscillations occurred with colder periods under the influence of air masses from the north and north-east, but also warmer periods due to the activity of Mediterranean cyclones.

Thus, late frosts and isolated frost occurred on the coldest mornings even at the beginning of May, but also hot days in June.

Also, in the spring, the first convective manifestations appeared with stormy phenomena, torrential rains, and hail. Average temperatures gradually increased from 5-6ºC at the beginning of spring to 16-17ºC at the beginning of summer. Seasonal averages range between 7 and 11ºC.

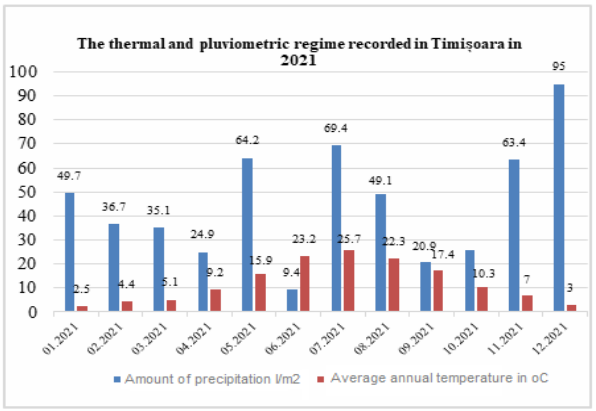

Fig. 2. Thermal and pluviometric regime recorded in Timișoara in 2021
Source: Meteorological Station in Timisoara [23].

Summer was dominated by formations related to the Azorean anticyclone and the Mediterranean cyclones, starting early, sometimes even in May and lasting until September. For the analysed interval, it can be observed that, in Timișoara, in the month of July, the average values exceeded 22ºC, the highest value being registered in 2021, 25.7ºC. That year, 16 hot days were recorded in Timișoara during the summer months.

The annual values of the atmospheric pressure (Figure 3) had a multiannual average of 984.4 mb, which represented the atmospheric pressure at the station level, i.e., the pressure read at the barometer, to which temperature and gravity corrections were applied.

In 2020, an average below the value of 980 mb was recorded, which means a more intense cyclonic activity and, implicitly, a higher number of cases for the respective years with manifestations of the wind.

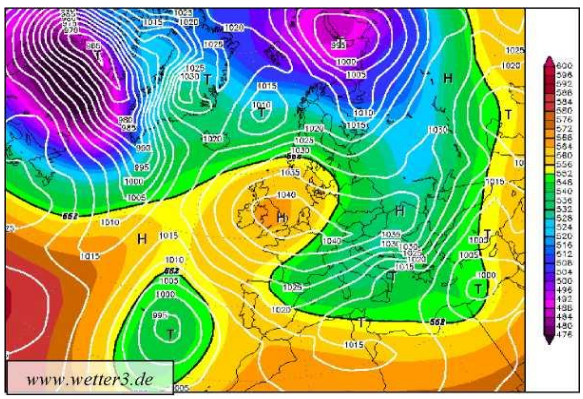

Fig. 3. Atmospheric pressure at ground level and geopotential at 500 hPa in January 2020
Source: Meteorological Station in Timisoara [23].

For the analysed interval, it can be observed that, in Timișoara, in the month of July, the average values exceeded 22°C, the highest value being registered in 2021, 25.7°C.

Sunshine duration is an indicator representing the time interval during a day in which the sun shines in the sky. It consists in determining the number of hours during which the sun illuminated the meteorological platform and its surroundings and it depends on cloudiness, latitude, seasons, and altitude. The annual average, in Timișoara, was around 2,000-2,100 hours, a range also found in the period analysed for the three years.

Analysis of economic efficiency for different technological options in sunflower in Timisoara during 2020-2022

Considering the economic efficiency indices of sunflower cultivation in Timișoara from the favourable soil and climate conditions of the year 2020 and the technological variant applied (Table 2), it was observed that the profit registered variations in the range of 695 RON/ha at the density of 59,524 g.g./ha (D_3) on the non-fertilized agricultural land prepared by scarification + ploughing and 1,752 RON/ha on the agricultural land $N_{50}P_{50}K_0$ and prepared by ploughing.

Thus, in 2020, the maximum amplitude of the economic efficiency on the unfertilized + ploughing agricultural land was recorded for the density of 66,756 g.g./ha (D_4), generating a profit of 1,808 RON/ha. Also, positive results were recorded on the agricultural land fertilized with $N_{50}P_{50}K_0$ and prepared by ploughing or scarification at densities of 59,524÷66,756 g.g./ha, generating profit rates of 151÷164% associated with profits of 1,808÷1,847 RON/ha.

Under the conditions of cultivation at densities of 49,261 g.g./ha (D_1), for the non-fertilized + scarification + ploughing agro-fund, a profit of 701 RON/ha was recorded, respectively 1,413 RON/ha for the scarification + fertilisation agro-fund with $N_{50}P_{50}K_0$. Under these conditions, the rate of profit associated with the variant $N_{50}P_{50}K_0$ + scarification + ploughing was 50.64% and, in the case of combining scarification + fertilization with $N_{50}P_{50}K_0$, 127.64%.

