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Article

Evaluation of Economic Efficiency of Apple Orchard Investments

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Abstract: The tree-growing sector is considered to be an important supplier of food and raw material for industry worldwide. Increasingly competitive decisions regarding international investment in orchards depend on business analysis. This study compares three apple orchards situated in Cluj-Napoca, on the Eastern limits of the Transylvanian Plain, Romania. While the climatic and soil conditions are relatively consistent among the three orchards, the technical and economic results (expressed in hectares) vary due to the use of three different technological systems of apple production: extensive, intensive, and super-intensive. The study compares the life cycle, starting with age of fructification, production level (quantity and quality), costs (investment and production costs—divided into material costs, mechanical costs, human costs, and overhead costs), income, profit (including rate of profit), and investment efficiency: Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP). It was observed that the most economically efficient technological system in terms of investments is the super-intensive one, with a higher production level, a higher share of Extra Class apples, and a younger age of initial fructification. However certain inconveniences of this system—such as a more expensive investment, a higher cost of running the business throughout the year, and a reduced life cycle—cannot be ignored.

Keywords: technological system; Romania; comparative analysis; apple cultivation technology; costs

1. Introduction

The most common fruit tree in Europe is the apple tree, which covers 35% (450,000 hectares) of the total orchard area [1]. In 2013 the EU-28 produced around 12 million tons of apples [1]. The leading apple producer in EU-28 was Poland with more than 3,000,000 tons, followed by Italy and France. Romania had an annual production of 503,000 tons of apples. In Romania, productivity is an obstacle. Apple production in the country decreased by 43% between 2003 and 2012 [2]. The apple production area in Romania represents 11% (51,226 hectares) of the total apple production area of the EU, while the French apple production area represents only 8% of the total EU area. However, France has a production level four times higher than that of Romania [1].

The area harvested with apple trees decreased during the last 24 years in the European Union and in Romania. In Romania the area harvested with apple decreased by 33%, while at the EU level by 15%. The decrease of the harvested area with apple can be explained by the increase of the yield. In Romania the apple yield increased by almost 8% from 1990 until 2013; this represents an average annual increase rate of 0.32%. At the EU level the apple yield increased by 12% during the same period (Figure 1).

