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ECONOMIC JUSTIFICATION OF DIFFERENT TILLAGE SYSTEMS IN AGRICULTURAL PRODUCTION

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Abstract: The application of different tillage systems also has an economic dimension of justification. Agroeconomics 2024/2025 an experiment with wheat on an area of 1 ha was established on the experimental field of the Research and Development Institute "Tamiš" from Pančevo, which was grown in a system of conventional and zero tillage. The aim of this research was to determine the economic benefits that can be realized depending on the applied soil cultivation system. The comparability of the results was achieved by calculating the gross coverage margin (Gcm) and the coefficient of economy of production (Cep). Both indicators (Gcm=132,898 dinars; Cep=3.5 dinars) are higher in the case of wheat cultivation in the zero-tillage system than in the case of conventional tillage.

Keywords: Economic justification, Gross coverage margin, Coefficient of economy of production

INTRODUCTION

Literature Review

In modern agricultural production, various systems of agricultural land processing are intertwined, which can directly affect the achieved economic profitability at the end of the production process. Traditional tillage dominates the world, but the interest of agricultural producers is slowly shifting to alternative tillage systems, such as conservation or zero tillage (Ahmad an Wang, 2023; Jug et al., 2025; Jayaraman and Dalal, 2022). Alternative soil cultivation systems represent a kind of response to the conservation of land resources and mitigation of climate change in the process of agricultural production (Vejedla et al., 2025; Sadiq et al., 2024; Mondal et al., 2023; Neufeldt et al., 2015).

By applying the system of reduced agricultural production, the economic and social position of producers is simultaneously strengthened (Stošić et al., 2022). The classic system of agricultural land processing creates high costs, where we primarily mean fuel and labor costs, which consequently affects financial and economic indicators and ultimately the profit of agricultural producers (Jaskulska, 2020). Therefore, the authors Wang et al. (2025) propose a transition to other tillage systems (reduced, conservation, regenerative) that achieve positive results not only in the economic sense, but also in relation to the environment, biodiversity and soil.

Switching from conventional to no-till on 1.000 acres can save about 4.160 gallons of diesel (approximately USD 8.500) per year in fuel alone, with additional savings in labor hours and machine maintenance costs (USDA, 2017).

According to the EU CAP Network (2025), reduced and no-till cultivation significantly reduces production costs in the Mediterranean parts of the EU, because it improves the soil structure, reduces erosion and increases the efficiency of inputs (labor, fuel).

In Croatia, research was conducted regarding the assessment of the economic profitability of winter wheat production with different tillage systems, and the results showed that the best economic results were achieved by wheat production without tillage (Stošić et al., 2022).

A study was conducted in Lithuania that showed that by switching from conventional to zero tillage, production costs are reduced by 23% (Saldukaitė-Sribikė et al., 2022).

In the Mediterranean and semi-arid areas of Europe, alternative agricultural land cultivation systems have a higher level of competitiveness compared to the classic land cultivation system. In Spain, no-tillage and reduced tillage have been shown to contribute to a higher value of gross margin coverage compared to traditional tillage by about 16%, especially in rotational systems of wheat and leguminous production (Serrano et al., 2011).

Overall, the literature indicates that the transition from traditional to alternative tillage systems in wheat production can bring significant economic benefits, but that their realization depends on local conditions, access to mechanization and the degree of willingness of producers to accept new technologies.

Analysis of the State of Different Agricultural Land Cultivation Systems in Europe and Serbia

In order to better observe the changes in the area cultivated and to which different tillage systems are applied per farm, we used secondary data from the internationally recognized database EUROSTAT (2025) and the electronic database of the Republic Institute for Statistics of the Republic of Serbia. For the European Union level, the analysis included the period 2016-2023. year, while the data for Serbia refer to 2012 and 2023, which are also census years. Table 1 shows changes in the size of arable land per agricultural holding, as well as the representation of different forms of land cultivation (conventional, conservation and no-till) for the EU, European countries and Serbia.

As we can see, most countries are recording an increase in arable land per farm, which indicates the continuation of the concentration (consolidation) of arable land. At the same time, there is a gradual transition from conventional to conservation tillage and the application of zero tillage methods. Serbia, although among the countries with the smallest farms, shows growth in all forms of processing, which confirms the trend of adopting more sustainable agrotechnical practices. We can conclude that there is a slow acceptance of conservation and zero tillage despite their potential to improve the sustainability of agricultural production.

