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Impact of Soil Tillage Systems on Maize Productivity, Mechanization Efficiency and Economic Performance under Irrigated Conditions in South-Eastern Romania

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ABSTRACT

This study evaluated the agronomic, mechanization and economic performance of maize cultivated under three soil tillage systems: conventional tillage, minimum tillage and no-tillage, under irrigated conditions in south-eastern Romania during the 2024–2025 agricultural year. The experiment was conducted on a carbonatic chernozem soil in the Poarta Albă area and involved two maize hybrids, DKC 6897 and DKC 5812, arranged in a randomized block design with farm-scale plots. Agronomic assessments included morphological traits and grain yield, while mechanization performance was evaluated through fuel consumption, number of field operations and working time per hectare. Economic analysis was based on production costs, revenues, gross profit and profitability. Climatic conditions during the study period were characterized by thermal extremes, late spring frost events and uneven precipitation distribution, highlighting the importance of irrigation and adaptive soil management.The results showed that conventional tillage ensured the highest grain yields, particularly for hybrid DKC 6897, but at the expense of increased fuel consumption and higher production costs. Minimum tillage provided a balanced compromise between yield performance and reduced operational inputs, resulting in consistently high profitability for both hybrids. Although no-tillage systems produced lower yields, their reduced mechanization intensity and lower costs led to competitive profitability levels. The findings indicate that minimum tillage represents a sustainable and economically viable alternative to conventional soil management for irrigated maize production under variable climatic conditions. Long-term studies are recommended to further assess the cumulative effects of conservation tillage systems on yield stability, soil quality and farm-level economic resilience.

1. Introduction

Maize (*Zea mays* L.) is one of the most important arable crops worldwide, playing a central role in food security, animal feed and industrial processing. Owing to its high yield potential, wide adaptability and versatility of use, maize cultivation holds strategic importance at both European and national levels. Nevertheless, contemporary maize production systems are increasingly confronted with multiple challenges, including climate variability, rising input prices, labour shortages and growing pressure on soil and water resources. These constraints require production systems that are not only agronomically

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productive but also economically efficient and environmentally sustainable, particularly in regions characterised by intensive crop management practices.

In Romania, especially in the south-eastern region, maize represents a key component of crop rotations under semi-arid climatic conditions, where irrigation plays a critical role in stabilising yields. Prolonged drought periods, uneven precipitation distribution and increasing mechanisation and energy costs significantly influence both productivity and farm profitability. Under these circumstances, soil tillage systems and mechanisation strategies become decisive factors affecting yield performance, fuel consumption, labour requirements and overall economic outcomes at farm level. While conventional tillage has traditionally been associated with high and stable yields, alternative systems such as minimum tillage and no-tillage are increasingly considered for their potential to reduce operational intensity and production costs. In this context, the present study aims to evaluate the agronomic and economic performance of different soil tillage systems applied to maize cultivation under irrigated conditions during the 2024–2025 agricultural year in south-eastern Romania, focusing on yield performance, mechanisation efficiency, production costs and profitability, and providing practical insights to support sustainable soil management decisions at farm level.

2. Literature review

Maize (*Zea mays* L.) has been extensively studied due to its global importance as a staple crop for food, feed, and industrial uses, as well as its sensitivity to management practices and climatic variability. Numerous studies highlight that maize productivity is strongly influenced by soil tillage systems, hybrid selection, water availability, and the efficiency of mechanization technologies applied at farm level (Cristea et al., 2004; Erenstein et al., 2022).

Research conducted in Romania has consistently emphasized the relationship between maize yield components and biomass accumulation, showing that grain yield is closely correlated with dry matter production and morphological traits, which are themselves affected by soil management and environmental conditions (Bășa et al., 2013; Bășa et al., 2015). Climatic constraints, particularly drought stress and water deficit, represent major limiting factors in the Dobrogea region, where several studies have demonstrated significant yield reductions associated with prolonged dry periods and high temperatures (Prăvălie et al., 2014; Barna & Mănescu, 2025).

Soil tillage practices play a crucial role in determining maize growth, soil physical properties, and resource use efficiency. Conventional tillage has traditionally been associated with improved soil loosening and early crop development, but it often leads to higher fuel consumption, increased labour demand, and greater risks of soil degradation (Díaz-Zorita, 2000; Sessiz et al., 2010). In contrast, conservation tillage systems, including minimum tillage and no-tillage, have been increasingly promoted as sustainable alternatives due to their potential to reduce energy inputs, preserve soil structure, and enhance water retention (Rusu, 2014; Liu et al., 2022).

Several international studies have reported that minimum tillage and no-tillage systems can maintain or even improve maize yields under certain conditions, particularly when combined with appropriate fertilization strategies and hybrid selection (Rashidi & Keshavarzpour, 2007; Anjum et al., 2019; Wakwoya et al., 2022). Long-term experiments further indicate that conservation tillage contributes to improved soil physical properties and nutrient balance, which can support stable productivity over time (Santos et al., 2024; Weidhuner et al., 2026; Long et al., 2026).

