Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 4, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MODELLING LIFE CYCLE COST ANALYSIS (LCCA) SCENARIOS ON THE USE OF COMPOST IN ORGANIC PEAR ORCHARD IN ROMANIA

Ana Cornelia BUTCARU, Ionela Mițuko VLAD, Cosmin Alexandru MIHAI, Liliana BĂDULESCU, Gina FÎNTÎNERU, Florin STĂNICĂ

University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Mărăști, District 1, 11464, Bucharest, Romania, Phone/Fax: 00 40 744 6474 10, E-mails: ana.butcaru@qlab.usamv.ro, vlad.ionela@managusamv.ro, cosmin.mihai@horticultura-bucuresti.ro, liliana.badulescu@horticultura-bucuresti.ro, gina.fintineru@usamv.ro, flstanica@yahoo.co.uk

Corresponding author: vlad.ionela@managusamv.ro

Abstract

This study aims to present the life cycle cost (LCC) for 1 kg of pear produced using organic technology in Southern Romania. Two principal stages were depicted: production stage costs (PC) and Transport costs (TC). For each stage, investment and operational costs were determined. Pear orchard establishment (POE), the first I-III years of orchard management (without harvest) (OM.I-III), and IV-XX years of orchard management (OM.IV-XX) were analyzed considering the elemental activities included. Three scenarios were applied for fertilization: (S1) compost produced at the farm level using a composter Oklin GG-50S combined with the one produced on outdoor platform in the farm, mainly from vegetable sources. (S2) compost from the outdoor platform for organic residues, and (S3) acquisition of a commercial organic fertilizer. The total LCC for 1 kg of pear ranged between 0.400 € (S2), 0.481 € (S3), and 0.496 € (S1). Details regarding the LCC components and optimization were presented.

Key words*: *life cycle cost analysis, Pyrus communis, composter, Romania

INTRODUCTION

Pear production declined in Romania in the last few years. Although it is a highly profitable crop compared to others, this is not the first option in the farmer's establishment of orchards. Recently, the excessive use of organophosphorus pesticides for pest control in pear orchards led to a massive attack of *Cacopsylla pyri* L. correlated to fumagine. After the 1992 year, when the first fire-blight attack on an orchard from Însurăței, Brăila county in the Southern part of Romania, the pear orchard area decreased dramatically. New resistant or tolerant pear cultivars have been introduced on the market, but there was no signal that the farmer's options were changed. Organic technology applied to pear culture was still a sensitive subject.
In the meantime, at the international level, the total pear production increased steadily, at 25,658,713.07 tons in 2021, compared to 11,309,786.29 tons in 1994. The area for pear orchards stabilized at 1,399,484 ha, although the production increased due to the technology and more productive cultivars [13].
In the USA, in November 2023, the retail price for pear ranged between 0.92-2.75 €/kg in Washington and New York. The export price constantly increased in the last five years, from $1.21 in 2017 to $1.38 in 2021. The prediction for 2023 goes to $1.43 and $1.47 in 2024. For the import price/kg, 2023 is predicted to be around $1.42, and 2024 around $1.44 [23].
DG Agri E2 published in 2022 a study regarding the fruit and vegetable market in Europe [11] with a section on the prices of the pear market in the EU. The prices (€/100kg) were listed monthly (pear producer prices) for 2007-2022 on the main European markets – Italy, Belgium, Netherlands, and Spain. A comprehensive study and trends were made on the Abate Fetel, Conference, and Williams cultivars. In Italy, in 2021-2022, prices (€/100kg) started at 185 in August, climbed to 245 in February, then declined at 165 in May.

Belgium began with 50 in July, went up to 90 in February, and then reached 73 in June. The Netherlands started with 85 in July and increased to 103 in September. In 2019/2020, prices started at 100, went down to 55 in December, and climbed to 115 in June.

In Spain, 95 was the starting point in July, and 105 in June next year, 2022.

Abate Fetel was sold at around 230 €/100kg (producer prices) in February – July 2022, Conference at about 180 €/100kg, and Williams between 77 (Spain) and 230 (Italy) €/100kg.

China is the leading producer in the world, with 12,475 million tons in 2021 (Faostat), and, at the same time, the main exporter. In November 2023, prices on the domestic market ranged between 0.51 – 0.87 $/kg for fresh pear.

In Romania, 49,460 tons were produced in 2021 from 3,170 ha. The import volume was 28.38 million kilograms in 2022 [20].

Pear, just like apple, is a climacteric fruit. The chemical composition of the fruits is rich and varied: carbohydrates 8-15%, pectic substances 0.14-0.71%, organic acids 0.12-0.60%, tanned substances 0.06-0.24%, mineral substances 0.14-0.55%, vitamins C, PP, A, B [1].