Table 1. Comparative presentation of arable land and types of land cultivation by agricultural holding in EU countries (2016-2023) and Serbia (2012-2023) (ha)

Territory	Arable land per holding		Conventional tillage per holding		Conservation tillage per holding		Zero tillage per holding	
	2016	2023	2016	2023	2016	2023	2016	2023
European Union (27 countries)	20.2	-	15.5	-	32.9	-	7.8	-
Belgium	26.5	-	24.7	-	16.3	-	8.4	-
Bulgaria	49.0	77.9	34.1	49.9	53.1	67.2	53.9	207.7
Czechia	146.8	122.0	105.3	88.7	224.6	169.2	46.4	60.0
Denmark	73.2	-	67.4	-	81.0	-	40.9	-
Germany	56.1	65.2	34.5	32.3	62.0	62.4	18.7	28.4
Estonia	83.0	99.0	46.4	45.4	106.7	135.6	108.6	66.3
Ireland	23.3	-	31.2	-	30.9	-	26.0	-
Greece	6.8	7.5	7.2	7.8	3.1	4.4	1.9	2.9
Spain	28.3	33.0	26.9	27.1	20.5	23.9	24.0	33.0
France	59.0	63.3	37.4	40.5	45.9	55.6	34.3	28.0
Croatia	10.0	11.3	9.4	9.6	16.0	25.9	3.3	7.7
Italy	11.1	-	10.8	-	14.2	-	4.4	-
Cyprus	6.9	11.0	7.3	12.3	5.1	2.7	45.6	-
Latvia	31.4	-	22.9	-	106.7	-	47.5	-
Lithuania	21.1	28.1	18.4	13.4	49.4	51.9	16.3	49.1
Luxembourg	45.9	46.4	26.1	23.8	26.0	30.5	7.6	16.1
Hungary	29.2	35.2	26.9	26.3	89.4	39.3	9.6	4.3
Malta	2.1	2.1	2.1	2.0	-	-	-	-
Netherlands	24.6	27.5	20.0	20.3	16.1	18.9	5.0	7.5
Austria	20.6	23.0	13.3	13.7	22.1	25.4	8.6	6.9
Poland	11.1	13.0	10.5	10.3	29.5	11.0	33.7	28.1
Portugal	7.4	7.0	3.6	3.7	15.9	12.6	19.5	17.5
Romania	7.0	10.0	5.8	8.8	8.0	19.2	2.2	4.5
Slovenia	2.1	-	1.7	-	2.9	-	-	-
Slovakia	92.0	111.1	72.5	73.4	184.0	192.4	149.5	108.8
Finland	45.1	-	21.4	-	23.2	-	23.6	-
Sweden	42.4	46.9	32.6	44.2	37.2	18.8	19.5	8.5
Norway	20.9	-	14.9	-	11.3	-	14.6	-
Switzerland	13.5	-	6.9	-	6.2	-	3.1	-
United Kingdom	70.1	-	57.3	-	92.7	-	50.9	-
Serbia*	4.1	5.3	4.1	5.3	4.6	8.6	1.6	2.1

Source: Author's calculation based on EUROSTAT (2025) and SORS data (2025), electronic database, Census of Agriculture for 2012 and 2023; Note: the symbol “-“ means that some data are not available for calculation, so there is no calculated value; *The data for Serbia refer to the years 2012 and 2023 because they are available for those years, and given that they are also census years.

MATERIALS AND METHODS

The paper presents the results of research according to the representation of soil cultivation systems in the European Union and European countries during 2016 and 2023, as well as in Serbia during 2012 and 2023.

The original part of the research consists of an economic evaluation of wheat production in the system of conventional and zero tillage. The data were obtained upon request from the „Tamiš“ Research and Development Institute Pančevo, Serbia, and for the purposes of making analytical calculations in wheat production with both production systems.

Realized income, agrotechnical operations and costs relate exclusively to wheat production in the system of conventional and zero tillage and may not be the same for other crops and production. The analysis was performed at the level of one production cycle (agro-economic year 2024/2025), on an area of 1 ha of arable land and is expressed in RSD.