In Romania, recent research has focused on evaluating conservation tillage systems as both agronomic and economic alternatives for sustainable maize production. Dinuță and Marin (2023) demonstrated that reduced tillage can lower production costs while maintaining competitive yields, especially under irrigated conditions. Similar conclusions were drawn by Stroe and Panaitescu (2025), who reported that the transition from conventional to minimum tillage systems resulted in improved mechanization efficiency and reduced energy consumption in maize cultivation.

Hybrid performance under different tillage systems has also been extensively investigated. Studies conducted in southern and south-eastern Romania reveal that maize hybrids exhibit distinct responses to soil management practices, drought stress, and climatic variability, affecting biomass accumulation, chlorophyll content, and yield stability (Călugăr et al., 2024; Kirchev, 2025; Stoian et al., 2025). These findings underline the importance of selecting hybrids adapted to conservation tillage systems and local agro-ecological conditions.

From an economic perspective, rising fuel prices, labour shortages and increasing input costs have intensified the need for cultivation systems that optimise mechanisation efficiency and resource use. Consequently, recent studies increasingly emphasise the integration of agronomic performance with economic indicators, such as fuel consumption, labour input, production costs and profitability, when assessing the suitability of different soil tillage systems (Rusu, 2014; Stanciu, 2024). Comparative analyses combining yield performance with mechanisation and financial indicators are therefore essential for supporting farm-level decision-making, especially in regions exposed to climatic stress (Santos et al., 2024; Stroe & Panaitescu, 2025).

Water management and irrigation represent additional key factors influencing maize productivity, particularly in regions affected by irregular rainfall. Research on drip irrigation and water-use efficiency in Eastern Romania has shown that optimized irrigation strategies can significantly enhance grain yield and resource efficiency (Nițu et al., 2024). At the same time, weed and pest management practices remain essential components of integrated maize production systems, with several studies highlighting the effectiveness of modern herbicides and crop rotation in reducing pest pressure and yield losses (Liu et al., 2022; Botoș, 2025; Nigussie, 2025).

In addition to soil tillage and water management, technological inputs and crop protection practices play a significant role in determining maize productivity and economic performance. Agrotechnical measures, including soil preparation, fertilisation strategies and crop maintenance operations, strongly influence crop establishment and yield stability (Dobre, 2019). Effective weed control remains essential, particularly during early growth stages, as weed competition can significantly reduce yield potential. Studies conducted under Romanian conditions highlight the importance of appropriate herbicide application before germination and during early vegetation stages to limit weed pressure and ensure optimal crop development (Yanev, 2023). Furthermore, integrated crop management approaches combining crop rotation and modern protection practices contribute to reducing pest incidence and improving production efficiency (Georgescu et al., 2014).

Beyond agronomic performance, recent literature increasingly emphasizes the economic and energetic dimensions of maize cultivation systems. Mechanization efficiency, fuel consumption, labour input, and production costs are decisive factors influencing farm profitability and decision-making processes (Rusu, 2014; Stanciu, 2024). Studies addressing Agriculture 4.0 and precision farming further highlight the potential of modern technologies and data-driven approaches to improve economic performance and sustainability in agricultural systems (Micle et al., 2024).

Beyond grain yield and production efficiency, maize cultivation is also evaluated in relation to biomass utilisation, nutritional quality and its role within integrated agri-food systems. Research focusing on the nutritional composition of maize cultivars highlights significant variation in bioactive compounds, influenced by hybrid selection and cultivation practices (Popoviciu et al., 2024). In addition, maize biomass represents an important feed resource in livestock systems, with studies showing that hybrid choice and management practices affect energy and protein feeding value in ruminant nutrition (Stoyanova & Ganchev, 2024). Recent experimental research further indicates that combining tillage management practices with plant growth regulators can improve root development, lodging resistance and overall maize productivity under semi-arid conditions, contributing to more resilient production systems (Zhang et al., 2026).

The reviewed literature indicates that while conservation tillage systems may involve certain agronomic challenges, particularly during the initial years of implementation, they offer significant advantages in terms of energy efficiency, cost reduction, and environmental sustainability. However, results remain highly context-dependent, influenced by climatic conditions, soil characteristics, irrigation availability, and hybrid selection. This variability underlines the need for farm-level case studies that integrate agronomic and economic analyses to support informed decision-making in maize production systems, particularly in regions exposed to climatic stress such as south-eastern Romania.

3. Materials and Methods

The study was conducted during the 2024–2025 agricultural year in the south-eastern part of Romania, in the Poarta Albă area (Constanța County), a region representative for maize cultivation under semi-arid climatic conditions. The area is characterized by fertile soils and increasing climatic variability, which makes it suitable for evaluating the agronomic and economic performance of different soil tillage systems.

The experimental field was located on carbonate chernozem soil, typical for the Dobrogea region, known for its good natural fertility, favourable physical structure, and suitability for arable crops such as maize. However, the soil is also sensitive to water stress, especially during prolonged drought periods, which justifies the use of irrigation in maize cultivation.

The experiment was designed as a bifactorial field trial, arranged in a randomized block design, with two experimental factors: factor A – maize hybrid, with two levels; factor B – soil tillage system, with three levels: conventional tillage, minimum tillage, and no-tillage. Each experimental variant covered an area of 5 hectares and was further divided into separate sub-plots used as operational replications, arranged in a randomized block design. Data analysis was performed using the average values recorded across these sub-plots. This approach ensured the reliability and reproducibility of the recorded agronomic, mechanization, and economic indicators under farm-level conditions. The relatively large plot size reflects a farm-level experimental approach, allowing a realistic assessment of mechanization efficiency, fuel consumption, labour input, and economic performance.