There are summer, autumn and winter cultivars, the most appreciated being the winter cultivars, followed by the autumn ones. The harvest moment is usually in the first and second decade of September. The late cultivars need cold rooms for a more extended storage capacity, which can vary between 6 to 8/12 months for some cultivars. Winter pear can be consumed six months after harvesting, coming in the market between January and May, when the new fruit species begin to be harvested [4], [5], and [8].

For the pear orchard establishment, seedlings are available in the nurseries for the main cultivars, the most popular being in Romania Williams, Red Williams, Abate Fetel, and Conference (in some parts of the country). Breeding programs came with more cultivars resistant or tolerant to the main pear diseases, the most well-known being Euras, Tudor, Cristal, Corina, Monica [1], [3], [7], [16], [17], and [21].

The cultivation technology is mainly similar to the apple ones with specific traits regarding the pear characteristics (pest and disease management, fertilization, harvesting). Fertilization is a crucial point in orchard management and a challenge for the organic ones.

The present research analyses three possible scenarios using compost and commercial organic fertilizer. Life Cycle Cost Analysis (LCCA) was used for cost evaluation on each phase activity. LCCA highlighted the overall economic cost of a specific product, service, or system [9], [18] and proved to be a powerful technique for making the most cost-effective decisions at different life cycle stages [2], [10], [14], [15].

In recent studies, it has been widely combined with the Life Cycle Assessment (LCA) (ISO 14040:2006) [12]. Few studies were performed regarding fruit production LCCA [6]. There are more instruments to perform LCC analysis [25].

This study aims to present the life cycle cost for 1 kg of pear produced using organic technology in Southern Romania.

MATERIALS AND METHODS

Life Cycle Cost Analysis (LCCA) is a technique that uses economic analysis principles to evaluate the whole investment performance [25].

The functional unit considered was 1 kg of fresh pear. Table 1 presents the principal evaluated elements. Two principal stages were depicted: Production stage (PC) and Transport costs (TC). For each stage, investment and operational costs were determined. Pear orchard establishment (POE), the first I-III years of orchard management (investment and operational costs in the period without harvest) (OM.I-III), and IV-XX years of orchard management (OM.IV-XX) were analyzed considering the elemental activities included (Table 1).

Three scenarios were applied for fertilization: (S1) compost produced at the farm level using a composter Oklin GG-50S that can transform

125 kg of organic residues daily in compost (it has been considered an average transforming rate of 15%). This compost is combined with the one produced on an outdoor platform in the farm, mainly from vegetable sources.

Oklin composter needs a daily labor force to input the organic residues and, at a specific time, to take the compost. The outdoor compost platform needs equipment attached to the tractor to oxygenate the organic residues, water to maintain the optimum humidity, and a labor force to operate these tasks.

(S2) uses only compost from the platform for organic residues, equipment attached to the tractor to oxygenate the residues, water to maintain the optimum humidity, and labor force to operate these tasks.

(S3) includes only the acquisition of a commercial organic fertilizer for which we considered 1.5 tons/ha twice per year (concentrated poultry fertilizer).

Table 1. LCCA stages and costs elements on the pear production chain

(A) Production stage (PC)
(I) Pear orchard establishment (POE)
(1) Investment costs for orchard establishment (POEinv)
1.1. Field preparation
1.2. Planting
1.3. Fertilisation
POEinv total cost
(1) Operational costs for orchard establishment (POEop)
1.1. Clearing (deforestation) - process
1.2. Field preparation
1.3. Fertilisation
1.4. Planting
1.5. Trelising system
1.6. Irrigation system
POEop total cost
POE total cost
(II) I-III years orchard management (period without harvest) (OM.I-III)
(1) Investment costs in the first 3 years of the orchard (OMI-III.inv)
2.1. Prunning
2.2. Weeds management
2.3. Fertilisation
2.4. Pest and disease
OMI-III.inv total
(2) Operational costs in the first 3 years of the orchard (OMI-III.op)
2.1. Prunning
2.2. Weeds control
2.3. Fertilisation
2.4. Pest and disease
2.5. Irrigation
OMI-III.op total
OMI-III.inv + OM.I-III.op total
(III) IV-XX years orchard management (OM.IV-XX)
(1) Investment costs (OM.IV-XX.inv)
3.1. Prunning
3.2. Weeds management
3.3. Fertilisation
3.4. Pest and disease
OM.IV-XX.inv total
(2) Operational costs (OM.IV-XX.op)
3.1. Prunning
3.2. Weeds management
3.3. Fertilisation
3.4. Pest and disease
3.5. Irrigation
3.6. Harvesting
OM.IV-XX.op cost total
OM.IV-XX.inv + OM.VI-XX.op cost total
Total cost (A) Production stage (PC).inv
Total cost (A) Production stage (PC).op
Total cost (A) Production stage (PC)
(B) Transport costs (TC)
(2) Operational costs (TCop)
2.1. Transport from the field to cold storage
2.2. Transport from the storage to retail
TC.op total cost

Source: Own presentation on costs elements.