With a density of 53,908 g.g./ha (D_2) for the non-fertilized scarification + ploughing agro-fund, a profit of 827 RON/ha was recorded, compared to 1,454 RON/ha when associating scarification + $N_{50}P_{50}K_0$. In this case, the profit rate registered an increase from 68.30% associated with the treatment with $N_{50}P_{50}K_0$ + scarification + ploughing to 129.13% in the case of fertilization with $N_{50}P_{50}K_0$ on the agricultural land prepared by scarification.

Table 2. Economic efficiency indices of sunflower in Timisoara in 2020 for different technological links

Technological links	Yield (kg/ha)	Income (RON/ha)	Costs (RON/ha)	Profit (RON/ha)	Profit rate/ha (%)
$D_1F_1T_1$	1,714	1,663	761	902	118.53
$D_1F_1T_2$	1,615	1,567	781	786	100.64
$D_1F_1T_3$	1,816	1,762	1,061	701	66.07
$D_1F_2T_1$	2,476	2,402	1,087	1,315	120.97
$D_1F_2T_2$	2,598	2,520	1,107	1,413	127.64
$D_1F_2T_3$	2,390	2,318	1,387	931	67.12
$D_1F_3T_1$	2,393	2,321	1,258	1,063	84.50
$D_1F_3T_2$	2,449	2,376	1,278	1,097	85.84
$D_1F_3T_3$	2,420	2,347	1,558	789	50.64
$D_2F_1T_1$	1,903	1,846	779	1,066	136.84
$D_2F_1T_2$	1,687	1,636	799	837	104.75
$D_2F_1T_3$	1,965	1,906	1,079	827	76.64
$D_2F_2T_1$	2,593	2,515	1,106	1,410	127.48
$D_2F_2T_2$	2,659	2,579	1,126	1,454	129.13
$D_2F_2T_3$	2,620	2,541	1,406	1,136	80.79
$D_2F_3T_1$	2,612	2,534	1,277	1,257	98.43
$D_2F_3T_2$	2,609	2,531	1,297	1,234	95.14
$D_2F_3T_3$	2,736	2,654	1,577	1,077	68.30
$D_3F_1T_1$	2,228	2,161	802	1,359	169.45
$D_3F_1T_2$	1,990	1,930	822	1,108	134.80
$D_3F_1T_3$	1,853	1,797	1,102	695	63.06
$D_3F_2T_1$	3,067	2,975	1,128	1,847	163.74
$D_3F_2T_2$	2,972	2,883	1,148	1,735	151.13
$D_3F_2T_3$	3,215	3,119	1,428	1,691	118.42
$D_3F_3T_1$	3,145	3,051	1,299	1,752	134.87
$D_3F_3T_2$	3,012	2,922	1,319	1,603	121.53
$D_3F_3T_3$	3,417	3,314	1,599	1,715	107.25
$D_4F_1T_1$	2,332	2,262	831	1,431	172.20
$D_4F_1T_2$	2,058	1,996	851	1,145	134.55
$D_4F_1T_3$	2,148	2,084	1,131	953	84.26
$D_4F_2T_1$	3,008	2,918	1,157	1,761	152.20
$D_4F_2T_2$	3,077	2,985	1,177	1,808	153.61
$D_4F_2T_3$	3,163	3,068	1,457	1,611	110.57
$D_4F_3T_1$	3,107	3,014	1,328	1,686	126.96
$D_4F_3T_2$	3,104	3,011	1,348	1,663	123.37
$D_4F_3T_3$	2,996	2,906	1,628	1,278	78.50

Source: Own calculation.

Under the conditions of using the same density (59,524 g.g./ha) (D_3), conditioned by the processing method, the profit recorded the following maximum values: non-fertilized agricultural land, scarification + ploughing, 695 RON/ha; agricultural land ploughed and fertilized with $N_{50}P_{50}K_0$, 1,847 RON/ha. Under these conditions, the profit rate showed an evolution within the limits of 63.06% to 169.45%.

The application of the density of 66,756 g.g./ha (D_4) depending on the processing

method generated the following profit: non-fertilized agricultural land, scarification + ploughing, 953 RON/ha; in the variant of the association of scarification + $N_{50}P_{50}K_0$, 1,808 RON/ha. Therefore, the profit rate registered an increase from 78.50% due to the use of scarification + ploughing associated with $N_{50}P_{50}K5_0$, up to 172.0% in the case of the control variant where it was ploughed.

Regarding the economic efficiency indices for different densities in the conditions of 2020 (Table 3), depending on density, the profit rate registered the following evolution: from 87.56% for 49,261 g.g./ha to 126.88% for 59,524 g.g./ha. Subsequently, the increase in density (66,756 g.g./ha) is associated with the reduction of the profit rate (122.27%).

Table 3. Indices of economic efficiency of sunflower in Timisoara in 2020 for different technological links

Technological links		Yield (kg/ha)	Income (RON/ha)	Costs (RON/ha)	Profit (RON/ha)	Profit rate/ha (%)
Density (g.g./ha)	**49,261**	2,208	2,142	1,142	1,000	87.56
	53,908	2,376	2,305	1,161	1,144	98.53
	59,524	2,767	2,684	1,183	1,501	126.88
	66,756	2,777	2,694	1,212	1,482	122.27
Fertilisation	**$N_0P_0K_0$**	1,942	1,884	900	984	109.33
	$N_{50}P_{50}K_0$	2,820	2,735	1,226	1,509	123.08
	$N_{50}P_{50}K_{50}$	2,833	2,748	1,397	1,351	96.71
Tillage	**Ploughing**	2,548	2,472	1,068	1,404	131.46
	Scarification	2,475	2,400	1,069	1332	124.60
	Scarification+ Ploughing	2,546	2,469	1,349	1,121	83.10

Source: Own calculation.

