ASPECTS REGARDING THE ECONOMIC EFFICIENCY OF DIFFERENT SOIL MAINTENANCE SYSTEMS IN VINEYARDS

ASPECTE PRIVIND EFICIENȚA ECONOMICĂ A DIFERITELOR SISTEME DE ÎNTREȚINERE A SOLULUI ÎN PLANTAȚIILE VITICOLE

ZALDEA Gabi[1], NECHITA Ancuța[1]*, ALEXANDRU Lulu Cătălin[1], FILIMON Roxana[1], FILIMON Răzvan[1]

*Corresponding author e-mail: ancuta.vasile@gmail.com

Abstract.
The vine-growing technologies in the vineyards of the country's north-eastern region are established differentially, according to ecopedoclimatic conditions, with specific technological practices applied depending on the area and the cultivated varieties. The implementation at SCDVV Iași of innovative technological practices aimed at reducing energy consumption, lowering pollutant emissions, and preserving soil structure for the promotion of sustainable agriculture involved testing four soil maintenance systems in the inter-row spaces. The analysis of manual and mechanical labor requirements, along with the inputs applied, allowed the assessment of the economic efficiency of different soil maintenance systems, highlighting their advantages and drawbacks under specific conditions. The results obtained highlight that the highest economic efficiency was recorded in variant V4, with a profitability rate of 44%, compared to only 8% in variant V1. Similar values were also achieved in variants V3 and V2, with profitability rates of 34% and 28%, respectively.
Key words: precipitation, vines, accessible moisture, soil

Rezumat.
Tehnologiile de cultură a viţei-de-vie din podgoriile din nord-estul ţării sunt stabilite diferenţiat, în funcţie de condiţiile ecopedoclimatice, intervenindu-se cu verigi tehnologice specifice zonei şi în funcţie de soiurile cultivate. Implementare la SCDVV Iași unor verigi tehnologice inovative pentru reducerea consumurilor energetice, a emisiilor poluante şi a conservării structurii solului în vederea promovării unei agriculturi durabile, a presupus experimentarea a patru sisteme de întreținere a solului pe intervalele dintre rânduri. Analiza consumurilor de forță de muncă manuală și mecanică, a input-urilor practicate, a permis stabilirea eficientei economice la diferite sisteme de întreținere a solului, cu plusurile și minusurile lor în anumite condiții. Rezultatele obținute evidențiază faptul că cea mai ridicată eficiență economică s-a înregistrat la varianta V4, cu o rată a rentabilității de 44 %, comparativ

[1] Viticulture and Oenology Research and Development Station in Iasi, Romania

cu varianta V1 de numai 8 %. Valori apropiate s-au obținut și la variantele V3 și V2, cu 34% și respectiv 28 % rată a rentabilității.

Cuvinte cheie: precipitații, viță-de-vie, umiditate accesibilă, sol

INTRODUCTION

In viticulture, it is well established that the monocultural production system, combined with the intensive application of cultivation technologies, accelerates entropic processes that negatively affect various components of the ecosystem. Consequently, periodic reassessment and adaptation of vineyard management practices are essential to address the challenges posed by climate change. Developing viable, sustainable technological solutions is crucial for maintaining long-term ecological stability and enhancing the resilience of viticultural ecosystems [Țârdea and Chivu, 1998].

Innovative technologies in viticulture must comply with a set of biological, ecological, technological, and economic criteria and requirements, ensuring both sustainability and efficiency across all stages of production. They aim to: mitigate the impact of viticultural ecosystems on the surrounding environment; eliminate, as far as possible, pollutant factors, reaching the threshold of a "biological product"; reduce mechanical soil maintenance operations through alternative grass-cover systems; promote organic fertilization as a foundation for conserving and enhancing the natural fertility of the soil, through the use of both organic and green fertilizers; generalize the application of biological methods for controlling diseases and pests; create optimal conditions for maximizing the capture of solar energy by the foliage through appropriate vine training forms and support systems; fully exploit the quantitative and qualitative production potential of grape varieties; reduce energy and labor consumption; and ensure the long-term economic utilization of vineyards.

