International Journal of Horticultural Science 2018, 24 (1-2): 28-38.
https://doi.org/10.31421/IJHS/24/1-2./1544

Effect of postharvest on the economic viability of walnut production

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Summary: In this study we were studying the question whether walnut production under domestic natural and economic circumstances shall be considered a profitable activity or not. Our partial objective is to determine, what level of natural inputs and production costs are required for walnut production, what yield level, selling price and production value can be attained, what level of profitability, rentability and efficiency may production have, is the establishment of a walnut orchard profitable on the entire lifespan of the plantation, and the production of which is more efficient: the dry shelled walnut production requiring postharvest activity or the raw, shelled walnut without postharvest activities. In this study, comparison of two systems is conducted. First version: producer establishes a walnut plantation and sells walnut raw and shelled. Second version: producer also invests into a drying facility, and in this case the end product is the dry, shelled walnut. If the producer sells walnut right after harvest in a raw bulk, total production costs in productive years reaches 974,011 HUF/ha. Attainable yield is 2.63 t/ha with 396.3 HUF/kg selling price, therefore the profit is 138,258 HUF/ha with 14.19% cost-related profitability. In the case when the producer sells dried, shelled walnut, production costs are 25% higher compared to that of raw walnut due to the cost of drying. By calculating with the postharvest loss, average yield is 1.84 t/ha, however, its selling price is way higher (882.84 HUF/kg), therefore the profit per hectare reaches 475,496 HUF with 39.01% cost-related profitability. Thus it can be stated that walnut production in an average year may be profitable even without postharvest, but efficiency is improved significantly when the producer sells the products dried. Investment profitability analysis revealed that production of raw, shelled walnut is not economically viable, since the plantation does not pay off on its entire lifespan (30 years), while walnut production with postharvest is efficient and rentable, since both net present value (NPV) and internal rate of return (IRR) showed more favourable values than in the previous case, and the orchard pays off in the 21th year after establishment.

Apáti, F., Kovács, E., Kocsis, M. (2018): Effect of postharvest on the economic viability of walnut production. International Journal of Horticultural Science 24 (1-2): 28-38. https://doi.org/10.31421/IJHS/24/1-2./1544

Key words: walnut, walnut production, postharvest, cost-benefit analysis, investment profitability analysis

Introduction

The output of the Hungarian fruit and vegetable sector in value is approximatively 280 billion HUF. The 850 thousand tons of fruit produced on 92 thousand hectares shows stagnation on a long term, but walnut production is significantly increasing (Fruitveb, 2016). The total global production is around 3 million tons of shelled walnuts on approximatively 1 million hectares production area. The largest producer of the world is China with 46% of total production and the United States with a 15% proportion in global production. The European Union has a 5% share in global walnut production. Globally, the volume of walnut production is around 3 million tons on approximatively 1 million hectares. The largest producer of the world is China with 46% of total production and the United States with 15% share in global production. The European Union produces 5% of global walnut production. Hungary produces 0.12% of global production which means 2.5% of European production. In 2014 Hungary produced 4,320 tons of walnuts which is a 5% decrease compared to the previous year (Faostat, 2014). The largest walnut exporter globally is the United States with 52% share of total exported volume. The largest importer is China with 20% of total imported volume (Eurostat, 2016). In the period beginning with 2010 the volume of exported shelled walnuts has been growing continuously, in 2016 this volume attained 1,400 tons (1 billion HUF in value) which is a 50% growth compared to 2010. The exported volume of nutmeat is 1600 tons, 3 billion HUF in value. The average sale price of shelled walnut is around 900 HUF/kg while that of nutmeat is 1,700 HUF/kg. These prices are stable on a long term, no significant fluctuation can be observed between different years (Eurostat, 2016). In Hungary, 5-6 thousand tons of walnut is produced annually on approximatively 6,400 hectares (NAK, 2016). Compared to 2000 the production area of walnut has been doubled, thus only walnut and elderberry are the two fruit species that showed increase both in terms of production area and volume in Hungary during the last 15 years while all other fruit species showed decline (Apáti et al., 2016). NAK (2016) supports the renewal of walnut production by showing that the majority of Hungarian walnut orchards are old, there is no common strategy and information sharing among producers, and another objective should be to increase yields which are currently around 2.0-2,5 t/ha. According to the Farm

StructureCensus the average size of walnut production area per one farm is 2.33 hectares, compared to France (5-7 hectares) and the United States (approx. 20 hectares) (Hennicke (2011).

Walnut can leave the production site or farm in two forms. The first one is the unhusked, raw, shelled walnut harvested at 20-45% moisture content. This is the product of farms that do not possess postharvest infrastructure with special regard to drying capacity. The second product is the dry shelled walnut dried to 7% moisture content with postharvest process. Walnut as a product shows up in commerce in two forms: as a dry shelled walnut, and after cracking as nutmeat.