The research showed that, in the non-fertilized variant, the effect of density on economic efficiency was low, associated with a profit of 984 RON/ha, compared to a profit rate of 109.33%, compared to the agro-fund fertilized with $N_{50}P_{50}K_{50}$, generating a profit of 1,509 RON/ha attached to a profit rate of 123.08%. Implicitly, the soil tillage/crop density interaction recorded a maximum profit of 1,404 RON/ha with a rate of 11.46% on the agrofund prepared by ploughing and a minimum of 1,121 RON/ha with a rate of 83.10% on the agricultural land prepared by scarification + ploughing (Table 3).

From the point of view of the profit, fertilization induces an increase in profit, generating 1,509 RON/ha while, at densities of 49,261 g.g./ha, the effect is decreasing, 1,000 RON/ha, close to that of the non-fertilized variant, where it used to be 984 RON/kg.

In terms of the profit rate, the biggest differences between the fertilized variants associated with a variation of 87.56% were observed at the density of 49,261 g.g./ha; in exchange, at the density of 59,524 g.g./ha, fertilization generated a smaller variation, i.e., 126.88%.

Fertilization had a higher effect on the profit in the agricultural land where scarification was used, realized by an amplitude of 1,332 RON/ha; in exchange, in the agricultural land prepared by ploughing, the difference was only 1,404 RON/ha. The profit rate showed a higher variation between fertilizations (131.46%) on the farm where ploughing was applied and a lower one (83.10%) in the case of the farm where scarification was used in association with ploughing.

The evolution of the profit rate on the soil works segment recorded values between 83.10÷131.46%.

Table 4. Indices of economic efficiency of sunflower in Timișoara in 2021 for different technological links

Technological links	Yield (kg/ha)	Income (RON/ha)	Costs (RON/ha)	Profit (RON/ha)	Profit rate/ha (%)
$D_1F_1T_1$	1,452	1,960	807	1,153	142.87
$D_1F_1T_2$	1,631	2,202	827	1,374	166.14
$D_1F_1T_3$	1,600	2,160	1,107	1,053	95.02
$D_1F_2T_1$	1,990	2,687	1,134	1,553	136.94
$D_1F_2T_2$	2,240	3,024	1,154	1,870	162.04
$D_1F_2T_3$	2,103	2,839	1,434	1,406	98.05
$D_1F_3T_1$	2,246	3,032	1,305	1,727	132.34
$D_1F_3T_2$	2,492	3,364	1,325	2,040	153.96
$D_1F_3T_3$	2,387	3,222	1,605	1,618	100.81
$D_2F_1T_1$	1,697	2,291	828	1,463	176.70
$D_2F_1T_2$	1,590	2,147	848	1,299	153.18
$D_2F_1T_3$	1,437	1,940	1,128	812	71.98
$D_2F_2T_1$	2,170	2,930	1,154	1,776	153.90
$D_2F_2T_2$	2,348	3,170	1,174	1,996	170.08
$D_2F_2T_3$	2,275	3,071	1,454	1,618	111.28
$D_2F_3T_1$	2,458	3,318	1,325	1,994	150.49
$D_2F_3T_2$	2,633	3,555	1,345	2,210	164.31
$D_2F_3T_3$	2,732	3,688	1,625	2,063	126.95
$D_3F_1T_1$	1,702	2,298	852	1,446	169.72
$D_3F_1T_2$	1,875	2,531	872	1,659	190.25
$D_3F_1T_3$	1,860	2,511	1,152	1,359	117.97
$D_3F_2T_1$	2,184	2,948	1,178	1,770	150.25
$D_3F_2T_2$	2,405	3,247	1,198	2,049	171.03
$D_3F_2T_3$	2,266	3,059	1,478	1,581	106.97
$D_3F_3T_1$	2,575	3,476	1,349	2,127	157.67
$D_3F_3T_2$	2,633	3,555	1,369	2,186	159.68
$D_3F_3T_3$	2,732	3,688	1,649	2,039	123.65
$D_4F_1T_1$	1,712	2,311	883	1,428	161.72
$D_4F_1T_2$	1,761	2,377	903	1,474	163.23
$D_4F_1T_3$	1,514	2,044	1,183	861	72.78
$D_4F_2T_1$	2,065	2,788	1,209	1,578	130.52
$D_4F_2T_2$	2,237	3,020	1,229	1,791	145.72
$D_4F_2T_3$	1,952	2,635	1,509	1,126	74.62
$D_4F_3T_1$	2,309	3,117	1,380	1,737	125.87
$D_4F_3T_2$	2,514	3,394	1,400	1,994	142.43
$D_4F_3T_3$	2,387	3,222	1,680	1,542	91.80

Source: Own calculation.

Regarding the evolution of economic efficiency conditioned by the constant technological options in 2021 (Table 4), it can be observed that most of the technological options registered a rate of profit above 100.