Maize cultivation was carried out under irrigated conditions, ensuring an adequate water supply throughout the growing season and reducing the influence of rainfall variability on crop performance. To isolate the effect of the soil tillage system, all other technological elements were kept constant across the entire experimental area, including crop rotation, fertilization rates, sowing date, planting density, row spacing, plant protection treatments, and harvesting operations. Both maize hybrids used in the experiment were adapted to irrigated conditions and intensive cultivation systems. The same agronomic practices were applied uniformly to all variants to ensure comparability of results and to attribute observed differences primarily to the tillage systems and their interaction with hybrid performance.

For each of the six experimental variants (two maize hybrids × three tillage systems), mechanization-related parameters were systematically monitored throughout the agricultural cycle. These included specific fuel consumption (l ha^{-1}) recorded for each agricultural operation, effective working time (h ha^{-1}) for each technological variant, and the number of field passes performed on each plot, highlighting the differences among the three tillage systems. Working time was monitored using GPS-based systems installed on the agricultural machinery.

The quality of field operations was also assessed, focusing on sowing accuracy, uniformity of crop emergence, and compliance with the target sowing depth. Field data were collected during operations with the support of machinery operators, using daily work logs that were completed in the field and digitally archived. Fuel consumption data were verified at refuelling and cross-checked with GPS records from tractors, sprayers, and harvesting machinery to ensure data accuracy. In parallel, biometric and yield-related measurements were carried out for each experimental variant, including average plant height, ear insertion height (relevant for combine harvester adjustment), ear length and average ear weight, actual plant density at harvest (plants ha^{-1}), final grain yield, and thousand-kernel weight. All experimental data were statistically processed and summarized in comparative tables, allowing a clear evaluation of the performance of each tillage system in relation to the maize hybrid used. This integrated approach enabled a realistic assessment of the impact of mechanization on productivity, energy efficiency, and economic performance under the specific conditions of the study area.

Data collection focused on agronomic, mechanization, and economic indicators. Agronomic parameters included grain yield at harvest and yield components, while mechanization indicators comprised specific fuel consumption, number of field operations, and effective working time per hectare. The economic evaluation was based on production costs, revenues, gross profit, and profitability for each experimental variant. The collected data were comparatively analysed to assess the performance of each tillage system and maize hybrid combination under the specific conditions of the study area.

4. Results

During the 2024–2025 agricultural year, the climatic regime in the Poarta Albă area deviated from the multiannual averages in terms of both temperature and precipitation. Total precipitation amounted to approximately 396.2 mm, about 40 mm below the multiannual average (436 mm), indicating a moderate water deficit.

Autumn and winter were generally mild, with average temperatures in December 2024 (4.7°C) and January 2025 (5.3°C) exceeding the long-term means. In contrast, February 2025 was colder than normal, recording an average temperature of 0.2°C and an absolute minimum of −13.6°C. Spring was characterized by pronounced thermal instability. March 2025 showed early warming, with an average temperature of 9.8°C, more than double the multiannual average, followed by late spring frost events in mid-April, when minimum temperatures dropped to approximately −11°C, posing a risk during maize emergence. Summer months were warmer than normal, with June and July 2025 recording average temperatures of 24.3°C and 27.6°C, respectively, and an absolute maximum of 39.9°C in July. Precipitation distribution during the growing season was highly uneven, with severe deficits in winter–spring and an extreme shortage in June (0.2 mm vs. 53.2 mm normal). Conversely, October 2025 registered 85 mm of rainfall, almost three times the multiannual average, occurring mainly during harvest. The 2024–2025 agricultural year was marked by thermal extremes, late spring frosts and irregular precipitation, emphasizing the importance of irrigation and adaptive soil tillage practices for ensuring stable maize production under south-eastern Romanian conditions. The monthly dynamics of air temperature and precipitation recorded during the 2024–2025 agricultural year in the Poarta Albă area are illustrated in Figure 1.

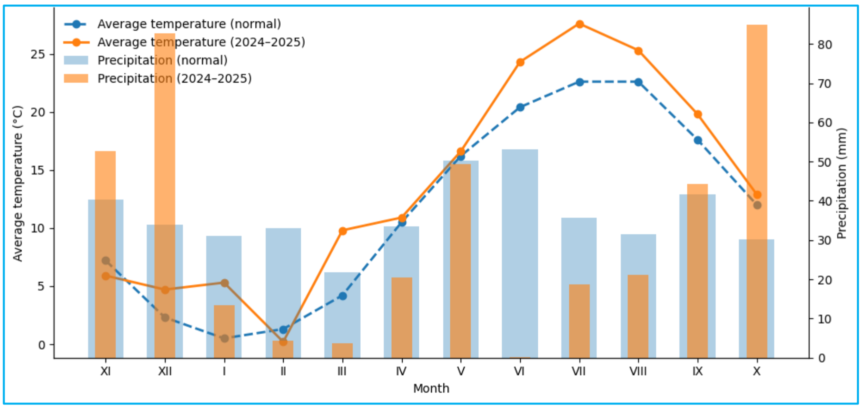

Figure 1. Monthly temperature and precipitation dynamics during the 2024–2025 agricultural year in Poarta Albă

Source: Meteorological data recorded at the farm weather station, authors' own processing.