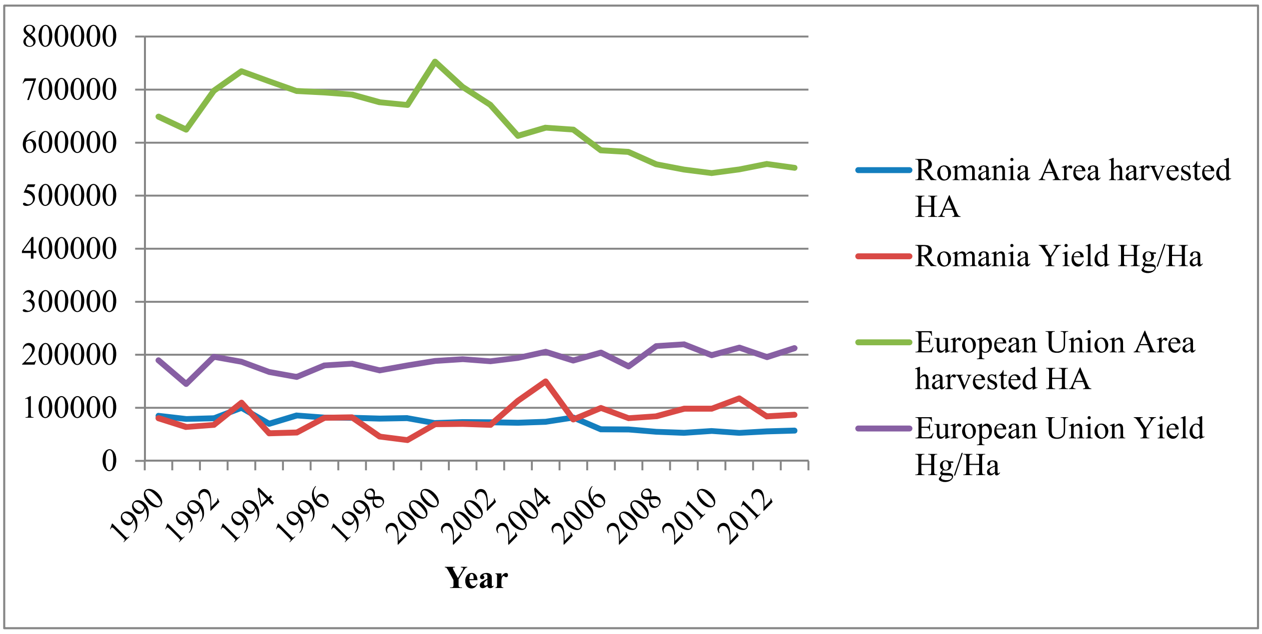

Figure 1. Time evolution of apple production indicators in Romania and the European Union. Source: after [3].

The average yield in Romania during the analyzed period displays larger fluctuations from year to year than in the European Union, mainly because of the lower level of controlling for climacteric and environmental factors (such as drought, frozen, soil pollution, and so on). This is mainly a direct result of out-of-date production technology. As a lack of resources for investment influenced the decision-making process for production technology options, The National Rural Development Plan 2014–2020 of Romania focused on the importance of orchard modernization, allocating more than 400 million Euros to two different specific measures: Measure 04—"Investment in physical assets" (Under-measure 4.1a "Investments in tree farms"), and Measure 09—"Formation of producers groups in tree sector" (Under-measure 9.1a "Formation of producers groups in tree sector") [4].

In this context the question arises of how efficient the system of apple production in Romania is. Apple growing requires high capital investment [5] and the choice of production system (organic or conventional) has a direct impact on apple orchard productivity [6]. Organic farming is increasing in popularity around the world and plays an important role in agriculture [7]; it is seen as an alternative to conventional farming, as well as a solution for sustainable development [8]. Previous studies have not revealed any differences in soil organic matter between conventional and organically grown apples [6].

The critical factors of apple production are: organic fertilizers, farmers' experience, and labor which, together, represent around 48% of the cost production [9]. Other researchers have argued that the six factors influencing the profitability of apple production are: yield; quality of the apples (as graded results); orchard size; number of cultivars; production costs; and specialization in organic production and/or farm gate sales [10]. Due to the farmers' lack of knowledge and access to proper technologies, in many cases fertilizers are used in excess [11] to the detriment of the environment. Organic farming and small agribusinesses benefit from higher prices and, ultimately, economic efficiency [10], but just because a production system is organic does not mean that its stability is ensured [12]. In order to be sustainable it is necessary to produce adequate, high-quality yields to be profitable, to protect the environment, to conserve the resources, and to be socially responsible in the long term [12]. In most regions of the world the apple growers have, instead, adopted the intensive system [13]. During the last 50 years the planting density in apple orchards rose from 40 trees/acre to more than 3000 trees in some cases [14]. The high-density system is expensive to establish, the highest cost being for the trees. Producing one's own trees reduces the initial cost, but the yields are delayed by one year [14]. The low-density apple system is disadvantaged by the slow development of full orchard production (5–8 years) [13]. The plating system is influenced by several factors: geographic location, variety and species, soil type, rootstock, local cultural and economic concerns [15].

While the social pillar of sustainable development is relatively unexplored territory, some of the work highlighted above suggests that a broad understanding is emerging regarding key concepts and policy objectives. This awareness is rooted in social policy discourse and has been transposed onto the social sustainability discourse, work that represents a major contribution to our appreciation of the social pillar.

The cultivation technology of apples has effects not only on production [16] but on economic efficiency, as well [17]. The more intensive the production system, the higher are the investments in the production. The objective of this paper is to investigate which apple production technology is the most economically-efficient in Romania and how it can be improved at the farm level. This is achieved by comparing production levels, costs, profits, and investment efficiency: Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP). The aim of the paper is to offer information to scholars for further studies and to farmers for investment decision-making.

Sustainability is based on three pillars: the environmental, the social and the economic, and this paper confronts each of them; the environmental and social pillars indirectly (based on references, mentioning that the social pillar is relatively unexplored territory related mainly to common policy objectives [18]), and the economical pillar directly though the conducted analysis.