For Profit, a minimum of 812 RON/ha was found for the $D_2F_1T_3$ option and a maximum of 2,210 RON/ha for $D_3F_3T_2$, considering that only two variants reached values below 1,000 RON/ha (812 and 861 RON/kg, respectively).

Considering the profit and the profit rate in the climate conditions of 2021, a high economic efficiency was highlighted (2,210 RON/ha corresponding to a profit rate of 164.31%) in the technological variant $D_2F_3T_2$, evolution also recorded in the case of the variant $D_3F_2T_2$ (2,049 RON/ha/171.03%), respectively $D_3F_3T_1$ (2,127 RON/ha 157.67%).

In the case of the variant $D_2F_2T_2$ also, superior economic results were obtained with a profit of 1,996 RON/ha and a profit rate of 170.08%.

On the $D_1F_1T_3$ agricultural fund, the profit recorded values between 1,053 RON/ha and 2,040 RON/ha in the $D_1F_3T_2$ variant where D_1 (49,261 g.g./ha) was constant. Regarding the profit rate, an increase from 95.02% in the D_{1F1T3} variant to 166.14% in the case of $D_1F_1T_2$ was observed.

Under the conditions of growing plants at a density of 53,908 g.g./ha (D_2), the profit shows an increase in the range of 812 RON/ha for the agricultural fund $D_2F_1T_3$ and 2,210 RON/ha for the agricultural fund $D_2F_3T_2$, respectively. In these growing conditions, the profit rate varied from 71.98% for $D_2F_1T_3$ to 176.70% in the case of the $D_2F_1T_1$ agricultural fund.

Under the effect of the density of 59,524 g.g./ha (D_3), the profit recorded values within the limits of 1,359 RON/ha (minimum) for the $D_3F_1T_3$ agricultural fund and 2,186 RON/ha (maximum) for the $D_3F_3T_2$ variant. Combined with the profit rate, a minimum of 106.97% is observed for $D_3F_2T_3$ and a maximum of 190.25% in the case of the $D_3F_1T_2$ agricultural fund.

Under the conditions of the technological variant D_4 (66,756 g.g./ha), the profit was within the limits of 861 RON/ha for the $D_4F_1T_3$ agricultural fund, respectively 1,994 RON/ha for the $D_4F_3T_2$ agricultural fund. In these technical conditions, the profit rate evolved from 72.78% for the $D_4F_1T_3$ variant, to 145.72% in the case of the $D_4F_2T_2$.

Considering the unilateral, compared effect of density (Table 4), it can be observed that the impact of plant density on crop profit was proportional to the applied fertilization, being higher (1,940 RON/ha) in the case of the $N_{50}P_{50}K_{50}$ variant and lower (1,282 RON/ha) for unfertilized agricultural land. The amplitude of the profit rate between densities was lower (118.91%) in the unfertilized agrofund and higher (134.16%) in the $N_{50}P_{50}K_{50}$ variant. The soil works showed a reduced influence on the profit related to different densities, within the limit of 1,365÷1,646 RON/ha. The differences between the densities in terms of the profit rate were higher in the case of the application of scarification in association with ploughing and lower, for the other agrofunds.

Table 5. Economic efficiency indices of sunflower cultivation in Timisoara from 2021 for different technological links

Technological links		Yield (kg/ha)	Income (RON/ha)	Costs (RON/ha)	Profit (RON/ha)	Profit rate/ha (%)
Density (g.g./ha)	**49,261**	2,016	2,721	1,189	1,533	128.93
	53,908	2,149	2,901	1,209	1,692	139.95
	59,524	2,248	3,035	1,233	1,802	146.15
	66,756	2,050	2,768	1,264	1,503	118.91
Fertilisation	**$N_0P_0K_0$**	1,653	2,231	949	1,282	135.10
	$N_{50}P_{50}K_0$	2,186	2,951	1,275	1,676	131.45
	$N_{50}P_{50}K_{50}$	2,508	3,386	1,446	1,940	134.16
Tillage	**Ploughing**	2,047	2,763	1,117	1,646	147.36
	Scarification	2,157	2,912	1,118	1,794	160.46
	Scarification+Ploughing	2,047	2,763	1,398	1,365	96.99

Source: Own calculation.

Regarding the economic efficiency indices for different fertilizations, a gradual increase in the profit of this crop was observed from 1,282 to 1,940 RON/ha by applying fertilization with nitrogen and phosphorus or nitrogen, phosphorus, and potassium. The effect of fertilization on the economic efficiency of the crop was less in the case of the density of 66,756 g.g./ha associated with a variation of the profit of 1,503 RON/ha and the profit rate of 118.91%, while on the background of the density of 53,908 g.g./ha

the profit varied by 1,692 RON/ha, and at 49,261 density, the profit rate had the highest amplitude (128.93%) between fertilizations. Considering the interaction with the soil works, fertilization showed a higher influence on the economic efficiency in the case of the agricultural fund prepared by scarification, where there was a variation of the profit of 1,794 RON/ha and the profit rate of 160.46%, while on the agricultural fund prepared by ploughing, the variations were 1,646 RON/ha, i.e., 147.36%. Considering the economic efficiency indices from the year 2022 (Table 6), it can be observed that the profit rate recorded a variation between 69.53% for the technological variant $D_1F_1T_3$ and 171.37% for $D_3F_1T_2$. The profit showed a variation between 849 RON/ha in the case of plants grown at a density of 49,261 g.g./ha on unfertilized agricultural land prepared by scarification + ploughing and 1,990 RON/ha for plants grown at a density of 59,524 g.g./ha on fertilized land with $N_{50}P_{50}K_0$ and prepared by ploughing. In 55% of cases, the studied technological variants presented a profit of over 1,500 RON/ha.