Figure 2 illustrates two key grain productivity indicators, namely thousand-kernel weight and average kernel weight per ear, for the two maize hybrids evaluated under the three soil tillage systems. Hybrid DKC 6897 recorded the highest thousand-kernel weight under conventional tillage (442.07 g), followed by minimum tillage (425.35 g) and no-tillage (408.02 g). Average kernel weight per ear showed the same decreasing pattern across the tillage systems for this hybrid. In contrast, hybrid DKC 5812 achieved the highest thousand-kernel weight under minimum tillage (433.11 g), compared to conventional tillage (410.29 g) and no-tillage (392.69 g). The highest average kernel weight per ear for this hybrid was also recorded under minimum tillage (242.68 g). For both hybrids, the lowest values for the analysed grain indicators were observed under no-tillage conditions.

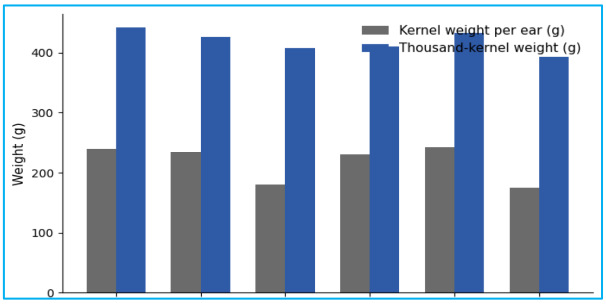

Figure 2. Comparison between kernel weight per ear and thousand-kernel weight of maize hybrids under different soil tillage systems (2025).

Source: Experimental data obtained through laboratory determinations conducted by the authors.

Figure 3 presents a comparative analysis of grain yield, expressed in kg/ha, for each combination of soil tillage system and maize hybrid. Hybrid DKC 6897 recorded the highest grain yields across all three tillage systems. Under conventional tillage, yield reached 11,430 kg/ha, followed by 10,780 kg/ha under minimum tillage and 10,300 kg/ha under no-tillage. For hybrid DKC 5812, the highest grain yield was obtained under minimum tillage (10,730 kg/ha), followed by conventional tillage (10,130 kg/ha), while the lowest yield was recorded under no-tillage (9,254 kg/ha). The results indicate clear yield differences among the analyzed tillage system–hybrid combinations. These results suggest that yield response to soil tillage systems is strongly hybrid-dependent, with minimum tillage providing favourable conditions for maintaining high productivity under irrigated conditions. The observed differences also reflect the interaction between soil disturbance intensity and hybrid adaptability, highlighting the importance of selecting appropriate soil management strategies for optimising maize yield at farm level.

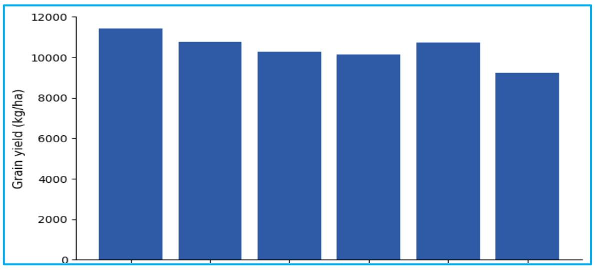

Figure 3. Maize grain yield per hectare as affected by soil tillage system and hybrid (2025)

Source: Experimental field data and yield calculations performed by the authors.

The performance of agricultural machinery plays an important role in the efficiency of soil tillage technologies applied to maize cultivation. Figure 4 presents the relationship between soil tillage system, fuel consumption per hectare and number of field operations. Under the conventional tillage system, fuel consumption reached approximately 125 l/ha, associated with a total of 8 field operations. The minimum tillage system reduced fuel consumption to about 105 l/ha, while the number of field operations decreased to 7. The no-tillage system recorded the lowest fuel consumption, approximately 90 l/ha, with only 6 field operations performed. The results indicate clear differences in mechanisation requirements among the analysed tillage systems, expressed through fuel use and operational intensity. This reduction in fuel consumption and number of field operations reflects the lower operational complexity of conservation tillage systems, which can contribute to improved mechanisation efficiency at farm level.

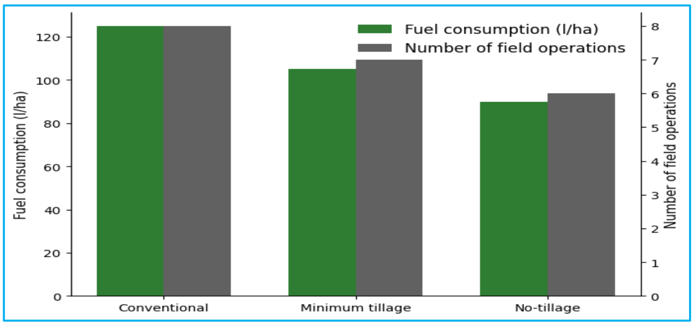

Figure 4. Fuel consumption and number of field operations under different soil tillage systems (2025).

Source: Experimental farm data based on field operation records and authors' calculations.