Expectations against a walnut cultivar is the long shelf-life of the crop, and it should be cracked easily and cleaned efficiently. In case of the dried shelled walnut several different characteristics are considered at the classification, such objective characteristics are the diameter of the nut, volume, shell thickness, crackability, meat ratio (crackout). There are also subjective characteristics like colour and surface of the shell and taste. Walnut can be sold in two forms, these are the shelled and unshelled (nutmeat) walnuts (Bujdosó et. al., 2011). Nutmeat is collected from households, commercial production facilities and farms crack only walnuts below 28 mm that cannot be sold as shelled walnuts. Raw shelled walnuts are never marketed, since these are wet and therefore can only be stored for 5-10 days. According to Bujdosó et. al. (2011) the Hungarian walnut has more positive characteristics in the shelled walnut category, e.g. The average nut diameter can attain 32 mm that falls into the I. class product size category. Product in the quality shelled walnut category is expected to have a uniform 32 mm diameter, light colour, appropriate shape and wrinkling. Walnuts of size 27-28 mm can also be sold but do not classify as I. class products. In case of nutmeat, halved kernels are considered as first class products, quartered kernels are considered as of inferior quality (G. Tóth, 2004).

According to Ledó (2015) postharvest process includes storage, classification, packaging, the word itself means activities, processes after harvesting like cooling or market arrangement. These processes have significant capital requirement. According to Apáti-Bálint (2007) postharvest process includes the activities following harvest, like storage, product preparation, marketing, logistics and commerce. These activities have significant impact on cost-benefit characteristics and value creation of production.

Objectives

Economic viability of production is determined by costs, revenues and profit of farming. In case of walnut production two types of products can be differentiated, these are the raw, shelled walnut and the dry shelled walnut. The sales price of the raw walnut - as my results from primary data collection show - is 396.30 HUF/kg in the average of several years, while the average selling price of dry shelled walnut is 882.80 HUF/kg. Thus it can be stated that the selling price of dry shelled walnut that underwent the postharvest process is far higher, however, postharvest process means a significant amount of plus costs and causes an approx. 30% weight reduction. Therefore, the objective of this study is to find an answer to the question which system has greater economic viability: either the sales of less expensive raw, shelled walnut or the dry shelled walnut production with the plus costs of investment and operation of a postharvest infrastructure.

In this study, the following main objective and the following lesser tasks have been determined in the case of both products as questions to be answered:

Is walnut production under domestic natural and economic circumstances an economically viable activity or not?

- What natural inputs and production costs are necessary for walnut production?
- What yield levels, selling prices and production values can be reached?
- What revenue generating capacity, profitability and efficiency are characteristic for the production?
- Is the establishment of a walnut plantation economically viable on the entire lifespan of the plantation - and if yes, under what conditions?
- Which is more effective, either the production of dry shelled walnut with postharvest activity or the raw, shelled walnut without postharvest activity?

Materials and methods

The subject of the study is a classical farm economic analysis in the course of which cost-benefit analysis and investment profitability analysis were conducted. To answer the question of the main objective, two complete systems were compared based on average models. The first system is a walnut plantation where the output product is the raw, shelled walnut. The second system is a walnut plantation with a postharvest facility, where the output product is the dry, shelled walnut.

In this study, we examined walnut plantations with good management standard, in a good condition and with a traditional growing system with the related postharvest cost and revenue characteristics. The parameters of the examined orchard type and drying facility are as follows:

- 10.0 m row space, 10.0 m tree spacing, thus 100 fa/ha tree density.
- Cultivars are decisively represented by Alsószentiváni 117, Milotai 10 and Tiszacsécsi 83.
- Irrigation with micro sprinklers, drip irrigation, 1/3 of the model plantation is irrigated.
- Combined harvest which means machine shaking and hand picking.
- The 5-year average yield is 2.63 t/ha in raw weight and 1.84 t/ha in dry weight, these two values are equivalent supposing 30% weight loss in the postharvest process.
- The end product is undried, raw, shelled walnut and dried, stored and packaged shelled walnut.
- The average selling price of raw, shelled walnut is 396.30 HUF/kg, and 882.80 HUF/kg of dry shelled walnut.
- The capacity of the drying facility of good standard is 700 - 1,000 t/season.

The investment cost of the drying facility includes the building, the technological equipment (washer, drier, sorting, packaging machine) and all other kinds of infrastructure. The capacity of the drying facility in 700 - 1,000 t/season, therefore it is capable of drying the crop of approx. 500 ha, cost: 303,328 thHUF.

The central element of data collection was the registration of natural inputs of production technology at the commercial production farms and facilities, and the primary result of production is shown by natural yields. In relation to this approach, the used quantity of input materials was sent by facilities and farms, and the price of input materials has been collected from the price lists of the relevant distributors. Yield data and selling prices were also sent by farms.

The prices of used inputs (materials, handwork, machine work) and prime costs reflects the price levels of 2015-2017, the prices of materials are presented without VAT (ÁFA) while wage costs of handwork with contributions. Time work has been calculated with 1,000 HUF/h cost and has been charged for each and every work hour utilized, irrespectively whether it came from paid or unpaid family workforce. Selling prices and yields are represented by 5-year averages. Data collection serving as a base for analyses has been conducted at walnut producing enterprises, the processed data came from 9 production facilities. These farms had a total production area of 600 ha, that represents 10% of total domestic productive area, thus the study is not representatives, but gives a true overview of the economic characteristics of the plantations of good standard (upper third).

Classical cost-benefit analysis and investment profitability analysis were conducted in order to conduct the economic analysis of walnut production and postharvest activities. Quantification of input and output indices of production in conducted in the classical cost-benefit analysis. Data were processed in a simulation-deterministic farm economic model based on Microsoft Excel. This model is able to quantify production costs and revenues, calculate efficiency indicators and conduct sensitivity analyses as well. The cost-benefit analysis was conducted according to the methodology of the Debrecen School of Farm Economy.