For grapevine growers, the costs and labor requirements associated with different technological options, as well as with each individual operation, are of at least equal importance to understanding the technologies themselves and the optimal timing of their implementation. Economic efficiency represents the ratio between effort and effect, where effort is reflected by expenditures, and effect is determined by the level of income achieved [Alexandrescu *et. al.*,1998].

The analysis of manual and mechanical labor consumption holds significant theoretical and practical importance, as, on the one hand, these factors represent a substantial share of direct production costs, and, on the other hand, they constitute highly flexible cost components on which efficiency-oriented interventions can be more effectively applied [Zaldea, 1999a; Zaldea, 1999b].

The study undertaken aimed to assess the impact of different soil management systems on production costs, with particular emphasis on the consumption of manual and mechanical labor and materials, in relation to production quality and revenue generated, and ultimately on the economic efficiency and profitability level of each system.

MATERIAL AND METHOD

The research was conducted within an experimental plot with the Riesling de Rhin variety. The plantation was established in 2010, on a flat plot with a predominantly southern exposure, not exposed to risk climatic factors, and at full fruiting capacity (Figure 1).

Fig. 1. Aspects from the experimental lot: soil maintenance systems in the row spacing

Four soil maintenance systems were experimented on the inter-row intervals (Table 1).

Table 1

Experimental variant scheme

Variant experimental	Operations performed
V1 – conventional system: tilled soil (TS)	– autumn plowing; – spring plowing; – 5 mechanical weedings per interval; – 5 manual weedings per row; – fertilization with NPK according to soil nutrient status.
V2 – conservative system: partial interval mulching with grape marc (PMM)	– application of composted grape marc in a 10 cm thick layer; – 2 post-emergence herbicide treatments per vine row; – fertilization with NPK at minimum dose; – application of foliar fertilizers to reduce water stress.
V3 – conservative system: mulching with plant materials (MP)	– chopping of plant species from the interval and leaving them on the soil surface as mulch; – application of foliar fertilizers to reduce water stress.
V4 – conservative system: minimal and superficial soil operations (MO)	– autumn plowing; – one deep mechanical weeding in spring; – application of foliar fertilizers to reduce water stress; – scarification every 3–4 years.

RESULTS AND DISCUSSIONS

To determine economic efficiency within the different soil management systems, a detailed analysis was conducted on production costs, with particular emphasis on the consumption of manual and mechanical labor and materials (standard technological sheets for each variant). These were correlated with quantitative and qualitative production and the revenues obtained, and, ultimately, economic efficiency indicators and profitability levels were calculated, which represent the essential elements of any productive activity.

The volume of expenditures was expressed in person-days per hectare for manual operations and machine hours per hectare for mechanical operations, and in physical and monetary units for the consumption of fuels and materials (pesticides, fertilizers, etc.).

In all analyzed variants, manual labor accounted for a significant share of direct production costs, with the highest consumption in person-days per hectare, and consequently in monetary terms observed in V1 – tilled soil (195.09 person-days/ha, corresponding to 53847.68 lei/ha), and the lowest in V3 – mulching with plant materials (157.87 person-days/ha and 43239.98 lei/ha). It should be noted that in determining labor consumption, the entire technology was considered, including operations specific to the cultivation area under study. Differences between variants were recorded at harvest, which were determined by the quantity of production obtained (Table 2).