The total working time required for maize cultivation varied significantly depending on the soil tillage system, being closely related to the number of field operations performed. Under the conventional tillage system, which involved eight field passes, the total working time reached approximately 9.6 hours per hectare, reflecting the intensive mechanization and repeated soil disturbance. Minimum tillage reduced the total working time to 7.7 hours per hectare by eliminating deep soil preparation, while maintaining operational efficiency. The no-tillage system recorded the lowest working time, approximately 6.0 hours per hectare, due to the complete elimination of soil preparation operations. When expressed relative to grain production, mechanization efficiency was lowest under conventional tillage (0.59 h per 1000 kg) and highest under no-tillage (0.47 h per 1000 kg), with minimum tillage showing intermediate values. These results highlight the advantages of conservation tillage systems in terms of labour efficiency and operational optimization under farm-level conditions.

Maize revenues were calculated based on the average grain yield per hectare and the market price recorded in 2024, estimated at 1.10 RON/kg for bulk grain delivered to a cereal purchasing centre in the Port of Constanța. In addition to grain sales, a direct area-based subsidy was included, calculated as an average value of 200 EUR/ha (approximately 1,000 RON/ha), applied uniformly across all experimental variants. As shown in Table 1, the highest gross revenues were recorded under the conventional tillage system, particularly for hybrid DKC 6897, due to higher grain yields. Minimum tillage generated slightly lower but relatively balanced revenues for both hybrids, while no-tillage resulted in the lowest gross revenues, reflecting reduced yield levels. However, the economic performance of each system must be interpreted in relation to total production costs, which are addressed in the following section.

Table 1. Grain sales revenues and total revenues of maize hybrids under different soil tillage systems (2024–2025)

Soil tillage system	Hybrid	Grain yield (kg/ha)	Grain price (RON/kg)	Sales revenue (RON/ha)	Direct payment (RON/ha)	Total revenue (RON/ha)
Conventional	DKC 6897	11,430	1.10	12,573	1,000	13,573
Conventional	DKC 5812	10,130	1.10	11,143	1,000	12,143
Minimum tillage	DKC 6897	10,780	1.10	11,858	1,000	12,858
Minimum tillage	DKC 5812	10,730	1.10	11,803	1,000	12,803
No-tillage	DKC 6897	10,300	1.10	11,330	1,000	12,330
No-tillage	DKC 5812	9,254	1.10	10,179	1,000	11,179

Source: Experimental field data, farm price records, and economic calculations performed by the authors

Table 2 illustrates the relationship between production costs, gross profit and profitability across the evaluated soil tillage systems. Profitability was calculated as the ratio between gross profit and total production costs, expressed as a percentage. The results indicate that, although the conventional tillage system generated the highest gross profit for hybrid DKC 6897, its profitability ratio was lower compared to conservation tillage systems due to higher expenditures related to fuel consumption, labour requirements and machinery depreciation. The minimum tillage system showed a more balanced economic performance, benefiting from both reduced production costs and relatively high grain yields for both hybrids, which supports its viability under similar agro-economic conditions. In contrast, the no-tillage system, despite generating lower absolute profits, achieved comparatively high profitability levels due to minimal operational and mechanization costs. These findings confirm that economic performance is not exclusively determined by yield level, but also by the efficiency of resource use. Conservation tillage systems may therefore represent strategic options for farms aiming to optimize production costs and enhance long-term economic sustainability.

Table 2. Production costs, gross profit and profitability per hectare under different soil tillage systems (2024–2025)

Soil tillage system	Hybrid	Total revenue (RON/ha)	Total production costs (RON/ha)	Gross profit (RON/ha)	Profitability (%)
Conventional	DKC 6897	13,573	6,825	6,748	98.87
Conventional	DKC 5812	12,143	6,825	5,318	77.91
Minimum tillage	DKC 6897	12,858	6,525	6,333	97.05
Minimum tillage	DKC 5812	12,803	6,525	6,278	96.21
No-tillage	DKC 6897	12,330	6,210	6,120	98.55
No-tillage	DKC 5812	11,179	6,210	4,969	80.01

Source: Experimental production and operational data, farm price records, and economic calculations performed by the authors.

The profitability analysis highlights clear differences among the evaluated soil tillage systems and hybrid combinations. Despite lower grain yields, the no-tillage system achieved profitability levels comparable to, or even higher than, the conventional system, primarily due to reduced production costs. The minimum tillage system showed the most balanced economic performance, combining moderate production costs with high yield levels for both hybrids, resulting in consistently high profitability values. In contrast, although the conventional tillage system generated some of the highest gross revenues, its profitability was reduced by higher expenditures related to fuel consumption, labour input and machinery depreciation. These results confirm that economic efficiency is not solely determined by yield performance, but also by cost structure and resource-use efficiency, supporting conservation tillage systems as economically viable options under farm-level conditions.

4. Discussion

The results of the present study highlight the complex interaction between soil tillage system, hybrid performance, mechanization efficiency and economic outcomes under irrigated conditions in south-eastern Romania. The agronomic responses observed confirm that both soil management strategy and genetic material play a decisive role in determining maize productivity and resource-use efficiency.