We applied static and dynamic indicators in our investment profitability analysis calculations, and evaluated the static payback period, cumulated cash flow, NPV (Net Present Value), DPP (Discounted Payback Period), IRR (Internal Rate of Return) and return on capital employed. The difference between static and dynamic indicators is the consideration of time value of money in calculations (Brealey - Myers, 2005). Calculations were made in the investment profitability model at the currently relevant prices, thus no inflation was considered on both input and output sides. Depreciation costs were not included among the expenses, nor its tax-shield effect has been considered. The reason for this was that the tax on profit payable is determined on company level, while our analysis just dealt with a part of the entire enterprise. The value of discount rate was determined in 3% by considering the relevant, currently available bank interest rates of government securities.

Company level was examined both during the analysis of cost-benefit analyses of production and investment-profitability analyses, this means that direct subsidies and general costs are also included in the calculations.

For answering the question set as the main objective, the approach in the doctoral thesis of Szabó (2016) was utilized. Szabó (2016) studied the economic viability of an apple storage facility in three kinds of combinations by handling the stage of production and postharvest as a unified, complete system. In the first case he analyzed only the investment of an apple orchard, in the second case the plantation was complemented with a cold storage facility investment, and in the third case there has also been a cold storage facility, sorting and packaging facility along with the apple orchard. He conducted investment profitability analysis for all the three combinations, thus models were compared on the basis of NPV, DPP, PI and IRR indicators. Cost-benefit analysis and investment profitability analysis were complemented with sensitivity analysis (Szűcs, 2004). This helps to determine the efficiency of production in case of emergence of abnormal conditions. Elasticity calculations help us to determine which factors have the greatest impact on the results of production. Critical value analysis helps us the determine what level of yield and price levels shall be reached to complete the minimum expected level of economic viability. Besides average version, we also create an optimistic and a pessimistic scenario in scenario analysis (Szőllősi - Szűcs, 2015). The BEC (break-even-chart) differentiates between fixed and variable costs when studying the reaction of costs (Bálint et.al., 2007). „Contribution volume shows that the per unit contribution of what product volume ensures the coverage of fixed costs (Nábrádi - Felföldi, 2008)".

Banaeian - Zangeneh (2011) conducted the economic analysis of walnut production in Iraq, and determined the production cost and production value. The yield of walnut became 2.2 t/ha, the selling price approx. 250 HUF/kg, therefore walnut production is profitable if the income is 520.000 HUF/ha. Krueger et al., (2012) showed the cost and revenue characteristics of walnut production in California also based upon the methodology of cost-benefit analysis. Calculations of the study were based on the data of an irrigated walnut plantation of 100 ha. The attainable yield is around 1 t/ha, and the production proved to be profitable.

Results

In the first part of the evaluation we present in detail the revenues and expenses in the investment period of the walnut plantation, then we are going to evaluate the cost-income characteristics of a productive orchard in an average, established technology, then we present an investment profitability analysis for the entire lifespan of the plantation.

Investment period

The establishment cost of a good standard walnut plantation introduced in the previous section in detail sums up to a total of 1,700,000 HUF/ha with the highest costs attributed to grafted trees and planting, landscape and soil preparation and building of the irrigation system. A modern but traditionally managed walnut orchard does not require a support system, but water-efficient dripping irrigation system is considered to be an organic part of the technology. Considering that 1/3 of the area of the data providing plantations are irrigated, this analysis also calculates with 1/3 irrigated area of the orchard.

A walnut plantation reaches full productive age at the age of 9, which means that the income from production exceeds operational costs. In the first 8 years caring costs sum up to 3,575,000 HUF/ha, therefore total investment cost along with establishment cost is 5,275,000 HUF/ha. No significant crop can be expected in the first 5 years following establishment, and between Year 6 and 8 the yield in total is 3.21 t/ha with a revenue of 1,273,000 HUF/ha. The orchard will be able to produce maximum crop, therefore a so-called transitional period sets in between Year 9 and 13, when yields are gradually increasing until the maximum yield of 2.60-2.80 t/ha is reached. Thus the net investment cost is 4,001,000 HUF/ha, and by calculating with 22 years of depreciation, the amount of amortization is 181,000 HUF/ha/year.

The total investment cost of the walnut drying facility is 33,328,000 HUF with the capacity to dry the crop of approx.

500 hectares, therefore the investment cost per one hectare is 606,656 HUF. Supposing 10 year of useful life, depreciation cost is 60,656 HUF/ha *(Table 1)*.

In both versions the total investment cost of the walnut plantation is identical. This includes the establishment cost of the plantation, the caring costs until the age of fruit-bearing with a total value of 5,275,000 HUF/ha. The investment cost of the drying facility shows up in the second version with a value of 606,656 HUF/ha. Therefore, the total investment cost in the first version is 5,275,000 HUF/ha, while it is 5,881,656 HUF/ha in the second version, which means that investment cost per hectare is 11.5% higher if a drying facility is built.