Compost is an ancient fertilizer that is mostly forgotten nowadays. The adverse effects of using chemical fertilizers in all crops and, at the same time, the need to capitalize on the organic residues highlighted the importance of composting at the farm level and not only [26].

The primary composting method is having controlled or uncontrolled composting of organic residues in a specific outdoor space.

More researchers studied the particular rate of the included elements, especially between nitrogen and carbon ratios. Different bacteria can be added to speed up the process with positive results on the output parameters. Also, a specific and highly recommended type of composting is vermicomposting, using earthworms [24].

The classical process usually can last 3 to 6 or more months according to the ratio of humidity and oxygen in the compost. More companies provide equipment for rapid composting with more positive traits (eliminating odours, fast decomposition, high-quality compost).

One of the newest and most innovative is the Oklin brand, tested and used in the University of Agronomic Sciences and Veterinary Medicine of Bucharest since 2021.

Research on the compost quality was done [18] and on the influence of pear production (manuscript, unpublished data).

The present study presents a comparison of LCC-based methodology for 1 kg of pear between (S1) compost from two sources (Oklin composter, concentrated and outdoor platform), (S2) compost from the outdoor platform, and (S3) fertilized with a commercial organic product. Microsoft Excel 2016, with a significance level of $p = 0.05$, was used for the descriptive statistics of the data.

RESULTS AND DISCUSSIONS

The results obtained in the three scenarios were valuable for identifying the life cycle cost (LCC) profile, respectively, hot points where a farm manager can actively intervene to optimize the costs.

The system boundaries were set from the orchard establishment to field production, including harvesting and transport to the storage facility. Total LCC was calculated on the production stage and on the transport stage.

For the production stage, three main periods were determined: pear orchard establishment, orchard management in the first three years (without production), and orchard management in the years IV-XX (with economic production).

Scenario 2 presented the best results considering the costs/functional unit of around 0.400 €/1 kg of pear, where compost from an outdoor platform for composting was used like fertilizer.

This is followed by Scenario 3, acquiring a commercial organic fertilizer with a total LCC of 0.481 €/1 kg. Scenario 1, where a composter (24h) and an outdoor platform for composting were used, had a total LCC of 0.496 €/1 kg of pear (Figure 1).

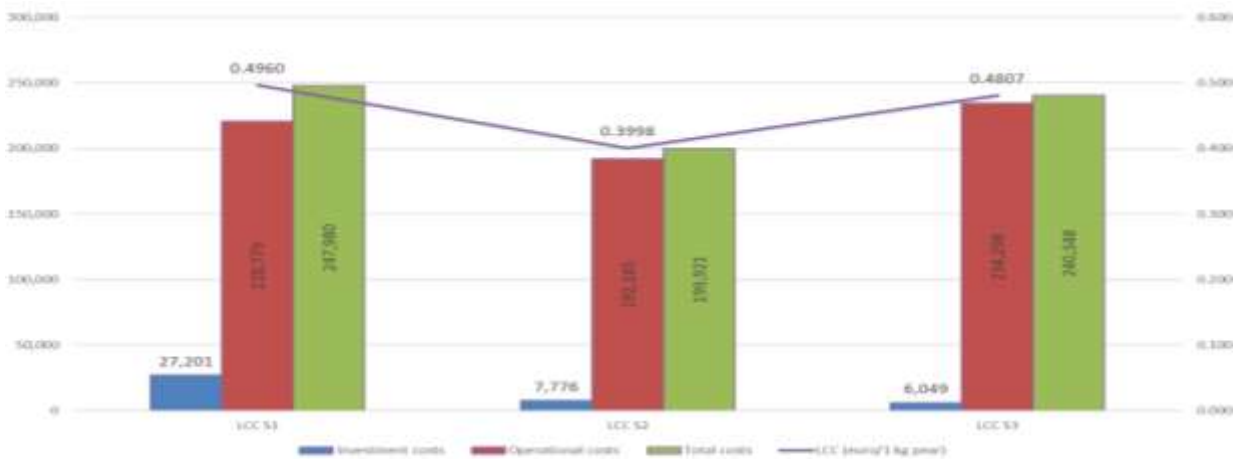

Fig. 1. Total LCC in the three scenarios
Source: own data.

Investment costs were the highest on S1 (0.054 €/1 kg), more than double that of S3 (0.012 €/1 kg) or S2 (0.016 €/1 kg), due to the composter acquisition and equipment usage. S3 had the higher operational costs (0.469 €/1 kg) due to the fertilizer acquisition, followed by S1 (0.442 €/1 kg) and S2 (0.384 €/1 kg) (Figure 1 and Figure 2).