Grain yield differences among tillage systems were consistent with findings reported in previous studies, which indicate that conventional tillage often provides favourable conditions for early crop establishment and biomass accumulation due to improved soil aeration and nutrient mineralization (Bășa et al., 2015; Călugăr et al., 2024; Stroe & Panaitescu, 2025). In the present experiment, hybrid DKC 6897 exhibited superior yield performance across all tillage systems, suggesting a higher capacity to exploit soil resources under intensive and reduced tillage conditions. Similar hybrid-dependent responses have been reported by Stoian et al. (2025) and Kirchev (2025), emphasizing the importance of matching genetic material with soil management practices. However, the results also demonstrate that reduced tillage systems, particularly minimum tillage, can achieve grain yields comparable to conventional systems when irrigation is applied and technological inputs are well managed. This observation aligns with earlier research indicating that minimum tillage preserves soil moisture and structure while maintaining adequate crop productivity (Mupangwa et al., 2007; Wakwoya et al., 2022). In contrast, the no-tillage system resulted in lower yields, especially for hybrid DKC 5812, which may be attributed to reduced nutrient availability and slower early root development, particularly during the initial years of no-tillage implementation, as reported by Liu et al. (2022).

Morphological traits such as ear insertion height, plant biomass and ear weight reflected similar trends, confirming that soil mobilization intensity influences vegetative growth and yield components. The superior morphological performance recorded under conventional and minimum tillage supports the findings of Zhang et al. (2026), who reported improved yield components under moderate soil disturbance combined with optimized fertilization.

From a mechanisation perspective, the reduction in the number of field operations under conservation tillage systems resulted in significant savings in fuel consumption, labour time and machinery wear. These results are consistent with studies highlighting the operational advantages of minimum and no-tillage systems in terms of energy efficiency and reduced soil compaction (Rusu, 2014; Santos et al., 2024). The improved mechanization efficiency observed under no-tillage, despite lower yields, underscores the trade-off between productivity and operational simplicity.

Economic analysis revealed that profitability was not solely dependent on yield level but strongly influenced by production costs. Although conventional tillage generated the highest gross revenues, its higher operational costs reduced overall profitability. Minimum tillage emerged as the most balanced system, combining high yields with moderate costs, leading to consistently high profitability for both hybrids. These findings are in line with previous economic assessments indicating that conservation tillage systems can enhance farm resilience by optimising cost structures under variable climatic conditions (Stanciu, 2024; Barna & Mănescu, 2025). Moreover, recent analyses suggest that foreign direct investment plays a key role in supporting technological adoption and economic efficiency in the agri-food sector, particularly through improved mechanisation, cost optimisation and productivity gains at farm level (Stanciu, 2024).

The climatic conditions recorded during the 2024–2025 agricultural year, characterized by thermal extremes, late spring frosts and uneven precipitation distribution, further emphasize the importance of adaptive soil management strategies. Under such conditions, irrigation and reduced soil disturbance play a crucial role in stabilizing production and mitigating climatic risks, as also noted by Zhang et al. (2021) and Prăvălie et al. (2014).

The results support the adoption of minimum tillage as a viable compromise between agronomic performance, mechanization efficiency and economic sustainability under irrigated maize production systems. While no-tillage offers clear advantages in terms of cost and energy efficiency, its agronomic performance may require longer-term adaptation and refined nutrient management strategies to fully exploit its potential.

5. Conclusions

The present study demonstrated that soil tillage system, hybrid selection and mechanization strategy significantly influence maize productivity, operational efficiency and economic performance under irrigated conditions in south-eastern Romania. Conventional tillage ensured the highest grain yields, particularly for hybrid DKC 6897; however, these gains were associated with higher production costs and lower overall profitability compared to conservation-based systems.

Minimum tillage emerged as the most balanced production system, combining high and stable yields with reduced fuel consumption, lower labour requirements and moderate operational costs. This resulted in consistently high profitability across both maize hybrids, highlighting its suitability as a sustainable alternative to conventional tillage under similar pedoclimatic conditions.

Although no-tillage systems recorded lower grain yields, especially for hybrid DKC 5812, their reduced mechanization intensity and lower production costs led to competitive profitability levels. These findings indicate that no-tillage can represent a viable option for farms prioritizing cost efficiency and soil conservation, particularly when supported by irrigation and adaptive nutrient management.

The results confirm that economic performance in maize production is not exclusively determined by yield level, but also by the efficiency of resource use and cost management. Conservation tillage systems, especially minimum tillage, offer a resilient and economically sound approach for maize cultivation under increasingly variable climatic conditions.

To further validate and extend the findings of this study, it is recommended that future research be conducted over a longer time horizon, covering multiple agricultural years. Long-term experiments would allow a more comprehensive assessment of the cumulative effects of conservation tillage systems on soil physical properties, nutrient dynamics, yield stability and economic performance. Multi-year studies should focus on the progressive adaptation of maize crops to no-tillage systems, as agronomic performance is known to improve after the initial transition period. Additionally, integrating detailed soil health indicators, such as organic matter content, soil compaction and water infiltration capacity, would enhance the understanding of long-term sustainability. Such extended research would provide robust, farm-relevant evidence to support decision-making processes regarding soil management strategies under the context of climate change and increasing production costs.