Table 1. Investment cost of the examined walnut orchard and drying facility

Name	Cost (thHUF/ha)
Walnut plantation	
Landscape and soil preparation	550
Support system	0
Grafted trees and planting	600
Irrigation system	300
Other	250
Total establishment costs	**1,700**
Caring costs until fruit-bearing age (8 years)	3,575
Total investment cost	**5,275**
Income until fruit-bearing age	1,273
Net investment cost	**4,001**
Annual depreciation cost in fruit-bearing age	181
Drying facility	
Investment cost of drying facility	**606**
Annual depreciation cost	60

Source: own calculation

Inputs and production cost in fruit-bearing age

The costs in an average productive year of a walnut plantation were studied as a complete system in both versions. In the first case the sold product is raw, shelled walnut. In this version the producer sells the product immediately after harvest with 20-45% moisture content. In the second case the sold product is dry, shelled walnut, which means that after harvest the producer will dry, package and store the crop. If the producer sells the raw walnut, direct production cost is 885,465 HUF/ha, 54% of which is constituted by plant protection and harvesting. The direct cost of one kg raw walnut is 338 HUF/kg. In case of the production of dry, shelled walnut the direct production cost is 1,108,051 HUF/ha with the three main cost items being plant protection, postharvest and harvesting constituting 63% of total direct costs. The direct cost of one kg dry, shelled walnut is 602 HUF/kg *(Table 2)*.

It can be stated that in the case when the end product is the raw walnut, total production cost is 974,011 HUF/ha and prime cost is 371 HUF/kg. Total production costs of dried, shelled walnut is 1,218,856 HUF/ha and the prime cost is 662 HUF/kg, therefore production cost is 25% higher, and the reason of difference is the postharvest cost. The difference in prime costs is way higher, since 25% higher production cost comes along with 30% lower marketed yield.

The difference between the two average models compared is the postharvest operation, therefore the economic analysis of this operation will be detailed below. Cost of product preparation including washing, drying and sorting is 54 HUF/one kg dried walnut that includes both material, personal and machinery costs of washing, drying and sorting. The dried, shelled walnuts are packaged into 10 kg sacks with an operation cost of 12 HUF/kg. The sales, transport and stowage costs sum up to 22 HUF/kg, thus the postharvest operational cost of walnut is 88 HUF/kg. If the depreciation cost of the drying facility is also considered, the postharvest cost sums up to 121 HUF/kg *(Table 3)*.

Table 2. Production cost of walnut plantation by different types of production operations in a full productive year

Operation	Product: Raw walnut (Yield: 2.63 t/ha)		Product: Dried walnut (Yield: 1.84 t/ha)	
	Cost (HUF/ha)	Cost (HUF/kg)	Cost (HUF/ha)	Cost (HUF/kg)
Pruning	32,000	12	32,000	17
Tillage, interrow cultivation	66,300	25	66,300	25
Fertilization	93,727	36	93,727	51
Plant protection	279,039	106	279,039	152
Irrigation	14,850	6	14,850	8
Harvest	192,600	73	192,600	105
Other	25,000	10	25,000	14
Orchard depreciation	181,949	69	181,949	99
PRODUCTION COST	**885,465**	**337**	**885,465**	**481**
Postharvest cost	0	0	222,586	121
TOTAL DIRECT COST	**885,465**	**337**	**1,108 051**	**602**
General cost	88,546	34	110,805	60
TOTAL PRODUCTION COST	**974,011**	**371**	**1,218 856**	**662**

Source: own data collection and calculation

Table 3. Postharvest cost of walnut as per dried walnuts

Name	Cost (HUF/kg)	Cost (HUF/ha)
Product preparation (washing, drying, sorting)	54	99,360
Packaging	12	22,080
Sales cost	17	31,280
Transport, stowage	5	9,200
Operation cost	**88**	**161,920**
Depreciation	33	60,666
Total direct cost	**121**	**222,586**

Source: own data collection and calculation

Yield, production value, income and profitability in productive age

The difference between the two products is 30% weight loss considering the output, since the moisture content of the raw walnut is around 20-45% (32% in average), that has to be dried to 7%, therefore 25% weight loss can be calculated at drying. An additional 5% weight loss is due to decreasing quality. According to the data from the last 5 years, the average yield of raw walnut has been 2.63 t/ha in the studied farms that is equal to 1.84 t/ha dried walnuts *(Table 4)*.

The selling prices of the two products vary greatly. While raw walnut was marketed in the last 5 years at an average price of 396.30 HUF/kg price then the dried shelled walnut was sold for a price more than twice of that, namely 882.84 HUF/kg, thus those producers who produced dried, shelled walnuts gained 486.54 HUF higher price for one kilogram. Based on these data the attainable income in case of selling raw walnut is 1,042,269 HUF/ha while the income is 55.8% higher, 1,624,352 HUF/ha in the case of dried walnut. SASP subsidy was also calculated with in the analysis. The product-level attainable profit in case of raw walnut was 226,804 HUF/ha while it was 586,301 HUF/ha for dried walnut, which means that 359,497 HUF/ha more profit can be obtained after drying. On company level it can be stated that in case of raw walnut production the attainable profit (net income) is 138,258 HUF/ha with 14.19% cost related profitability, but due to the higher selling price of dried shelled walnut the attainable profit is 475,496 HUF/ha with 39.01% cost-related profitability even if its cost is higher by 222,586 HUF/ha. The prime cost of raw walnut is 370.35 HUF/kg which is paired with 396.30 HUF/kg selling price, while the prime cost of dried walnut is 662.42 HUF/kg with 882.84 HUF/kg. Therefore, the profit for 1 kg raw walnut is 25.95 HUF, while the profit for 1 kg dried walnut is 220.38 HUF without direct subsidies. It can be stated that the production of both raw and dried walnut is profitable, but by selling shelled walnut after drying 55.8% higher income and 3.4 times higher profit can be obtained.