When we analyzed the LCC elements for all scenarios, LCC for the transport stage was similar (0.036 €/1 kg) (Figure 3).

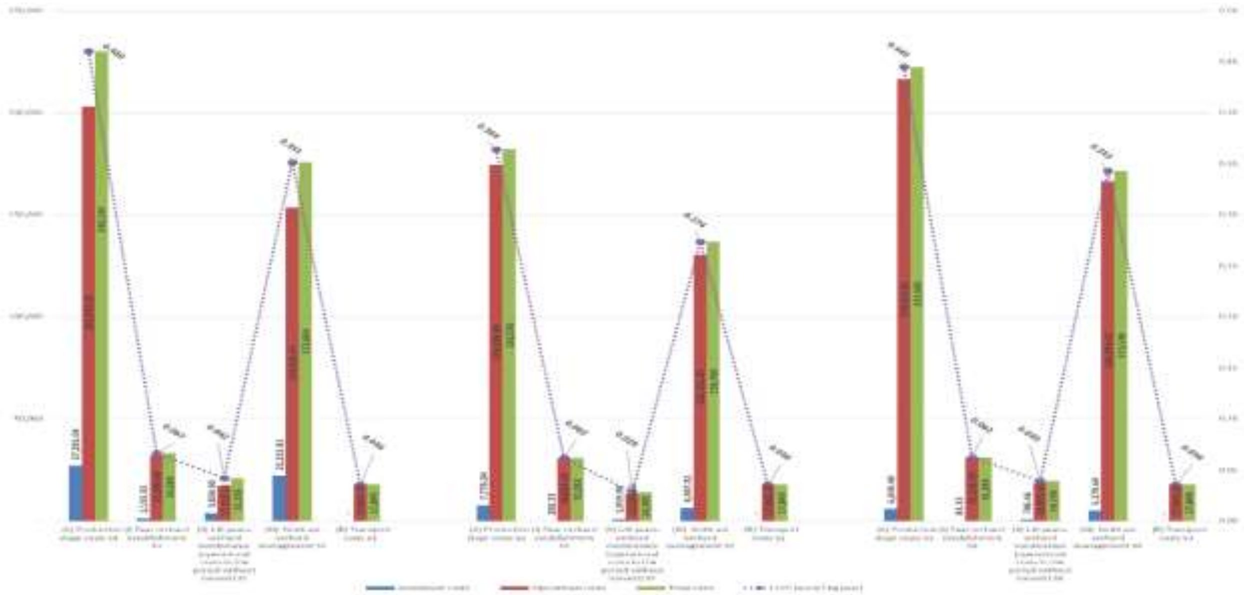

Fig. 2. LCC on the three scenarios detailed in the primary stages
Source: own data.

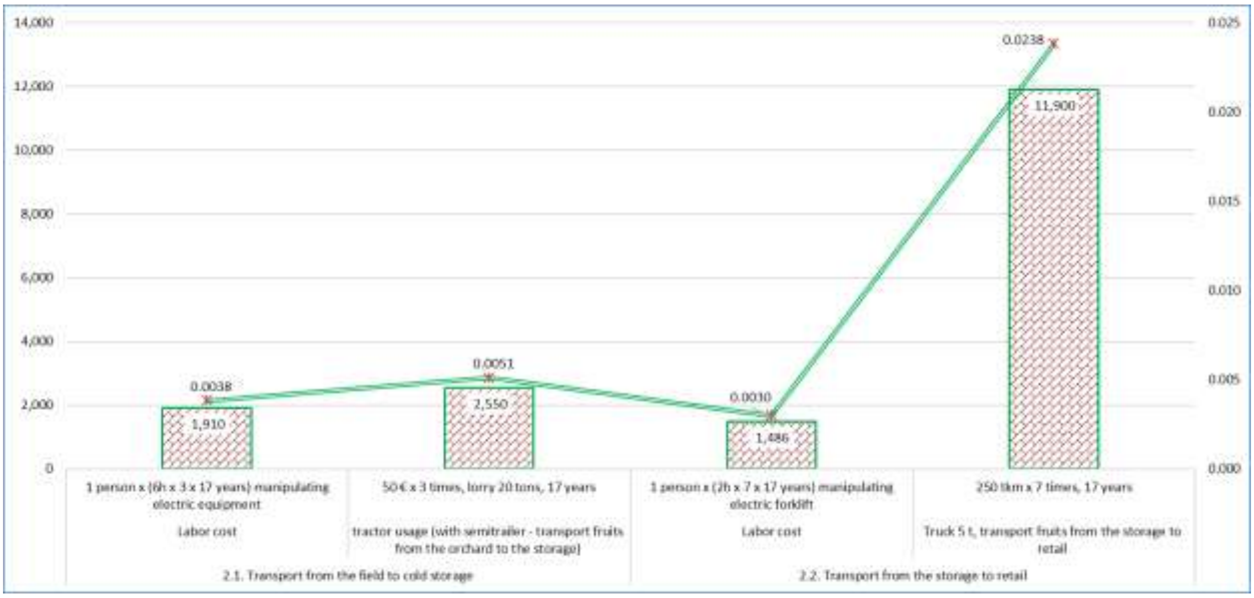

Fig. 3. LCC for the transport stage, Scenario 1
Source: own data.