The different production systems should be used as a management tool in order to increase the competitiveness of production [19]. The new Common Agricultural Policy proposes to increase the competiveness of the agricultural sector and its sustainability [20]. To achieve this, it is necessary to obtain high quality production while also preserving the natural environment [20].

The social component of sustainable development aims to enhance the living standards of the community. This can be achieved by increasing the level of education and improving the managerial skills of farmers [21]. The sustainable development of apple production takes into account, besides the protection of the environment, the income of fruit-growers and the health of farmers and consumers [22]. Sustainable environmental development involves the maintenance of good soil fertility, management and optimization of water use, minimizing the adverse impacts on the global environment, and on climate change.

2. Materials and Methods

The apple orchards studied are situated in Cluj-Napoca, on the Eastern limits of the Transylvanian Plain, Romania. Climate and soil conditions assure proper circumstances for apple production, reducing the risk of production instability and fluctuation. The physical, chemical and biological characteristics of the soil are adequate, having a pH between 5.5 and 7.5. The texture of the soil is argillaceous-clayey with a moderate humus deposit.

Temperature is within limits during the vegetation period, the average annual temperature being 8.2 °C (within the recommended limits of 8 °C–10 °C), the lower monthly average temperature occurring in January (−4.4 °C) and the higher in July (18.9 °C). The temperature limits for apples (from −30 °C in winter to 30 °C–40 °C in summer) are not reached, thus temperature is not a limiting factor in the region. The period of temperatures below 0 °C begins in October (6.3 days), with the maximum number of negative-temperature days registered in January (28.7). In some cases, negative-temperature days are also registered in May and September. The interval of days with positive temperatures is 180 days. The amount of temperatures between March and October are 3171.2 °C, and between May and October 2802 °C, with an average temperature of 15.2 °C [23].

The average annual precipitation is 615 mm, often above 700 mm. Months with higher precipitation are June and July, while lower precipitations are registered in January, February, and March. The average annual number of days with precipitation is 93. The quantity of precipitation is relatively equally distributed throughout the year, during March and October, being registered at 503.7 mm out of 613 mm while, between March and October, are registered 425.7 mm. The depth of phreatic water is 5–6 m. Winds are most frequently from the northwest and west with a fervency of 12.8% and 10.4%, respectively. The calm period is 4.45% and the winds do not negatively affect the apple orchards in the region [23].

Three different orchards were studied, all of them belonging to SC Agroindustriala SA Cluj-Napoca: an extensive one (32 ha), an intensive one (18 ha), and a super-intensive (6 ha) one situated in the area described above.

The apple varieties for the orchards consist of Golden Delicious, Idared, Florina, and Starkinson. The parent stocks used differ on the technological system: M11 for extensive orchard, MM106 for intensive orchard, and M9 for super-intensive orchard.

The information about investment, production (quantity and/or quality), costs (technical, materials, human), and resources (labor, phytosanitary treatments) was obtained from internal documents of SC Agroindustriala SA Cluj-Napoca. Selling prices were estimated using the average market prices in the region, while results indices were computed based on this primary information.

One of the most obvious indices for the production technologies studied, the tree density per hectare, was computed based the distance between rows (dr) and the distance between trees on each row (dt) (Table 1).

$$d = \frac{10{,}000}{\mathrm{dr} \times \mathrm{dt}} \quad (1)$$

Table 1. Tree density (trees per hectare).

Technological system	Distance between rows (dr) m	Between trees on row (dt) m	Tree density (*d*) number/ha
Extensive	6	5	333
Intensive	4	2	1250
Super-intensive	3.5	0.9	3175

The level of production, as well as its quality, was determined by taking the annual average of production during the fructification period (Q), based on the specifications provided by the tillers supplier according to the specific climate and soil conditions. Even if the climate and conditions are considered generally favorable for apple production, they still can have an influence on the level of production. To reduce this influence, the annual average was computed for consecutive fructification periods (qi, where i represents the year) for each of the 3 technological systems (extensive, intensive and super-intensive).

$$Q = \frac{\sum_{i=1}^{10} qi}{n_f} \quad (2)$$

where qi is the production on the year i, while n_f is the number of years of economic fructifications (life period).