Table 4. Income, profit and profitability of the walnut plantation in a full productive year in case of different products

Name	**Unit**	**Product: Raw walnut**	**Product: Dried walnut**
Yield (t/ha)	**t/ha**	2.63	1.84
Selling price	HUF/kg	396.30	882.84
Revenue (HUF/ha)	**HUF/ha**	**1,042 269.00**	**1,624,352.00**
SAPS	HUF/ha	70,000.00	70,000.00
Total revenue	**HUF/ha**	**1,112,269.00**	**1,694,352.00**
Direct production cost	HUF/ha	885,465.00	1,108,051.00
Total production cost	HUF/ha	974,011.00	1,218,856.00
Contribution margin	**HUF/ha**	**226,804.00**	**586,301.00**
General cost	**HUF/ha**	**88,546.00**	**110,805.00**
Net income	**HUF/ha**	**138,258.00**	**475,496.00**
Cash flow	**HUF/ha**	**408,753.00**	**768,250.00**
Direct cost related profitability	%	25.61	52.91
Cost-related profitability	%	14.19	39.01
Prime cost	**HUF/kg**	**370.35**	**662.42**

Source: own data collection and calculation
Note: both products are marketed in-shell

Sensitivity analysis of cost-income characteristics of productive age

Elasticity calculations

Elasticity analysis reveals how 1% change in the affecting factor will impact the main profitability indicators. Since the most important indicator is the income, we assessed the impacts of the factors on contribution margin, net income and cost-related profitability. The favourable case during the changes in a positive direction of income affecting factors were the 1% increase of original values of yield and selling price, while in case of costs 1% reduction was the positive case. Based on the data of *Table 5* it can be seen that change of selling price has the greatest impact on contribution margin and net income in the course of both raw and dried walnut production, and the change of yield had the second most important impact. Similar proportion can be seen in case of cost-related profitability. Among the costs, the change in machine work costs had the greatest effect on income, this was followed by input material costs and finally personal costs. It became visible that values of elasticity are higher in the calculation of raw walnut production, this means that the income characteristics of this technology react more sensitively to the change in affecting factors. Thus it can be stated that in both examined technological variant of walnut production the changes in selling price and yield exert the greatest impact followed by the changes in cost of machine work costs and input materials, and finally the changes in personal costs.

Table 5. Elasticity values of main factors affecting income and profitability

Name	**Factor**	***Contribution margin***	***Net income***	***Cost-related profitability***
		unit: %		
Product: raw walnut	Yield	3.47	5.64	5.59
	Selling price	4.68	7.55	7.50
	Input material cost	1.24	2.24	2.55
	Machine work cost	1.38	2.46	2.81
	Personal cost	0.70	1.25	1.46
Product: dried walnut	Yield	2.64	3.25	3.11
	Selling price	2.81	3.45	3.49
	Input material cost	0.48	0.65	0.92
	Machine work cost	0.54	0.67	1.02
	Personal cost	0.27	0.37	0.49

Source: own data collection and calculation

Critical value analysis

Critical value analysis examines those critical values of the affecting factors at which the income is equal to zero. Based on the results obtained from elasticity calculations the selling price and the yield were the two factors having greatest impact on income, therefore the critical values of these factors shall be quantified. General cost was not included in the critical value calculations, but direct subsidies were utilized.

The value of critical yield can be determined by using the BEC separately for raw and dried walnut production. The break-even-chart (BEC) differentiates between fixed and variable costs when studying the reaction of costs (Bálint et.al., 2007). „Break-even point determines the volume where nor profit nor loss is incurred, since income and production costs are equal (Bálint et.al., 2007).” The relevant yield range selected in the course of contribution margin calculation is between 1.00-4.00 t/ha in case of raw and 0.70-3.70 t/ha in case of dried walnut production. Walnut production - similarly to the majority of fruit species - may be affected most importantly by weather factors, but the effect of these on the crop is not known before harvest. Therefore, the cost of operations before harvest can be considered as fixed by assuming an “established” technology and average annual condition, since these operations shall be conducted irrespective of the volume of the yield. The cost of harvest may be accounted in two cost types. The cost of machine harvest (machine shaking) is fix in its entirety. The cost of hand picking is partially fixed, since 83% of working hours are incurred irrespectively from the yield, only the remaining part may change as function of the yield. These cost items belong to the variable costs in case of production of raw walnut, but if the producer will dry the product, then the operation costs of the postharvest process will also belong to the variable costs (unhusking, washing, drying, sorting, packaging, selling, transport, stowage).

Figure 1 shows the break-even chart of raw walnut production. Fix cost is 832,865 HUF/ha; this amount does not depend on the quantity of the crop. Variable cost (AVC=20,000 HUF/t) increases those costs that are reacting to the change in quantity proportionally to the increase in yield. The total direct cost of production is in the range of 852,865 HUF/ha and 912,865 HUF/ha in case of 1.00-4.00 t/ha yields. Income can increase from 396,300 HUF/ha to 1,585,200 HUF/ha in case of the studied technology. Contribution margin is the difference between income and total direct costs that changes to positive range above 2.00 t/ha average yield. The following formula is used to calculate the value of critical yield: fix cost / unit price minus average variable cost; FC/p-AVC) (Nábrádi - Felföldi, 2008). The result of this calculation shows that the critical product quantity belonging to zero contribution margin is 2.21 t/ha in raw weight, which means that this yield has to be reached to avoid loss. Our calculations did not include general cost and SAPS subsidies, therefore the BEC was determined on product level, without subsidies.