The principal cost component of the LCC was in the production stage, being analyzed in three main periods: orchard establishment, the first three years of orchard maintenance (where there was no economic production), and the IV-XX years of orchard management (with economic production).

In the **orchard establishment phase**, the main cost in all scenarios was done by irrigation system (0.114 €/1 kg), trellising system (0.027 €/1 kg), and seedlings (0.018

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 4, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

€/1 kg). The costs for the production stage, Scenario 2 are presented below (Figure 4).

In the **first three years**, where no economic production was counted, the main elements in the LCC were at (S1) fertilization (0.121 €/1 kg) and pest and disease (0.014 €/1 kg), at (S2) pest and disease (0.014 €/1 kg) and fertilization (0.004 €/1 kg), and at (S3) pest and disease (0.016 €/1 kg) and fertilization (0.013 €/1 kg).

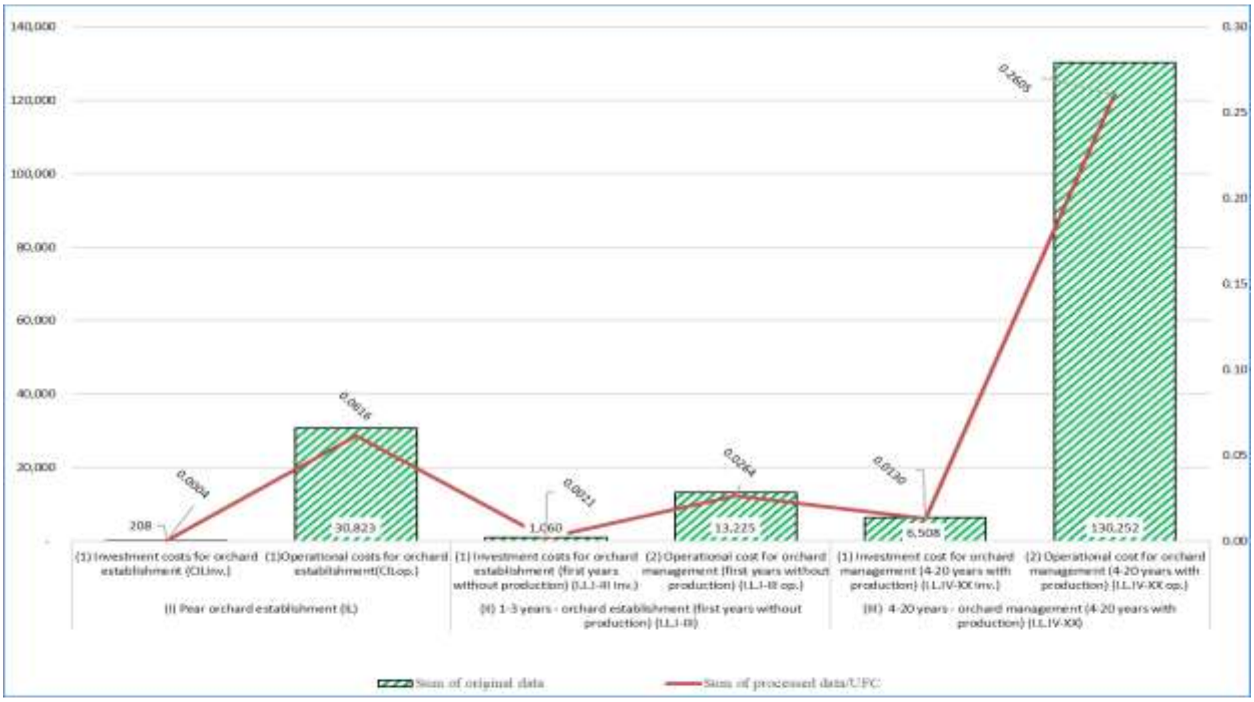

Fig. 4. LCC for the production stage in Scenario 2
Source: own data.