The technical characteristics of orchards depend on the technological systems used (Table 2). In addition to tree density, the average annual production differs as well.

Table 2. Technical characteristics of orchards by technological system.

Specification	UM	Technological system		
		Extensive	Intensive	Super-intensive
Tree density	trees/ha	333	1250	3175
Average production, from which:	ton/ha	18,000	28,000	55,500
- Extra Class	ton/ha	5400 (30%)	14,000 (50%)	43,500 (82%)
- Class I	ton/ha	2700 (15%)	3360 (12%)	7000 (8%)
- Class II	ton/ha	3780 (21%)	3920 (14%)	2000 (4%)
- apples for industrial processing	ton/ha	6120 (34%)	6720 (24%)	3000 (6%)
Starting age of fructification	year	5	4	2
Life period	years	30	22	15

The extensive technological system of apple production has a longer life period (double the one of the super-intensive orchard and one third higher than the life period of the intensive orchard), while the starting age of fructification is lower for the super-intensive technological system.

The evaluation of apple quality is based on European legislation and includes three classes: Extra Class ("superior quality"), Class I ("good quality") and Class II ("above minimum requirements"). This "quality classification" is based on the degree of defects (such as skin defects, development defects, misshapenness and so on) [24]. The apples that have a lower quality than Class II are not included in any class and are used only for industrial use.

The expenditures consist of investments and production costs. The production costs were divided into four categories (technical costs—generated by machine use; human costs—remuneration of labor; materials costs—value of raw materials and other resources used, and overhead costs—the ones that could not be individualized from the costs of the company). The overhead costs (rent, assurance, management, *etc*.) were estimated at 10% of the total. All of the used costs (investment, production costs) and incomes were computed per hectare rather than for the entire orchard in order to more effectively compare results.

In order to achieve the results, a complex system of indices of economic efficiency of investments was used, including tools which are found throughout the literature [25] and in practice: Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP).

Net Present Value (NPV) was used to determine the present value of each investment in orchards by the discounted sum of all cash flows received from the investment.

$$NPV = -C_0 + \sum_{i=1}^{t} \frac{C_i}{(1+r)^i} \tag{3}$$

where C_0 is initial investment, C is cash flow, t is time, and r is discount rate. The discount rate was considered to be 5%, the level nationally used for determining the present value for investment financed from national and/or European funds during 2007–2013, when the investments were made.

Internal Rate of Return (IRR) is the interest rate at which the NPV of all the cash flow from an investment becomes zero. IRR represents the level of discount rate that equates the present value of the future cash flows of an investment with the initial investment that generated the cash flows.

$$NPV = -C_0 + \sum_{i=1}^{t} \frac{C_i}{(1+r)^i} = 0 \text{, or}$$
$$C_0 = \sum_{i=1}^{t} \frac{C_i}{(1+r)^i} \tag{4}$$

Payback Period (PP) is the period of time required to fully recover the initial cash outflow of the investment.

$$PP = C_0 / \text{Cash Inflow per Period} \text{, or}$$
$$PP = n_n + C_a / C_b \tag{5}$$

where n_n is the last period with a negative cumulative cash flow, C_a is the absolute value of cumulative cash flow at the end of the period n_n, and C_b is the total cash flow during the period after n_n.

Rate of Profit (r) is the percentage of the income that is profit after reducing the costs that generated the income.

$$r = \left((\text{I-C}) / \text{C} \right) \times 100 = \frac{P}{C} \times 100 \tag{6}$$

where I is the income, C is the costs, and P is the profit.

Workforce productivity (Wp) refers to the amount of work hour per output produced.

$$\text{Wp} = (\text{work hours}) / (\text{output}) \tag{7}$$

where output is the production of apple (in tons).

3. Results and Discussion

Comparing the investment costs, major differences can be observed among the technological systems of apple production. The investment costs effect the economic efficiency of the orchards, as well as the production costs and incomes. Due to a larger number of trees (see Table 1) and special facilities specific to intensive and super-intensive methods (especially the highly expensive hail protection systems and repellent tree), the extensive technological system is more than 11 times less expensive than the super-intensive one. At the same time, an investment in the super-extensive technological system is 4.5 times more expensive than in an intensive one (Table 3).