Thus, in 2022, the highest economic efficiency was obtained by using the density of 59,524 g.g./ha on non-fertilized agricultural land where scarification was used, which allowed a profit of 1,932 RON/ha associated with a profit rate of 129.75%.

Also, a high economic efficiency was found in the case of plants grown at a density of 66,756 g.g./ha (D_4) on unfertilized agro-funds and prepared by ploughing or scarification, which allowed profit rates of 72.53-168 .97% associated with profits of 1,310-1,990 RON/ha. When growing plants at a density of 49,261 g.g./ha (D_1), the profit showed an amplitude between 849 RON/ha for the non-fertilized agricultural land where the association of scarification + ploughing was applied and 1,574 RON/ha for the agricultural land prepared by ploughing + fertilisation with $N_{50}P_{50}K_{50}$. The rate of profit in these crop conditions varied from 69.53% for the combination of scarification + ploughing on unfertilized agricultural land to 148.25% in the case of scarification on unfertilized agricultural land.

Table 6. Indices of economic efficiency of sunflower in Timișoara in 2022 for different technological links

Technological links	Yield (kg/ha)	Income (RON/ha)	Costs (RON/ha)	Profit (RON/ha)	Profit rate/ha (%)
$D_1F_1T_1$	1,631	2,137	921	1,216	132.03
$D_1F_1T_2$	1,783	2,336	941	1,395	148.25
$D_1F_1T_3$	1,580	2,070	1,221	849	69.53
$D_1F_2T_1$	2,114	2,769	1,247	1,522	122.05
$D_1F_2T_2$	2,094	2,743	1,267	1,476	116.50
$D_1F_2T_3$	2,152	2,819	1,547	1,272	82.22
$D_1F_3T_1$	2,284	2,992	1,418	1,574	109.10
$D_1F_3T_2$	2,173	2,847	1,438	1,409	97.98
$D_1F_3T_3$	2,336	3,060	1,718	1,342	78.11
$D_2F_1T_1$	1,747	2,289	944	1,344	142.37
$D_2F_1T_2$	1,730	2,266	964	1,302	135.06
$D_2F_1T_3$	1,844	2,416	1,244	1,172	94.21
$D_2F_2T_1$	2,259	2,959	1,270	1,689	132.99
$D_2F_2T_2$	2,205	2,889	1,290	1,598	123.87
$D_2F_2T_3$	2,386	3,126	1,570	1,555	99.04
$D_2F_3T_1$	2,200	2,882	1,441	1,441	100.00
$D_2F_3T_2$	2,307	3,022	1,461	1,561	106.84
$D_2F_3T_3$	2,288	2,997	1,741	1,256	72.14
$D_3F_1T_1$	1,996	2,615	972	1,643	169.03
$D_3F_1T_2$	2,055	2,692	992	1,700	171.37
$D_3F_1T_3$	2,057	2,695	1,272	1,422	111.80
$D_3F_2T_1$	2,405	3,151	1,298	1,852	142.68
$D_3F_2T_2$	2,480	3,249	1,318	1,930	146.43
$D_3F_2T_3$	2,315	3,033	1,598	1,434	89.74
$D_3F_3T_1$	2,507	3,284	1,469	1,815	123.55
$D_3F_3T_2$	2,612	3,422	1,489	1,932	129.75
$D_3F_3T_3$	2,595	3,399	1,769	1,630	92.14
$D_4F_1T_1$	2,040	2,672	1,008	1,664	165.08
$D_4F_1T_2$	2,111	2,765	1,028	1,737	168.97
$D_4F_1T_3$	2,008	2,630	1,308	1,322	101.07
$D_4F_2T_1$	2,538	3,325	1,334	1,990	149.17
$D_4F_2T_2$	2,350	3,079	1,354	1,724	127.32
$D_4F_2T_3$	2,412	3,160	1,634	1,525	93.33
$D_4F_3T_1$	2,539	3,326	1,506	1,821	120.92
$D_4F_3T_2$	2,420	3,170	1,526	1,645	107.81
$D_4F_3T_3$	2,378	3,115	1,806	1,310	72.53

Source: Own calculation.

On the background of the density of 53,908 g.g./ha (D_2), the profit recorded values between 1,172 RON/ha for the non-fertilized agricultural land where scarification associated with ploughing was used and 1,689 RON/ha for the variant represented by the association of ploughing + $N_{50}P_{50}K_0$. Regarding the profit rate, an amplitude of 72.14% is observed for the $N_{50}P_{50}K_{50}$ combination based on the use of scarification + ploughing up to 135.06% in the case of ploughing the unfertilized agrofund.

With the density of 59,524 g.g./ha (D_3), the profit recorded levels between 1,422 RON/ha for the non-fertilized agricultural land where the association of scarification + ploughing was applied and 1,930 RON/ha for the agricultural land prepared by scarification + fertilized with $N_{50}P_{50}K_0$.