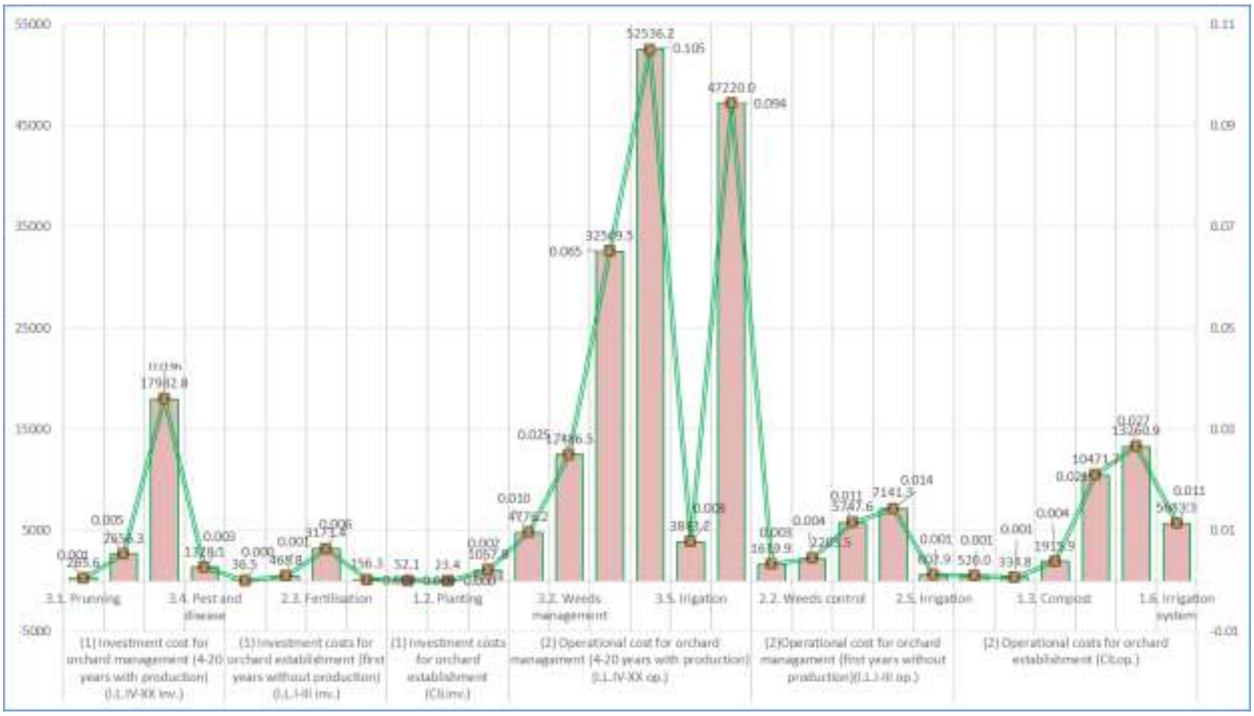

Fig. 5. LCC for the production stage in Scenario 1
Source: own data.

In **the following years (IV-XX)**, the main cost elements were (S1) pest and disease (0.105 €/1 kg), fertilization (0.101 €/1 kg), and harvesting (0.094 €/1 kg). At (S2), the highest values were for pest and disease (0.105 €/1 kg), harvesting (0.094 €/1 kg), and fertilization (0.026 €/1 kg). At (S3), the main costs were due to pest and disease (0.119 €/1 kg), harvesting (0.094 €/1 kg), and fertilization (0.078 €/1 kg) (Figure 4, 5 and 6).

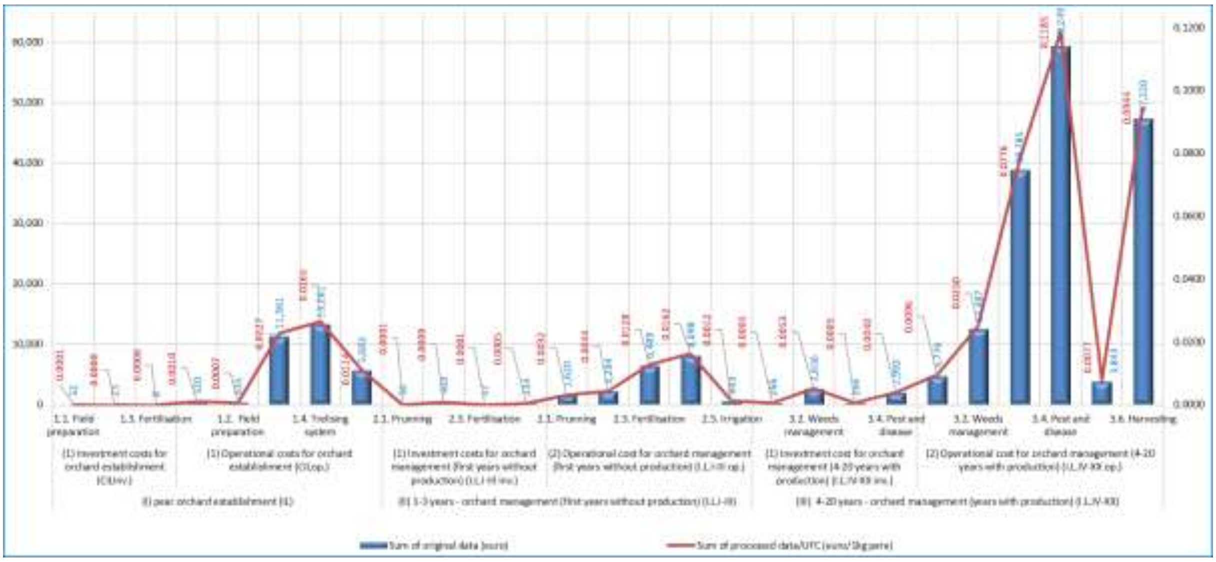

Fig. 6. LCC for the production stage in Scenario 3
Source: own data.