Table 3. Investment of orchards by technological system.

Specification	Technological system		
	Extensive	**Intensive**	**Super-intensive**
Material costs (Euro/year)	1460 (33%)	4260 (39%)	28,427 (56%)
Human costs (Euro/year)	1070 (24%)	2788 (25%)	9900 (20%)
Mechanical costs (Euro/year)	1489 (34%)	2979 (27%)	7649 (15%)
Overheads costs (Euro/year)	402 (9%)	1003 (9%)	4598 (9%)
Total (Euro/year)	4421	11,030	50,574

Of the investments considered, all were costs generated by creating the orchard and by running it before the first age of fructification.

Besides investment, the orchards, as in any business, generate production costs. The costs depend also on the technological system not only as the value, but on their share among the cost categories, as well (Table 4).

Table 4. Production costs of orchards by technological system.

Specification	Technological system		
	Extensive	**Intensive**	**Super-intensive**
Material costs (Euro/year)	1376 (42%)	2240 (39%)	3375 (42%)
Human costs (Euro/year)	988 (30%)	1872 (33%)	2246 (28%)
Mechanical costs (Euro/year)	631 (19%)	1121 (19%)	1724 (21%)
Overhead costs (Euro/year)	299 (9%)	523 (9%)	734 (9%)
Total (Euro/year)	3294	5756	8079

The more intensive the technological system for apple production, the higher not only the total production costs, but the mechanical costs as well, as the labor force is replaced by technology.

After starting the fructification, the incomes obtained per hectare depend both on the level of production and on the quality classes. Quality classes influence the price at which the product can be sold (Table 5), starting from 0.46 Euro for one kilogram of Extra Class apples and ending on 0.05 Euro/kg for apples used for industrial processing. The prices used are an average of the prices for the last five years on the Romanian apple market; apple prices can be highly volatile due to inconsistencies in apple production in Romania, on the one hand, and of massive imports, on the other hand.

Table 5. Incomes of orchards by technological system.

Incomes	Price (Euro/kg)	Technological system		
		Extensive	Intensive	Super-intensive
- Extra Class (Euro/year)	0.34	1836 (58.25%)	4760 (75.96%)	13,940 (91.77%)
- Class I (Euro/year)	0.22	594 (18.85%)	739.2 (11.80%)	880 (5.79%)
- Class II (Euro/year)	0.11	415.8 (13.19%)	431.2 (6.88%)	220 (1.45%)
- apples for industrial processing (Euro)	0.05	306 (9.71%)	336 (5.36%)	150 (0.99%)
Total Income (Euro/year)		3899.8	8046.4	22,020
Total Production Costs (Euro/year)		1894	4356	8708
Total Profit (Euro/year)		605.8	2290	12,141
Rate of Profit (%)		18.39	39.78	150.28
Total Profit (Euro/life cycle)		18,174	50,380	145,692

It can be observed that incomes are more than five times higher in the case of the super-intensive technological system of production when compared with the extensive system. This ratio is not reflected in profit and/or rate of profit, as the annual production cost is only 2.5 times higher for the super-intensive technological system of production compared with the extensive one. As a result, the annual profit is no less than 20 times higher for the super-intensive technological system of production compared with the extensive system.

The life period of orchards also influences the economic efficiency of investment, as the annual profit is multiplied by the number of years the orchard is economically productive (30 years for the extensive technological system, 22 years for the intensive technological system and 15 years for the super-intensive technological system) (Table 2).

Table 6. Economic efficiency of investment.

Indices	UM	Technological system		
		Extensive	Intensive	Super-intensive
Net Present Value (NPV)	Euro	9312.63	30,143.28	114,047.37
Internal Rate of Return (IRR)	%	13.39%	20.20%	22.18%
Payback Period (PP)	years	10.30	6.86	4.17

Based on the information presented above, the Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP) were computed for each of the three technological systems. Major comparative differences were observed, but all technological systems proved to be economically efficient on all three computed indices (Table 6).