In the preparation of the analytical calculation, certain costs were not taken into consideration, namely: the cost of purchasing the necessary machinery for the implementation of certain agrotechnical operations because the service engagement of this equipment was paid for; depreciation of existing equipment because due to their average age we believe that it does not affect the gross coverage margin; labor cost due to the fact that seasonal labor was not hired.

The data analysis is based on the Institute's internal information, primarily when it comes to the purchase prices of seeds, pesticides, fertilizers, the costs of maintaining machines and transporting wheat to warehouses. Data on the price of fuel (euro diesel) and paid mechanization services were taken from the Price List of Machinery Services in Agriculture 2024, published by the Cooperative Union of Vojvodina. These prices per unit of measure are shown without value added tax (VAT). Data on the purchase price of wheat in 2025 was taken from the website of the Novi Sad Comodity Exchange in the period 07.07 - 07.11.2025. year. Wheat yield represents the actual state of the finished agro-economic year.

The applied methodology should also be taken into account when making the analytical calculation. Total income is the product of the realized yield and the purchase price at a given time. The total variable costs were calculated based on the actual activities in the wheat production process in the system of conventional and zero tillage, namely:

- cost of wheat seeds;
- the type of fertilizers used is the same in wheat production for both tillage systems, but it was applied in different quantities. More precisely, NPK 10:46:0 was applied in the amount of 200 kg/ha and AN in the amount of 250 kg/ha in conventional wheat processing. The use of these fertilizers in the production of wheat in the zero tillage system was reduced by 50%;
- the type of pesticides used is the same in both wheat production systems, namely: Metmark, Lodin, Olimp, tetar plus, Unify, Grom and Polux;
- fuel costs are lower in wheat production in the system of zero tillage due to a significantly lower number of agrotechnical operations;
- the costs of agrotechnical operations are lower in wheat production in the system of zero tillage due to the reduced number of machine operations (sowing and harvesting costs).
- other variable costs (costs of maintaining machines and transporting wheat to the warehouse) occurred in both wheat production systems and are of the same value;

– the costs of cover crops in the production of wheat in the system of zero tillage are not shown, considering that vegetation is provided on the arable surface throughout the year.

After analyzing the analytical calculation, we moved on to the analysis of the critical values of wheat production in the system of conventional and zero tillage according to the following equations (equations 1, 2 and 3):

$$CP = \frac{VC-S}{EY}\ (1),\ CY = \frac{VC-S}{EP}\ (2),\ CVC = (EY * EP) + S\ (3)$$

where is: *CP* - critical price, *VC* - variable costs, *S* - subsidies, *EY* - expected yield, *CY* - critical yield, *EP* - expected price, *CVC* - critical variable costs.

The analysis of the analytical calculation of wheat production in both production systems continued with the assessment of the sensitivity of the gross margin in wheat production depending on the change in yield (t/ha) and purchase price (RSD/t), and in accordance with the obtained results, an adequate comment was given.

Finally, the efficiency coefficient of wheat production in the system of conventional and zero tillage was calculated according to the following equation (4):

$$\textit{Coefficient of economic of production (Cep)} = \frac{Production\ value}{Total\ costs} \qquad (4)$$

All tables and comments retain the presentation of data in the national currency (RSD). This part shows the average exchange rate of the Serbian dinar against the euro (1 EUR = 117.1666 RSD) on the reference date (July 11, 2025) in order to enable comparison and interpretation of values ().

The research used the method of descriptive statistics, analysis of quantitative indicators, as well as induction and deduction in drawing conclusions.

RESULTS AND DISCUSSION

In this part of the paper, indicators of the economic sustainability of conventional and zero tillage in wheat production will be presented based on the experiment set up on the experimental field of the „Tamiš“ Research and Development Institute Pančevo, Serbia. Given that agricultural production consists of many factors, it is necessary to take into account the value and costs of production for the assessment of economic results (Subić et al., 2023).

Economic Assessment of Wheat Production in the System of Conventional Tillage

According to the previously defined methodology, we moved on to the analysis of the economic assessment of wheat production in the system of conventional tillage. Accordingly, Table 2 shows the calculation of the gross margin of wheat production per 1 ha.