As we can see, the hot points in the LCC analysis were the pest and disease management, fertilization, and harvesting costs in the orchard management periods.
For the harvesting stage, the main operational component was the price for the labor force. At the farm level, for the pear crop, at this moment, we have not found sustainable solutions for optimizing this component. Mechanical harvesting in the pear orchards is in the exploratory stage, and no commercial orchards have included it until now at a large scale. Regarding the fertilization cost, in (S1), the significant component is the labor cost, considering the specificity of the equipment (daily to be fed with organic residues and constantly emptied) and the composter usage. In (S2), the main components are fuel for tractors with equipment and labor force for the compost in the outdoor platform. Optimization had already proceeded; mechanical equipment was being used. In (S3), the most significant component is the price for the fertilizer acquisition. The scenario included an organic fertilizer in a solid state and with agrochemical parameters to be at least similar to the two other scenarios. For optimization, the market price and the source can be thought of in a specific strategy. An essential element of the LCC in the production stage was pest and disease management, with lower values in S1 and S2 and higher in S3.
Mainly in organic agriculture, but not only pests and diseases have to be thought of in correlation with fertilization.
When a comprehensive nutrition program is applied, correlated to growth stages, the plants are healthier, consequently lowering the pest and disease costs.
Compost is a complex fertilizer with specific actions in the plant ecosystem. Many studies highlighted the correlation between compost application in the orchard and the plant status compared to other fertilizers.
In conclusion, for this specific hot point in the LCC, we recommend further specific studies with the two components. Considering the compost specificity, the best scenario for LCC is S2, and after, we can consider S1, although the cost is higher than S3.
Compared to other research results, [22], a study considering 2011 prices in Italy found a total LCC cost of 0.430 €/1 kg of pear for

conventional technology, which is very close to our results.

Considering as a prediction of the revenues on the pear market in Romania, we could take into consideration 1.0 – 1.6 €/1 kg of fruits (higher for organic fruits), which can lead to a difference between revenue and LCC at 0.20-0.62 €/1 kg (S1), 0.22-0.64 €/1 kg (S3), and 0.30-0.72 €/1 kg (S2).

CONCLUSIONS

The broad approach to the production life cycle, as well as the scenarios designed in this article, have guided to the conclusion that the results of the work are innovative and fundamental for the fruit market, especially for the pear farm.

Pear crop is considered to be a highly profitable one, and the study results confirmed. Considering one of the most critical aspects of the technology, fertilization, three scenarios were analyzed and based on the LCC. The best results were for (S2) with compost produced in an outdoor platform, followed by (S3) acquisition of an organic fertilizer, and (S1) a mix of compost produced with an innovative composter and with the outdoor platform. Due to the compost qualities and the recirculation of the organic residues, S1 can be considered compared to S2.

ACKNOWLEDGEMENTS

This work was supported by a grant from the University of Agronomic Sciences and Veterinary Medicine of Bucharest, project number 2021-6/2021.07.17 acronym CIRCULAR-ECO-PĂR, within Joint Junior Competition 2021 and project FDI-2021-0430.

REFERENCES

[1]Andreieş, N., 2017, Achievements in pear breeding obtained at the Research Station for Fruit Growing Voineşti, Voineşti Own Publishing House, 5-48.

[2]Bosona, T., Gebresenbet, G., Dyjakon, A., 2019, Implementing life cycle cost analysis methodology for evaluating agricultural pruning-to-energy initiatives, Bioresource Technology Reports, 6, 54-62, https://doi.org/10.1016/j.biteb.2019.02.006.

[3]Branişte, N., Andreieş, N., Ghidra, V., 2008, Pear genetic breeding to improve the Romanian varieties, Acta Horticulturae, 800, 491-496.

[4]Branişte, N., Budan, S., Butac, M., Militaru, M., 2007, Fruit tree, small fruits and strawberry cultivars released in Romania, Bucharest, Paralela 45 Publishing House, 105-134.

[5]Butcaru, A.C., Mihai, C.A., Barbu (Stan), A., Asănică, A.C., Hoza, D., Stănică, F., 2021, Post-harvest monitoring of pear fruit quality parameters using Da-meter, Annals of the University of Craiova, 26, 21-26.