The rate of profit in these conditions varied from 89.74% for the agricultural land fertilized with $N_{50}P_{50}K_0$ where the combination of scarification + ploughing was

applied, up to 171.37% in the case of the unfertilized agricultural land prepared by scarifying. Under the effect of the density of 66,756 g.g./ha (D_4), the profit recorded values with limits between 1,310 RON/ha for the agricultural fund fertilized with $N_{50}P_{50}K_{50}$ where scarification + ploughing was used and 1,990 RON/ha for the variant represented by the combination of ploughing + $N_{50}P_{50}K_0$. Regarding the profit rate, an amplitude of 72.53% is observed for the combination of the $N_{50}P_{50}K_{50}$ variant based on the use of scarification + ploughing, up to 168.97% in the case of unfertilized agricultural land where scarification was used. Regarding the economic efficiency indices for different densities in the conditions of 2022 (Table 7), it can be observed that the profit rate was between 102.84% for the density of 49,261 g.g./ha and 126.16% for the density of 59,524 g.g./ha.

Thus, considering the unilateral effect of crop density, a gradual increase in the economic efficiency of this crop can be seen by changing the density from 49,261 to 59,524 g.g./ha, subsequently the increase in plant density being associated with a slight reduction in profit.

Table 7. Indices of economic efficiency of sunflower in Timisoara in 2022 for different technological links

Technological links		Yield (kg/ha)	Income (RON/ha)	Costs (RON/ha)	Profit (RON/ha)	Profit rate/ha (%)
Density (g.g./ha)	**49,261**	2,016	2,641	1,302	1,339	102.84
	53,908	2,107	2,761	1,325	1,435	108.30
	59,524	2,336	3,060	1,353	1,707	126.16
	66,756	2,311	3,027	1,389	1,638	117.93
Fertilisation	**$N_0P_0K_0$**	1,882	2,465	1,068	1,397	130.81
	$N_{50}P_{50}K_0$	2,309	3,025	1,394	1,631	117.00
	$N_{50}P_{50}K_{50}$	2,387	3,126	1,565	1,561	99.74
Tillage	**Ploughing**	2,188	2,867	1,236	1,631	131.96
	Scarification	2,183	2,860	1,237	1,623	131.20
	Scarification+ Ploughing	2,188	2,866	1,517	1,349	88.92

Source: Own calculation

Considering the interaction with the soil works, the density of the crop showed a higher influence on the economic efficiency in the case of the agricultural fund prepared by scarification where a variation of the profit of 1,339 RON/ha and the profit rate of 102.84% was observed, while on the agricultural land prepared by scarification + ploughing, the amplitudes were 1,349 RON/ha, i.e., 88.92%.

The economic indices for the fertilized variants, from the point of view of profit, showed that fertilization showed a higher influence on the background of the density of 53,908 g.g./ha, and less at 66,756 g.g./ha.

Considering the unilateral effect of tillage in Table 6, it is observed that the effect on crop profit was more evident in the case of the density of 66,756 g.g./ha and less for the density of 53,908 g.g./ha. The amplitude of the profit rate between soil works was lower at the densities of 49,261-53,908 g.g./ha and higher for the densities of 59,524-66,756 g.g./ha. The economic efficiency of the soil works was inversely proportional to the level of fertilization, obtaining a high variation in the case of the unfertilized agrofund and lower on the agrofund fertilized with $N_{50}P_{50}K_{50}$. Regarding the economic efficiency for different densities, in the period 2020-2022 it was found that the climate conditions had the highest influence on the economic indices related to the density of 49,261 g.g./ha. In the respective crop conditions, the profit recorded values between 1,000 RON/ha in 2020 and 1,533 RON/ha in 2021, while the profit rate varied from 91.32 to 128.93%.

For the density of 53,908 g.g./ha, the same trend is observed on the background of profit levels from 1,144 RON/ha in 2020 to 1,692 RON/ha in 2021 associated with a profit rate between 98.53% and 139.95%.

With a density of 59,524 g.g./ha, the profit recorded values between 1,501 RON/ha in 2020 and 1,802 RON/ha in 2021, while the profit rate varied from 126.88 to 146.15%.

With a density of 66,756 g.g./ha, a smaller variation was found from one year to the next on the background of profit levels from 1,482-1,503 RON/ha in 2020-2021 to 1,707 RON/ha in 2022 associated with a rate of the profit between 122.27-117.93% in 2021-2022 and 118.91% in 2020. As such, it is found that the effect of the climate conditions on the economic efficiency of the crop has decreased as the plant density increases, while obtaining the better indices at the density of 59,524 g.g./ha.

Considering the economic efficiency indices for different fertilization plans, it is observed that, on the non-fertilized agrofund, the profit

rate was between 113.48% in 2020 and 140.15% in 2021, while the profit varied from 984 in 2020 to 1,631 RON/ha in 2022.

Under the conditions of fertilization with $N_{50}P_{50}K_0$, a smaller variation of the economic indices from one year to the next is noted, on the background of profit levels from 1,509 RON/ha in 2020 to 1,676 RON/ha in 2021 associated with a profit rate between 117.00% in 2022 and 131.45% in 2021.