Table 2. Calculation of the gross margin of wheat production per 1 ha of arable land in the system of conventional tillage

Category	Value (RSD/ha)
I Total income	**148,000**
II Variable costs	**91,326**
Seeds	9,900
Fertilizer	26,288
Pesticides	6,598
Diesel fuel	6,060
Paid services by machinery	37,160
Other variable costs	5,320
III Gross margin	**56,674**

Source: author's calculation based on the Institute's internal data

The total estimated variable costs of RSD 91,326/ha actually make up more than half of the total income (61.7%), which is why it is considered insufficient and economically justified. Certainly, the highest cost value is the expenditure for paid services by mechanization, then for fertilizer, and together they make up close to 70% of the total variable costs in the production of wheat in the system of conventional tillage.

The value of the gross margin of RSD 56,674/ha shows us the low level of profitability of wheat production, and this result may indicate the necessary optimization of certain inputs in those segments where there are opportunities for greater savings or efficiency.

In the continuation of the analysis, a tabular overview of the critical values of wheat production in the conventional production system was given, and the parameter values were calculated based on the equation presented in the methodological part of the paper.

Table 3. Critical values of yield and price of wheat in the system of conventional tillage on an area of 1 ha

Category	EY, t/ha	EP, RSD/t	S, RSD	VC, RSD/ha	CP, RSD/t	CY, t/ha	CVC, RSD/ha
Value	6.5	20,000.0	18,000.0	91,326.0	11,280.0	3.7	148,000.0

Source: author's calculation based on the Institute's internal data

In order to achieve a neutral coverage margin, the purchase price of wheat must not be less than RSD 11,280.9/t, the yield minimum 3.7 t/ha, and the total variable costs must not exceed the total income (RSD 148,000/ha).

The next table (Table 4) shows the sensitivity analysis of the gross margin in wheat production in the system of conventional tillage depending on the change in yield (t/ha) and purchase price (RSD/t). Deviations from expected values for both parameters of ±10% and ±20% were applied.

Table 4. Sensitivity analysis of the gross margin in wheat production in the system of conventional tillage on an area of 1 ha

Price change		**Price (RSD/t)**				
Yield change		**-20%**	**-10%**	**Realized**	**+10%**	**+20%**
Yield (t/ha)		**16,000.0**	**18,000.0**	**20,000.0**	**22,000.0**	**24,000.0**
-20%	**5.2**	9,874	20,274	30,674	41,074	51,474
-10%	**5.9**	20,274	31,974	43,674	55,374	67,074
Realized	**6.5**	30,674	43,674	**56,674**	69,674	82,674
+10%	**7.2**	41,074	55,374	69,674	83,974	98,274
+20%	**7.8**	51,474	67,074	82,674	98,274	113,874

Source: author's calculation based on the Institute's internal data

The results clearly indicate that the total income from production depends on the value of yield and prices. In this example, we see that in the case of a 20% increase in yield and price, the income per hectare is RSD 113,874, which is more than double compared to the situation where both parameters are lower by 20% (RSD 9,874/ha).

In general, any positive change in one of the variables leads to a proportional increase in income, while negative changes, especially if they occur simultaneously, significantly reduce the financial result. Such results emphasize the importance of risk management strategies in agricultural production, both in terms of yield stabilization (eg through agrotechnical measures) and in terms of protection against market fluctuations (eg through contractual sales or insurance).

Based on the obtained values in the calculation of the gross margin of wheat production in the conventional production system, we can also determine the efficiency coefficient of wheat production, and the equation for the calculation is presented in the methodological part of the paper. In our case, the coefficient of economy of production is 1.6 and shows that for every RSD of expenses, 1.6 RSD of income was realized.

Economic Assessment of Wheat Production in the Zero-Tillage System

According to the previously defined methodology, we moved on to the analysis of the economic evaluation of wheat production in the system of zero tillage, and Table 5 shows the calculation of the gross margin of wheat production on an area of 1 ha.

Table 5. Calculation of the gross margin of wheat production on the surface of 1 ha of arable land

Category	**Value (RSD/ha)**
I Total income	**187,000**
II Variable costs	**54,102**
Seeds	9,900
Fertilizer	13,144
Pesticides	6,598
Diesel fuel	3,030
Paid services by machinery	16,110
Other variable costs	5,320
III Gross margin	**132,898**

Source: author's calculation based on the Institute's internal data

Total variable costs estimated at RSD 54,102/ha make up about 29% of the realized income. The largest share in the structure of variable costs is provided by machinery (29.8%) and fertilizer (24.3%). These two costs together make up 54.1% of the total variable costs in wheat production.