References

1. Bășa, A. G., Ion, V., Dumbravă, M., Fîntîneru, A., Epure, L. I., Dicu, G., & State, D. (2015). Results regarding the correlation of grain yield with dry matter yield in maize crop. *Scientific Papers. Series A. Agronomy*, *58*, 143–148. https://agronomyjournal.usamv.ro/pdf/2015/vol.LVIII/art26.pdf

2. Bășa, A. G., Ion, V., Dicu, G., State, D., Epure, L. I., & Ștefan, V. (2013). Above-ground biomass of different maize hybrids cultivated in South Romania under drought conditions. *Scientific Papers. Series A. Agronomy*, *56*, 177–184. https://agronomyjournal.usamv.ro/pdf/vol.LVI/Art32.pdf
3. Barna, F. M., & Mănescu, A. C. (2025). The impact of drought risk on maize crop in Romania. *Sustainability*, *17*, 8870. https://doi.org/10.3390/su17088770
4. Botoș, L. F., Hinda, I.-A., Imbrea, F., Niță, S., Niță, L. D., & Bătrîna, Ș.-L. (2025). Modern maize cultivation technologies in the context of climatic challenges. *Scientific Papers. Series A. Agronomy*, *68*(1), 275–280. https://agronomyjournal.usamv.ro/pdf/2025/issue_1/Art31.pdf
5. Călugăr, R. E., Varga, A., Vana, C. D., Ceclan, L. A., Racz, I., Chețan, F., Șimon, A., Popa, C., Tritean, N., Russu, F., Ghețe, A. B., & Muntean, L. (2024). Influence of changing weather on old and new maize hybrids: A case study in Romania. *Plants*, *13*(23), 3322. https://doi.org/10.3390/plants13233322
6. Cristea, M., Căbulea, I., & Șarca, T. (2004). *Maize – A monographic study*. Romanian Academy Publishing House.
7. Díaz-Zorita, M. (2000). Effect of deep-tillage and nitrogen fertilization interactions on dryland corn (*Zea mays*) productivity. *Soil and Tillage Research*, *54*(1–2), 11–19. https://doi.org/10.1016/S0167-1987(99)00100-2
8. Dinuță, I. C., & Marin, D. I. (2023). Research on the influence of the conservative tillage system on maize culture, an agrotechnical and economic alternative for sustainable agriculture, under the conditions of A.R.D.S. Pitesti – Albota. *Scientific Papers. Series A. Agronomy*, *66*(1), 54–62. https://agronomyjournal.usamv.ro/pdf/2023/issue_1/Art7.pdf
9. Dobre, M. (2019). *Agrotechnics*. Universitaria Publishing House.
10. Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., & Prasanna, B.M. (2022). Global maize production, consumption, and trade: Trends and R&D implications. *Food Security*, *14*, 1295–1319. https://doi.org/10.1007/s12571-022-01315-5
11. Georgescu, E., Toader, M., Cana, L., & Gărgăriță, R. (2014). Draught influence concerning maize leaf weevil (*Tanymecus dilaticollis* Gyll.) attck in maize crops at NARDI Fundulea. *Scientific Papers. Series A. Agronomy*, *57*, 186–191. https://agronomyjournal.usamv.ro/pdf/2014/art33.pdf
12. Kirchev, H. (2025). Comparative study of grain maize hybrids in the agro-ecological conditions of Southern Dobruja. *Research Journal of Agricultural Science*, *57*(1). https://doi.org/10.59463/RJAS.2025.1.15
13. Liu, S., Gao, Y., Lang, H., Liu, Y., & Zhang, H. (2022). Effects of conventional tillage and no-tillage systems on maize growth, soil structure and water regime in the Loess Plateau of China. *Land*, *11*(11), 1881. https://doi.org/10.3390/land11111881
14. Long, A., Ji, X., Li, X., Wang, X., Yang, L., Chang, L., Yang, J., Hua, Q., & Gong, X. (2026). Response of maize productivity and protein quality to straw incorporation combined with nitrogen fertilization in Northeast China: A 10-year field experiment. *European Journal of Agronomy*, *174*, 127965. https://doi.org/10.1016/j.eja.2025.127965
15. Micle, D. E., Drența, R. F., & Arion, F. H. (2024). Technology and big data in agriculture: An analysis on agriculture 4.0, precision farming, and the role of SMEs in driving economic growth. *Bulletin of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture*, *81*(1). https://doi.org/10.15835/buasvmcn-hort:2024.0009