When applying $N_{50}P_{50}K_{50}$, the profit recorded values between 1,351 RON/ha in 2020 and 1,940 RON/ha in 2021, while the profit rate varied from 96.71% to 135.83%. The impact of the variation of climate conditions on the economic efficiency of the crop was higher on the agrofund fertilized with $N_{50}P_{50}K_{50}$ and lower in the case of the treatment with $N_{50}P_{50}K_0$.

Fertilizers with nitrogen, phosphorus and potassium had a high effect on the economic efficiency of the crop in 2021, while those with nitrogen and phosphorus were used more efficiently from an economic point of view in the conditions of 2020 and 2022.

Considering the economic efficiency for different soil works, it was found that the climate conditions showed the highest influence on the economic indices on the agricultural land prepared by scarification, where the profit recorded values between 1,332 RON/ha in 2020 and 1,794 RON/ha in 2021, while the profit rate varied from 124.60 to 160.46%.

For the agricultural fund prepared by ploughing, profit levels are observed from 1,404 RON/ha in 2020 to 1,646 RON/ha in 2021 associated with a profit rate between 131.46 and 147.36%.

In the case of the agricultural fund where ploughing + scarification was used, the profit recorded values between 1,121 RON/ha in 2020 and 1,365 RON/ha in 2021, while the profit rate varied from 83.10% to 96.99%. As such, it was found that the effect of climate conditions on the economic efficiency of the crop was less on the agricultural land prepared by ploughing, in the conditions of obtaining the best indices on the agricultural land prepared by scarification, respectively a lower economic efficiency in the case of the agricultural land prepared with ploughing + scarification.

CONCLUSIONS

From a climate point of view, the analysed period (2020-2022) was characterized as follows:

- Regarding the rainfall regime, the least precipitation was recorded in the spring of 2020, the total amount of precipitation was 540 l/m^2, while the year 2022 stood out with a value of 470 l/m^2.
- Regarding temperatures, the highest temperature was recorded in July 2021, which was 25.7ºC. Average temperatures gradually increase from 5-6ºC at the beginning of spring to 16-17ºC at the beginning of summer. Seasonal averages ranged between 7 and 11ºC.
- Regarding the atmospheric pressure, the multiannual average is 984.4 mb. In 2020, an average below the value of 980 mb was recorded, which means a more intense cyclonic activity and, implicitly, many cases with intense wind.

Depending on the technological links and climate conditions, the economic efficiency indices had different values, from one year to the next, as follows:

In the climate conditions of 2020, the economic efficiency, on the unfertilized + ploughing agro-fund for the density of 66,756 g.g./ha (D_4) generated a profit of 1,808 RON/ha. Positive results were also recorded on the agricultural land fertilized with $N_{50}P_{50}K_0$ and prepared by ploughing or scarification at densities of 59,524÷66,756 g.g./ha, which generating profit rates of 151÷164%, associated with profits of 1,808÷1,847 RON/ha. At densities of 53,908 g.g./ha, unfertilized, scarification + ploughing, a profit of 827 RON/ha was recorded compared to 1,454 RON/ha in the option of associating scarification + $N_{50}P_{50}K_0$. In this case, the profit rate registered an increase from 68.30% associated with the treatment with $N_{50}P_{50}K_{50}$ + scarification + ploughing, to 129.13% in the case of fertilization with $N_{50}P_{50}K_0$ on the agricultural land prepared by scarification. Regarding the economic

efficiency indices for different densities in 2020, the profit rate registered an evolution from 87.56% for 49,261 g.g./ha, to 126.88% for 59,524 g.g./ha. The increase in density (66,756 g.g./ha) is associated with the reduction of the profit rate (122.27%).

Regarding the evolution of economic efficiency in 2021, most of the technological variants recorded a profit rate above 100. The profit recorded a minimum of 812 RON/ha for the $D_2F_1T_3$ variant and a maximum of 2,210 RON/ha for $D_3F_3T_2$. The profit and profit rate were high (2,210 RON/ha corresponding to a profit rate of 164.31%) in the $D_2F_3T_2$ variant and in the case of the $D_3F_2T_2$ variant (2,049 RON/ha/171.03%), respectively $D_3F_3T_1$ (2,127 RON/ ha/157.67%), with a profit of 1,996 RON/ha and a profit rate of 170.08%. With densities of 53,908 g.g./ha, the profit shows an increase of 812 RON/ha for the $D_2F_1T_3$ agricultural fund, respectively of 2,210 RON/ha for the $D_2F_3T_2$ agricultural fund. Under these conditions, the profit rate varied from 71.98% for $D_2F_1T_3$, up to 176.70% in the case of the $D_2F_1T_1$ agricultural fund, while at a density of 59,524 g.g./ha, the profit was between 1,359 and 2,186 RON/ha and the profit rate between 106.97% for $D_3F_2T_3$ and 190.25% for $D_3F_1T_2$. Considering the unilateral, comparative effect of density, the amplitude of the profit rate between densities was lower (118.91%) in the unfertilized agrofund and higher (134.16%) in $N_{50}P_{50}K_{50}$. Soil works showed a reduced influence on the profit related to different densities, between 1,365 and 1,646 RON/ha.