Figure 2 shows the break-even chart of dried walnut production. Fix cost is 893,531 HUF/ha; this amount does not depend on the quantity of the crop. Variable cost (AVC=116,571 HUF/t) increases those costs that are reacting to the change in quantity proportionally to the increase in yield. The total direct cost of production is in the range of 975,131 HUF/ha and 1,324,845 HUF/ha in case of 0.70-3.70 t/ha yields. Income can increase from 617,960 HUF/ha to 3,266,360 HUF/ha in case of the studied technology. The critical yield belonging to zero contribution margin is 1.17 t/ha in dry weight.

Table 6 shows the critical values of main factors that exert the greatest impact on income. The first column lists the affecting factors indicated separately for raw and dried walnut production. The second column shown the critical value - this is the value that has to be reached to attain a production result of zero. We also indicated the base or baseline value, and the difference between critical and original values. The value of critical yield in raw weight is 2.21 t/ha (disregarding SAPS), which means that compared to the 2.63 t/ha yield used in the calculation even a 15.97% decrease in yield will be sufficient to reach the turning point of profitability. In case when dried walnut is the product after harvest, the critical value disregarding SAPS is 1.17 t/ha compared to the baseline value of 1.84 t/ha, which means that a 36.42% decrease in yield will result in zero profit. By including SAPS, even a yield decrease of 0.57 t/ha in case of raw and 0.73 t/ha yield decrease in dried walnut can be allowed to reach the critical values.

The critical selling price is the direct prime cost itself when disregarding subsidies. If we include SAPS, the value of critical selling price will be 310.06 HUF/kg for raw, and 564.21 HUF/kg for dried walnut. This means that compared to the baseline value, a 21.76% decrease in average price of raw walnut, and a 36.09% decrease in the selling price of dried walnut will give us a zero contribution margin.

Thus it can be stated that by producing raw walnut, a smaller change compared to baseline values will result in turning the production into loss. In comparison, in case of dried walnut production a much higher change will be necessary to turn production into loss.

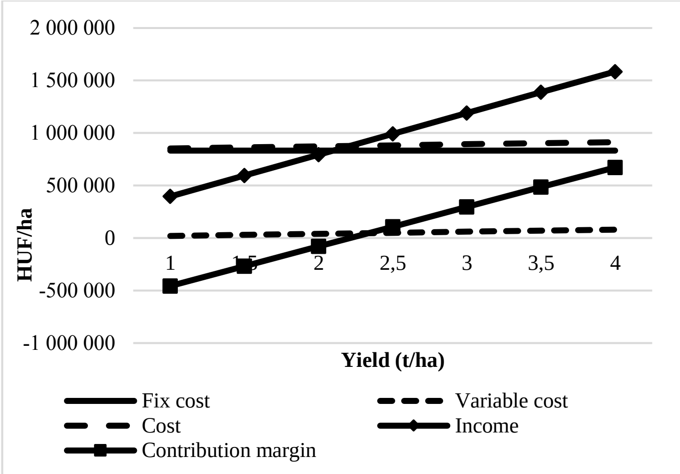

Figure 1. Break-even chart of raw walnut production on the level of direct costs and contribution margin
Source: Own calculation

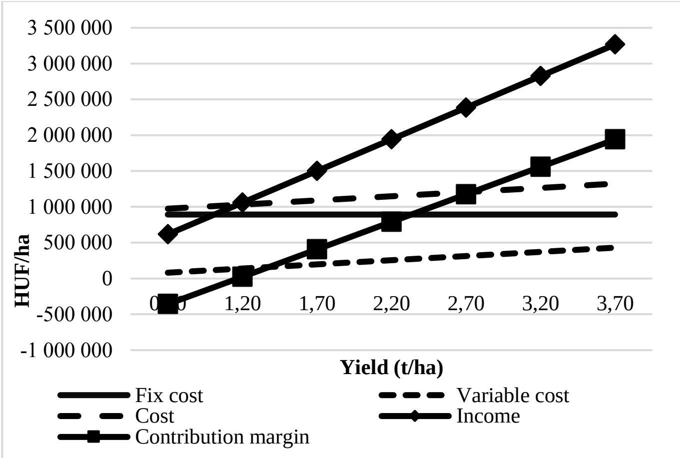

Figure 2. Break-even chart of dried walnut production on the level of direct costs and contribution margin
Source: Own calculation

Table 6. Critical values of main factors affecting profit (contribution margin = 0)

Name	Critical value		Baseline value		Difference	
	Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
Yield with subsidies (t/ha)	2.06	1.11	2.63	1.84	-21.68	-39.67
Yield without subsidies (t/ha)	2.21	1.17	2.63	1.84	-15.97%	-36.42%
Selling price with subsidies (HUF/kg)	310.06	564.21	396.30	882.80	-21.76%	-36.09%
Selling price without subsidies (HUF/kg)	336.68	602.20	396.30	882.80	-15.04%	-31.74%

Source: own data collection and calculation

Scenario analysis

In the course of scenario analysis, we assessed three different scenarios in which simultaneous changes made in interdependent factors and combinations affecting profit were analyzed. The studied factors were changes in yield, selling price and input material costs *(Table 7)*. These factors were selected because these are liable to change year-by-year, and these are the decisive factors of profit.