Again it was observed that the super-intensive technological system of apple production had the best results for all three indices (the highest NPV, the highest IRR and the lower PP), exhibiting significant differences compared to the other two technological systems.

Besides the economic pillar of sustainability, the social and environmental pillars affecting the three technological systems were studied. The data was obtained from internal documents of SC

Agroindustriala SA Cluj-Napoca. The requirement of level of the labor force was computed as an annual average to reduce the influence of the climate and production conditions of a specific year (Table 7).

Table 7. Labor force.

Indices	UM	Technological system		
		Extensive	**Intensive**	**Super-intensive**
Before fructification				
Average annual labor force	h/ha	368.0	1202.4	1531.2
During fructification period				
Average annual labor force	h/ha	810.0	916.0	1002.0
Average annual workforce productivity	h/tone	46.67	32.17	18.22

The social impact of the analyzed production technological systems for apples could be expressed on the number of working hours (meaning the number of employees on the farm). On average, per hectare, 0.42 fulltime employees are required for extensive orchards, 0.45 fulltime employees for intensive orchards and 0.50 fulltime employees for super-intensive orchards. The results were based on an annual average of 253 working days, according to Romanian legislation for the year 2015. It can be seen that an additional employee will be required for every 12.5 hectare of super-intensive orchards compared with an extensive one. One must also mention the impact on the quality required from the employee. The super-intensive orchard demands more qualified and better-paid work, as the level of machinery and modern technology used is superior. That will reflect a change in the labor market for farms, offering a chance for qualified farmers to remain in the rural area and not migrate to cities and/or abroad. In such a way, it has the potential of generating a positive effect on a long-term trend of qualified persons leaving agriculture and the rural area.

The utilized production technology influences the environmental pillar of sustainability as well. The number of phytosanitary treatments used for all of the technology systems are similar, but the volume used is different: 500 L/hectare for super-intensive orchard, 1000 L/hectare for intensive orchard, and 1500 L/hectare for extensive orchards, no less than three times higher than in the case of a super-intensive one. This is also a result of the fact that the density of trees has a direct influence of the quantity of phytosanitary treatments that can accumulate on soil; the smaller the distance among trees, the higher the quantity of solution taken by leaves. In the case of super-intensive orchards, 80% of the substance remains on the leaves and only 20% reaches the ground, while the intensive orchards assure a proportion of 70% of the substance remains on the leaves and only 20% reaches the ground. The lowest quantity of substance remaining on the leaves is in the case of extensive orchards, with up to 50%—half of it—reaching the ground. This generates the highest risk of accumulation of heavy metals including copper, zinc, *etc*.

4. Conclusions

The study indicates that the most efficient technological system is the super-intensive one. This is explained by the fact that the system begins producing from the second year, that it is the most productive, and that it has the highest ratio of Extra Class apples (more than 80%), which are better appreciated on the market (both in terms of quantity consumed and in terms of premium price).

Results of this research confirm previous studies [14,25], which have attributed better returns to the super-intensive technological system of apple production. This system thus uses local resources such as a land, labor force, and capital in a more efficient way.

However, a manager must also take into consideration a disadvantage: a high level of investment and production costs, which can generate additional expenses (in the case of a bank loan, for instance) and have a negative effect on the above-computed indices. There is also a second major disadvantage: the fact that the life cycle in this system is the shortest one, so the investment process has to be renewed an additional time when compared with the extensive technological system. That is why some researchers [16] recommend investing in intensive technological systems of apple production. The lack of investment funds for farm managers or the difficulty in finding external resources for investments can also influence the investment decision. These conclusions are based on local/national realities, as is the lack of interest of banks in investing in agricultural activities, based on the low prices of land (around 2000–3500 Euro/hectare), on market instability, on fiscal uncertainty, on climate unpredictability, on insufficient insurance availability *etc*., so borrowing money is quite a difficult process, often discouraging potential investors.

As the consumption of apples is increasing, the above-mentioned results of the study recommend that new investments in apple orchards are based on super-intensive technological systems. It should be stressed that this system offers a better basis for sustainable business development.

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Author Contributions

All authors contributed equally to this work. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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