[6]Butcaru, A.C., Certan, I., Catuneanu, I.L., Stanica, F., Badulescu, L., 2021, A literature review of Life Cycle Cost Analysis technique applied to fruit production, Scientific Papers. Series B, Horticulture, Vol. LXV (2), 19-24.

[7]Chira, L., Chira, A., Delian, E., Ion, L., Nicolae, C., 2020, Studies regarding the economic approach of pear fruits commercialization according to the qualitative aspects, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 20(1), 131-136.

[8]Cimpoieș, G., 2018, Pomicultură specială (Sistematic pomology), Chișinău, Print Caro Publishing House, 96-127.

[9]Davis, M., Coony, R., Gould, S., Daly, A., 2005, A guidelines for Life cycle cost analysis, Stanford University Land and Buildings, 3-27.

[10]Estevan, H., Schaefer, B., 2017, Life Cycle Costing State of the art report, ICLEI – Local Governments for Sustainability, European Secretariat.

[11]European Commission - DG Agri E2, 2022, EU fruit and vegetables market observatory. Pip fruit subgroup. The pear market in the EU Prices, https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/fruit-and-vegetables/pip-fruit-subgroup_en, Accessed on September 11, 2023.

[12]European Platform on Lice cycle Assessment, 2023, ELCD database, https://eplca.jrc.ec.europa.eu, Accessed on September 11, 2023.

[13]Food and Agriculture Organization (FAO), FAOSTAT, 2023, Crops and livestock products, https://www.fao.org/faostat/en/#data/QCL/visualize, Accessed on September 11, 2023.

[14]Fuller, S., 2010, Life-Cycle Cost Analysis (LCCA), National Institute of Standards and Technology, https://www.nist.gov, Accessed on September 11, 2023.

[15]Hunkeler, D., Lichtenvort, K., Rebitzer, G., 2008, Environmental Life Cycle Costing. USA, Boca Raton, FL, CRC Press, 1-53.

[16]Militaru, M., Branişte, N., Sestraş, A., Andreieş, N., Butac, M., Stanciu, C., 2010, Contributions to the improvement of the Romanian pear varieties in the past 10 years, Scientific Papers, Horticulture, Iași, LIII (1), 341-346.

[17]Pândaru, R.C., Butcaru, A.C., Stănică. F., 2019, Behaviour of some new Romanian pear disease

resistant genotypes cultivated in Bucharest area, Scientific Papers. Series B, Horticulture. LXIII (2), 87-94.

[18]Peticilă, A.G., Madjar, R.M., Drăghici, E.M., Stănică, F., Asănică, A.C., Butcaru, A.C., 2023, Results regarding the 24-hour composts (Oklin) composition and their use as fertiliser, Scientific Papers Series B, LXVII (2).

[19]Perera, O., Morton, B., Perfrement, T., 2009, Life Cycle Costing a question of value, International Institute for Sustainable Development (IISD), http://www.iisd.org, Accessed on September 11, 2023.

[20]Selina Wamucii.com, 2023, US Pears Prices, https://www.selinawamucii.com/insights/prices/united-states-of-america/pears/#:~:text=The%20retail%20price%20range%20for%20US%20pears%20in,US%24%200.45%20and%20US%24%200.91%20per%20pound%20%28lb%29, Accessed on September 11, 2023.

[21]Stănică, F., Butcaru, A.C., Pândaru, R.C., Asănică, A.C., Mihai, C.A., Bezdadea-Cătuneanu, I.L., Andrieș, N., 2022, Behaviour of Romanian pear cultivars self-rooted and grafted on pear and quince rootstocks under Parallel U and Trident training systems, Acta Hortic. 1346, 311-318.

[22]Tamburini, E., Pedrini, P., Marchetti, M.G., Fano, E.A., Castaldelli, G., 2015, Life Cycle based evaluation of environmental and economic impacts of agricultural productions in the Mediterranean Area. Sustainability, 7, 2915-2935. https://doi.org/10.3390/su7032915.

[23]Tridge, 2023, Fresh Pear, https://www.tridge.com/intelligences/pear/RO/price, Accessed on September 11, 2023.

[24]Usman, A., Sajid, N., Khalid, A., Riaz, L., Rabbani, M.M., Syed, J.H., Malik, R.N., 2015, A review on vermicomposting of organic Wastes, Environmental Progress & Sustainable Energy, Wiley Online Library, DOI 10.1002/ep.12100, 1-13.

[25]Vlad, I.M., Butcaru A.C., Bădulescu, L.A., Fîntîneru, G., Certan, I., 2022, Review on the tools used in the Life Cycle Cost Analysis, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(4), 807-816.

[26]von Heynitz, K., 2012, Compostul în gospodărie (Compost in the household). Casa Publishing House, 6-92.