Table 7. Values of main factors affecting profit in different scenarios

Name	Unit	Pessimistic		Realistic		Optimistic	
		Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
Yield	t/ha	2.32	1.62	2.63	1.84	3.19	2.23
Selling price	HUF/kg	383.3	821.7	396.3	882.8	410.5	945.0
Input material cost	HUF/ha	308,916	308,916	280,833	280,833	252,750	252,750

Source: own data collection and calculation

In case of yield, we calculated an average value from the data collected from the farms from the best five years in optimistic case, and averaged the worst five yields in the pessimistic case, while in case of realistic case data were provided by the average model itself, namely the yield data of the 9 examined farms. Values of selling price in these three scenarios were determined also by using this scheme detailed above (5 best years - optimistic, 5 worst years - pessimistic, average values - realistic). In case of input material costs, we decreased them by 10% in the optimistic case, while increased them by 10% in the pessimistic scenario. Scenario analysis includes direct subsidies.

Results of scenario analysis are shown by *Table 8*. According to the realistic scenario, 226,804 HUF/ha contribution margin can be reached with 25,61% direct cost-related profitability in case of raw walnut production. Compared to that, profit increased to 523,164 HUF/ha along with 61.09% direct cost-related profitability in the optimistic version. This means that if yield, selling price and input material costs are changing in the favourable direction in case of raw walnut production, contribution margin more than doubles. In case of the pessimistic version the value of contribution margin is 45,062 HUF/ha with 4.93% direct cost-related profitability. This means that if the studied variables change in the unfavourable direction, then production would significantly lose from its profitability even if subsidies were included. According to the realistic scenario, 586,301 HUF/ha contribution margin can be reached with 52,91% direct cost-related profitability in case of dried walnut production. Profit increases to 1,604,113 HUF/ha along with 95.59% direct cost-related profitability in the optimistic version, which means that profit is almost double if changes happen towards the positive direction. Compared to that, profit decreases to 283,734 HUF/ha along with 25.39% direct cost-related profitability in the pessimistic version.

As a conclusion it can be stated that the production of both the raw and dried walnuts proved to be profitable even in the realistic, optimistic and pessimistic cases, but profit significantly decreases in the pessimistic case and if general costs were also considered, the production of raw walnut will turn into unprofitable.

Table 9 shows the direct cost-related profitability in case of raw walnut production in different variations of selling price and yield. The interval selected in case of selling price was 250-500 HUF/kg while it was 1.00-4.00 t/ha in case of yield.

The cost-related profitability of a walnut plantation in a productive year can range between -67.27% and 113.21%. According to the average data from the recent 5 years the studied profitability indicator was 14.19% beside 396.30 HUF/kg selling price and 2.63 t/ha average yield. If the selling price of the raw walnut should fall to around 250.00 HUF/kg, then at least 4.00 t/ha average yield is required to make production profitable. In case of 500.00 HUF/kg selling price, positive profitability can be achieved even with average yields above 2.00 t/ha.

Table 8. Results of scenario analysis

Name	unit	Pessimistic		Realistic		Optimistic	
		Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
Contribution margin	HUF/ha	45,062	283,734	226,804	586,301	523,164	1,064,113
Direct cost-related profitability	%	4.93	25.39	25.61	52.91	61.09	95.59

Source: own calculation

Table 9. Cost related profitability of the production of raw walnut as a function of average price and yield

Name		Price of product (HUF/kg)					
		250.00	300.00	350.00	400.00	450.00	500.00
Yield (t/ha)	1.00	-67.27%	-62.15%	-57.04%	-51.92%	-46.81%	-41.69%
	1.50	-54.43%	-46.75%	-39.07%	-31.39%	-23.71%	-16.03%
	2.00	-41.56%	-31.31%	-21.06%	-10.81%	-0.55%	9.70%
	2.50	-28.65%	-15.82%	-2.99%	9.84%	22.67%	35.51%
	3.00	-15.74%	-0.33%	15.08%	30.49%	45.91%	61.32%
	3.50	-2.77%	15.23%	33.24%	51.24%	69.25%	87.25%
	4.00	10.21%	30.81%	51.41%	72.01%	92.61%	113.21%

Source: own calculation

Table 10. Cost related profitability of the production of dried walnut as a function of average price and yield

Name		Price of product (HUF/kg)					
		700.00	750.00	800.00	850.00	900.00	950.00
Yield (t/ha)	0.70	-49.64%	-46.50%	-43.35%	-40.20%	-37.05%	-33.91%
	1.20	-21.47%	-16.30%	-11.12%	-5.94%	-0.76%	4.41%
	1.70	4.49%	11.54%	18.59%	25.64%	32.69%	39.73%
	2.20	28.53%	37.31%	46.09%	54.87%	63.65%	72.44%
	2.70	50.79%	61.17%	71.56%	81.95%	92.33%	102.72%
	3.20	71.54%	83.42%	95.30%	107.19%	119.07%	130.95%

Source: own calculation

Concerning dried walnut production, the cost-related profitability that can be reached in a productive year ranges between -49.64% and 130.95%. According to the average data from the recent 5 years the studied profitability indicator was 39.01% beside 882.80 HUF/kg selling price and 1.84 t/ha average yield. If the selling price of the dried walnut should fall to around 700.00 HUF/kg, then at least 1.70 t/ha average yield is required to make production profitable. In case of 950.00 HUF/kg selling price, positive profitability can be achieved even with average yields above 1.20 t/ha *(Table 10).*

Investment profitability study

In this section we were seeking the answer to the question that either with or without a postharvest investment is walnut production more profitable considering the entire lifespan of the plantation. Therefore, we compared two versions: in the first version only establishment of a walnut plantations takes place, while in the second place there is also a building of a drying facility along with orchard establishment. Table 1 shows the investment costs of the plantation and the drying facility.