16. Mupangwa, W., Twomlow, S., Walker, S., & Hove, L. (2007). Effect of minimum tillage and mulching on maize (*Zea mays* L.) yield and water content of clayey and sandy soils. *Physics and Chemistry of the Earth*, *32*(15–18), 1127–1134. https://doi.org/10.1016/j.pce.2007.07.030
17. Nigussie, A. (2025). Effects of nitrogen application and tillage on maize (*Zea mays* L.) yield, nitrogen use efficiency, and nutrient stocks under contrasting soils. *Agrosystems, Geosciences & Environment*, *8*(2), e70156. https://doi.org/10.1002/agg2.70156
18. Nitu, O. A., Gheorghe, M., Ivan, E. S., & Bălan, M. (2024). Optimizing drip irrigation yield in grain maize cultivation in Eastern Romania. *Scientific Papers. Series A. Agronomy*, *67*(1), 307–313. https://agronomyjournal.usamv.ro/pdf/2024/issue_2/Art42.pdf
19. Popoviciu, D. R., Panaitescu, L., & Stroe, T. C. (2024). Quantitative analysis of nutritional bioactive compounds in maize cultivars. *Annals of the University of Craiova*, *29*(65). https://doi.org/10.52846/bihpt.v29i65.170
20. Prăvălie, R., Sirodoev, I., Patriche, C. V., Bandoc, G., & Peptenatu, D. (2014). The analysis of the relationship between climatic water deficit and corn agricultural productivity in the Dobrogea plateau. *Carpathian Journal of Earth and Environmental Sciences*, *9*(4), 201–214. https://www.cjees.ro/viewIssue.php?issueId=27
21. Rashidi, M., & Keshavarzpour, F. (2007). Effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.). *International Journal of Agriculture and Biology*, *9*(2), 274–277. https://www.fspublishers.org/paper/1411
22. Rusu, T. (2014). Energy efficiency and soil conservation in conventional, minimum tillage and no-tillage systems. *International Soil and Water Conservation Research*, *2*(4), 42–49. https://doi.org/10.1016/S2095-6339(15)30057-5
23. Santos, J. D. A., Pedrotti, A., Holanda, F. S. R., Santos, L. D. V., Andrade, B. M. D. S., & Carvalho, L. D. S. (2024). Impacts of tillage systems on green maize production in long-term experiments. *Soil Use and Management*, *40*(2), e13061. https://doi.org/10.1111/sum.13061
24. Sessiz, A., Alp, A., & Gursoy, S. (2010). Conservation and conventional tillage methods on selected soil physical properties and corn (*Zea mays* L.) yield and quality under croppin system in Turkey. *Bulgarian Journal of Agricultural Science*, *16*(5), 597–608. https://www.agrojournal.org/16/16.htm#5
25. Stanciu, S. (2024). Assessing the resilience and adaptability of Romanian agriculture to climate change. *Journal of Agriculture and Rural Development Studies*, *1*(1), 34–45. https://doi.org/10.35219/jards.2024.1.04
26. Stanciu, S. (2024). Foreign direct investment in Romania: Impact on the agri-food sector. *Journal of Agriculture and Rural Development Studies*, *(1)*, 5–17. https://doi.org/10.35219/jards.2024.1.01
27. Stoian, V. A., Vâtcă, A., Trușcă, M., Stoian, V., Popa, A. L., Toșa, A., Gădea, Ș., Vidican, R., Păcurar, F., & Vâtcă, S. (2025). Unveiling the effects of drought stress on maize hybrids: Changes in chlorophyll content, morphological traits and soil-plant water dynamics. *Scientific Papers. Series A. Agronomy*, *68*(1), 599–607. https://agronomyjournal.usamv.ro/pdf/2025/issue_1/Art74.pdf
28. Stoyanova, A., & Ganchev, G. (2024). Energy and protein feeding of biomass from two maize hybrids in ruminants. *Scientific Papers. Series A. Agronomy*, *67*(1), 691–697. https://agronomyjournal.usamv.ro/pdf/2024/issue_1/Art89.pdf
29. Stroe, T. C., & Panaitescu, L. (2025). Assessment of the transition from conventional soil tillage to minimum tillage technology in a maize crop with three hybrids – A three-year case study in Lanurile,

Constanța County. *International Journal of Innovative Approaches in Agricultural Research*, *9*(3), 217–231. https://doi.org/10.29329/ijiaar.2025.1356.5

30. Wakwoya, M. B., Woldeyohannis, W. H., & Yimamu, F. K. (2022). Effects of minimum tillage and liming on maize (*Zea mays* L.) yield components and selected properties of acidic soils in Assosa Zone, West Ethiopia. *Journal of Agriculture and Food Research*, *8*, 100301. https://doi.org/10.1016/j.jafr.2022.100301
31. Weidhuner, A., Zandvakili, O. R., Koduru, S., Krausz, R., Cook, R. L., Hanauer, A., Jones, K., & Sadeghpour, A. (2026). Effect of long-term tillage practices on soil physical properties, corn and soybean yield, and nutrient balance. *Field Crops Research*, *336*, 110210. https://doi.org/10.1016/j.fcr.2025.110210
32. Yanev, M. (2023). Application of herbicides for weed control before germination and in the early vegetation in maize. *Scientific Papers. Series A. Agronomy*, *66*(1), 631–644. https://agronomyjournal.usamv.ro/index.php/scientific-papers/past-issues?id=1613
33. Zhang, J., Wu, J., Ge, Z., Xing, L., Han, S., Shen, C., & Kong, F. (2021). Impact of climate change on maize yield in China from 1979 to 2016. *Journal of Integrative Agriculture*, *20(1)*, 289-299. https://doi.org/10.1016/S2095-3119(20)63244-0
34. Zhang, H., Ali, S., Kong, R., Liu, H., Lu, H., Tian, X., Rong, F., Assal, M. E., Shaik, M. R., & Sajid, M. (2026). Tillage management practices in combination of plant growth regulators to improve root growth, lodging characteristics and maize productivity under semi-arid regions. *Scientific Reports, 16, 1809*. https://doi.org/10.1038/s41598-025-32460-6