Table 2

Cost structure of experimental variants, RON per hectare

Specification	V1 (TS) mt	V2 (PMM)	V3 (MP)	V4 (MO)
Specification	53847.68	44658.49	43239.98	45203.63
Manual labor	1725.14	1543.06	1484.85	1613.95
Mechanical operations	55572.82	46201.55	44724.83	46817.58
Total wages	19450.49	16170.54	15653.69	16386.15
Contributions (social security, taxes, etc.)	75023.31	62372.09	60378.52	63203.73
Total remuneration	5213.90	5447.95	5483.35	5617.90
Materials (pesticides, diesel, etc.)	80237.21	67820.04	65861.87	68821.63
Total direct costs	12035.58	10173.00	9879.28	10323.24
TOTAL	**92272.79**	**77993.04**	**75741.15**	**79144.87**

Within the applied technology, mechanical operations targeted the following categories of activities: soil maintenance, pest and disease control, fertilization, and the transport of various materials. Consequently, the share of mechanical operations varied depending on the soil management system employed.

In the structure of production costs, material consumption accounted for a significant share, ranking second after manual labor. The materials considered included plant protection products, fertilizers, herbicides, and diesel, which contributed to the differences between variants. The value of materials ranged from 5213.90 lei/ha in variant V1 to 5617.90 lei/ha in variant V4.

To highlight the contribution of different cost components to production, such as labor consumption and its corresponding shares, as well as materials, these were quantified in monetary terms. In determining the value of these expenditures, the prices and rates used in 2025 were taken into account.

Economic efficiency was assessed using a series of indicators, including grape yield, sugar content, expenditures, production cost, delivery price, revenue, and profit per hectare. Production costs were calculated as the ratio between expenditures per hectare and the yield obtained (kg/ha).

The delivery price was determined based on the sugar content of the grapes (Table 3).

Table 3

Economic efficiency indicators

Specification	U.M.	V1 (TS) mt	V2 (PMM)	V3 (MP)	V4 (MO)
Grape yield	kg/ha	18068	16591	15644	17576
Sugar content	g/L	182	195	204	215
Expenditures per hectare	RON/ ha	92282.79	77993.04	75741.15	79144,87
Production cost	RON /kg	5.10	4.70	4,84	4.50
Delivery price	RON /kg	5.50	6.00	6.50	6.50
Revenue per hectare	RON /ha	99374.00	99546.00	101686.00	114244.00
Profit per hectare	RON /ha	7101.21	21552.96	25944.85	35099.13
Profitability rate	%	8	28	34	44

The revenues resulted as the product of the delivery price and the quantitative production, and the profit calculated by the difference between revenues and expenses per hectare ranged between 7101.21 lei/ha for variant V1 and 35099.13 lei/ha for variant V4.

The results obtained highlight that the highest economic efficiency was recorded in variant V4 – minimal soil operations – with the highest profitability rate of 44%, compared to variant V1 – tilled soil – which achieved only 8%. Similar economic efficiency values were observed in variants V3 and V2, with profitability rates of 34% and 28%, respectively.

In addition to the quantified aspects of economic efficiency, there are non-quantifiable economic effects, such as:

- ✓ improvement of the physical and chemical properties of the soil (maintaining soil structure, looseness, etc.);
- ✓ prevention of soil erosion by ensuring a minimum cover of perennial grasses;
- ✓ maintenance of optimal levels of organic matter in the soil and preservation of its biodiversity;
- ✓ ensuring a minimum level of soil maintenance by reducing the number of operations;
- ✓ reduction of soil, groundwater, and environmental pollution through minimal use of chemical fertilizers;
- ✓ improvement of both the quantitative and qualitative grape yield;
- ✓ possibility of marketing grapes at higher prices.

CONCLUSIONS

In all analyzed variants, manual labor accounted for a significant share of direct production costs, with the highest consumption in person-days per hectare observed in variant V1 – bare tilled soil, and the lowest in variant V3 – mulching with plant materials.

Regarding direct expenditures, the conventional system (tilled soil) proved to be the most costly, whereas the conservative system (composted grape marc mulching) incurred the lowest expenses. Within these costs, manual labor represented 34%, while materials accounted for 18%.

In the structure of material costs, plant protection products held the largest share, followed by diesel.

The lowest production costs were recorded in variant V4 (minimal and superficial soil operations), followed by variant V2 (grape marc mulch).

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