The economic efficiency indices for different fertilizations registered a gradual increase in the profit of this crop from 1,282 to 1,940 RON/ha by applying fertilization with nitrogen and phosphorus or nitrogen, phosphorus, and potassium. The effect of fertilization on the economic efficiency of the crop was less in the case of the density of 66,756 g.g./ha associated with a variation of the profit of 1,503 RON/ha and the profit rate of 118.91%, while on the background of the density of 53,908 g.g./ha profit varied by 1,692 RON/ha, and at 49,261 density, the profit rate had the highest amplitude (128.93%) between fertilizations.

In 2022, the profit rate recorded a variation between 69.53% for the technological variant represented by $D_1F_1T_3$ and 171.37% for $D_3F_1T_2$.

The profit showed a variation between 849 RON/ha and 1,990 RON/ha for the plants grown at the density of 59,524 g.g./ha on the agrofund $N_{50}P_{50}K_0$ + ploughing. In 55% of cases, the studied technological variants presented a profit of over 1,500 RON/ha.

Thus, in the climate conditions of the year 2022, the highest economic efficiency was obtained by using the density of 59,524 g.g./ha on the unfertilized agro-fund where scarification was used, which allowed a profit of 1,932 RON/ha associated with a profit rate of 129.75, as well as in the case of plants grown at a density of 66,756 g.g./ha (D_4), on unfertilized agrofunds and prepared by ploughing or scarification, which allowed obtaining profit rates of 72.53-168.97% associated with profits of 1,310-1,990 RON/ha. At densities of 59,524 g.g./ha (D_3), the profit recorded levels between 1,422 RON/ha and 1,930 RON/ha and the profit rate varied from 89.74% to 171.37% in the case of unfertilized and scarified agricultural land.

Regarding the economic efficiency indices for different densities in the conditions of 2022, it is observed that the profit rate was 102.84% for the density of 49,261 g.g./ha and 126.16% for the density of 59,524 g.g./ha. There is a gradual increase in the economic efficiency of this crop by changing the density from 49,261 to 59,524 g.g./ha, subsequently the increase in plant density being associated with a slight reduction in profit. Considering the interaction with soil works, the crop density showed a higher influence on the economic efficiency in the case of the agricultural land prepared by scarification of 1,339 RON/ha and the profit rate of 102.84%, while on the agricultural land prepared by scarification + ploughing the amplitudes were 1,349 RON/ha, i.e., 88.92%.

The economic indices for the fertilized variants showed that fertilization had a higher influence on the background of the density of 53,908 g.g./ha, and lower at 66,756 g.g./ha.

Regarding the economic efficiency for different densities, in the period 2020-2022 it was found that the climate conditions showed

the highest influence at densities of 49,261 g.g./ha, when the profit recorded values between 1,000 RON/ha in 2020 and 1,533 RON/ha in 2021, while the profit rate varied from 91.32 to 128.93%.

For the density of 53,908 g.g./ha, the same trend was observed, on the background of profit levels from 1,144 RON/ha in 2020 to 1,692 RON/ha in 2021 associated with a profit rate between 98.53% and 139.95%. With a density of 59,524 g.g./ha, the profit recorded values between 1,501 RON/ha in 2020 and 1,802 RON/ha in 2021, while the profit rate varied from 126.88 to 146.15%.

With a density of 66,756 g.g./ha, a smaller variation is found from one year to the next, on the background of profit levels from 1,482-1,503 RON/ha in 2020-2021 to 1,707 RON/ha in 2022 associated with a rate of the profit between 122.27-117.93% in 2021-2022 and 118.91% in 2020. Thus, the effect of climate conditions on the economic efficiency of the crop decreased as the plant density increased, on the background of obtaining the most good indices at the density of 59,524 g.g./ha.

Taking into account the indices of economic efficiency for different fertilization plans, it was observed that, on the unfertilized agrofund, the profit rate was between 113.48% in 2020 and 140.15% in 2021, while the profit varied from 984 in 2020 to 1,631 in 2022, while under conditions of fertilization with N50P50K0, a smaller variation of the economic indices from one year to the next was noted on the background of profit levels from 1,509 RON/ha in 2020 to 1,676 RON/ha in 2021 associated with a profit rate between 117.00% in 2022 and 131.45% in 2021. Nitrogen, phosphorus, and potassium fertilizers had a high effect on the economic efficiency of the crop in 2021, while those with nitrogen and phosphorus were capitalized more efficiently from an economic point of view in the conditions of 2020 and 2022.

Considering the economic efficiency for different soil works, it was found that the climate conditions showed the highest influence on the economic indices on the agricultural land prepared by scarification, where the profit recorded values between 1,332 RON/ha in 2020 and 1,794 RON/ha in 2021, while the profit rate varied from 124.60 to 160.46%. For the agricultural fund prepared by ploughing, profit levels were from 1,404 RON/ha in 2020 to 1,646 RON/ha in 2021 associated with a profit rate between 131.46 and 147.36%. If ploughing was used in combination with scarification, the profit recorded values between 1,121 RON/ha in 2020 and 1,365 RON/ha in 2021, while the profit rate varied from 83.10% to 96.99%.

As such, it was found that the effect of climate conditions on the economic efficiency of the crop was less on the agricultural land prepared by ploughing, in the conditions of obtaining the best indices on the agricultural land prepared by scarification, respectively a lower economic efficiency in the case of the agricultural land with ploughing + scarification.

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