Table 6 shows the critical values of wheat production in the no-tillage system based on the previously set formula.

Table 6. Critical values of yield and price of wheat in the production system without tillage on the surface of 1 ha of arable land

Category	EY, t/ha	EP, RSD/t	S, RSD	VC, RSD/ha	CP, RSD/t	CY, t/ha	CVC, RSD/ha
Value	8.5	20,000.0	18,000.0	54,102.0	4,272.4	1.8	187,000.0

Source: author's calculation based on the Institute's internal data

In order to achieve a neutral coverage margin, the purchase price of wheat must not be less than 4,272.4 RSD/t, the yield at least 1.8 t/ha, and the total variable costs must not exceed the value of the total income (187,000 RSD/ha).

Table 7 shows the sensitivity analysis of the gross margin in wheat production in the no-tillage system depending on the change in yield (t/ha) and purchase price (RSD/t).

Table 7. Sensitivity analysis of the results of gross margin calculation in wheat production in a system without wheat cultivation on an area of 1 ha

Price change		**Price (RSD/t)**				
Yield change		**-20%**	**-10%**	**Realized**	**+10%**	**+20%**
Yield (t/ha)		**16,000.0**	**18,000.0**	**20,000.0**	**22,000.0**	**24,000.0**
-20%	**6.8**	72,058	85,578	99,098	112,618	126,138
-10%	**7.6**	85,578	100,788	115,998	131,208	146,418
Realized	**8.5**	99,098	115,998	**132,898**	149,798	166,698
+10%	**9.3**	112,618	131,208	149,798	168,388	186,978
+20%	**10.1**	126,138	146,418	166,698	186,978	207,258

Source: author's calculation based on the Institute's internal data

Even in the most unfavorable scenario (price and yield drop by 20%), the gross margin remains positive (RSD 72,058/ha), which shows the resistance of wheat production in the zero tillage system to market changes. Any increase in yield and/or price significantly increases the coverage margin, where it can be up to 1.6 times higher in the case of a 20% increase in yield and price compared to the achieved gross coverage margin.

In the end, we determined the efficiency coefficient of wheat production, which in the system without tillage is 3.5. The economy of production showed us that for every RSD of costs, 3.5 RSD of income was realized. This model provides a more sustainable basis for planning wheat production, especially in the face of an uncertain market and rising input costs.

Overall, no-till wheat production provides a different and more rational approach to inputs than conventional no-till wheat production. Also, there are obvious savings in the costs of mechanization, fertilizers and fuel, which contributes to the economic sustainability of production.

CONCLUSION

A review of relevant domestic and foreign research confirms that, although conventional tillage is still dominantly applied in many countries, a gradual but continuous shift towards alternative land tillage systems, primarily reduced and zero tillage, is observed, especially in conditions of rising input costs.

Overall, the research results confirm that zero tillage represents a more economically viable and stable wheat production system compared to conventional tillage, especially in the face of rising input costs and market uncertainty. In addition to its cost-reducing effects, zero tillage contributes to greater production efficiency and improves the resilience of farming systems, which is particularly important in conditions of increasing price volatility of agricultural inputs and growing climate-related risks.

However, the scope of this research also opens several directions for future studies. Further research could expand the analysis to include a longer time horizon and a larger sample of farms, as well as other crop types, in order to assess the long-term economic and environmental effects of different tillage systems. Moreover, integrating indicators of soil quality, carbon sequestration, and yield stability would enable a more comprehensive evaluation of the sustainability of zero tillage systems. Future studies could also apply advanced econometric methods or panel data analysis to better capture regional heterogeneity and the dynamic effects of technology adoption in agricultural production.

From a policy perspective, the findings of this study provide important implications for decision-makers in the agricultural sector. The demonstrated economic advantages of zero tillage suggest that public policies should further encourage the adoption of conservation tillage practices through targeted subsidies, investment support for appropriate machinery, and advisory services aimed at knowledge transfer. In countries such as Serbia, where farm size remains relatively small, tailored policy measures could play a crucial role in reducing financial barriers to adoption and supporting farmers during the transition period. Additionally, incorporating zero tillage into agri-environmental and rural development programs could contribute not only to improved farm profitability but also to broader environmental and sustainability objectives.

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