The two versions start from identical baseline capital requirement, however, it is a boundary condition that the postharvest investment is realized in the first year of the full productive period - meaning Year 9 of the orchard - until then raw walnuts are sold in both models. Therefore, the baseline capital requirement in both economic calculations is the cost of orchard establishment itself, which means that in all eight years until reaching full productivity period annual income are compared to annual expenses. Based on net present value (NPV) it can be observed that by excluding investment subsidy the walnut orchard does not pay back within 30 years without a drying facility, this means that production of raw walnut is uneconomic. If we calculate with 50% investment subsidy, then NPV gets positive at Year 27, which means that the investment pays back. In the second version, when walnut orchard is complemented with a drying facility without investment subsidy, NPV reaches positive range in Year 21. If we consider in this version that the investor can also get a 50% investment subsidy, NPV get positive at Year 18 *(Figure 3)*. This version attains the minimum expected level of economic viability, exceeds 0, and produces 3,047,172 HUF/ha NPV in the end of the examined period.

When assessing static indicators of the investment it can be stated that without investment subsidy, at the end of the lifespan of the investment in case of establishing a walnut orchard the value of cumulated cash flow will be equal to 2,140,980 HUF/ha, thus the orchard pays back in Year 24. In the combination of walnut plantation and drying facility the value of cumulated cash flow is 8,650,670 HUF/ha without investment subsidy, and the investment pays back in Year 18.

When assessing the dynamic indicators, it can be stated that if producer establishes a traditional walnut plantation without investment subsidy and sells walnut in raw bulk, the net present value over the lifespan of the plantation does not exceed the minimum expected level of economic viability (value 0), the internal rate of return will be 2.35% with 0.73 profitability index. According to these indicators the investment is not economically viable, since NPV has a negative value, IRR does not exceed the value of discount rate, and the investment does not pay back within 30 years. When subsidy is included NPV gets positive in Year 27 and reaches 441,310 HUF/ha in Year 30, IRR is 3.84%, which represents an economically viable orchard, however, these are only modestly positive values. In the case when producer builds a drying facility at the time when the plantation reaches full productivity and sells the product in the form of dried shelled walnut, the investment will reach the minimum expected level of economic viability even without subsidies: NPV is 3,047,170 HUF/ha with 6.40% IRR, and the orchard pays back (DPP) in Year 21 *(Table 11).*

Table 11. Investment profitability indicators in the two examined versions with and without 50% investment subsidy

Name	Product: raw walnut		Product: dried walnut	
	Without subsidy*	With 50% investment subsidy	Without subsidy*	With 50% investment subsidy
Cumulated cash flow (thHUF/ha)	2,140.98	2,990.98	8,650.67	9,804.00
Static payback period	24	21	18	16
NPV (thHUF/ha)	-408.69	441.31	3,047.17	4,129.65
IRR (%)	2.35	3.84	6.40	8.48
DPP (year)	> 30	27	21	18
PI	0.73	1.40	1.99	4.03

Source: own editing
**investment realized from 100% own capital*

Sensitivity analyses of investment profitability calculations

Elasticity calculations

We also conducted elasticity calculations in case of investment profitability analysis. In this analysis we studied the change of NPV as a consequence of changing by 1% the values of the following affecting factors: yield, selling price, input material cost, machine work and personal costs. With the help of this calculation we can determine the sequence of the impact of factors determining economic viability. This analysis has been mad for both models. In both studied versions the selling price was the factor of greatest importance: 1% change in this factor caused the greatest change, impact in the value of NPV. The selling price was followed by cost of machine work, input material cost, and finally, the least impact has been caused by change in personal costs. In the first version (establishment of a walnut orchard without drying facility) elasticity values significantly exceeded the values of the second version, thus it can be stated that the economic viability of the first version reacts more sensitively to the change of affecting factors than the second version *(Table 12)*.

Table 12. Elasticity values of main factors affecting income and profitability

Name	Yield		Selling price		Input material cost		Machine work cost		Personal cost	
	Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
NPV (%)	26.17	5.89	33.26	6.24	8.81	1.15	9.78	1.29	4.89	0.64

Source: own editing

Critical value analysis

Based on calculations made above, selling price and yield were the two factors with the greatest impact on payback, thus we determined the critical values of these factors *(Table 13)*. In both cases we were looking for the critical value where net present value is zero at the end of the useful lifespan (Year 30).

Determination of critical value has not been made in an absolute quantity (t/ha) but in the critical yield on a percentage, regarding to the fact that between Year 5 and 12 (in the period of growing yields until reaching full productivity) different yields were realized every year. In case of production of raw walnut, the investment does not pay back until the end of the useful lifespan of the plantation. The critical yield level shows by how much yield should be increased to make the investment economically viable. This value has been found to be 103.20%, which means that 100% yield (2.63 t/ha) should be increased by 3.20% to make the investment pay back, and make the value of NPV reach zero. If producer can use the 50% investment subsidy, then the critical yield level may decrease to 96.70%. In case of production of dried walnut, the critical yield level is 82.61%, which means that even by 17.39% decrease in yield the orchard will still reach the turning point of the investment's economic viability. In absolute quantity this means 0.30 t/ha. With investment subsidy for plantation and drying facility this may decrease to 76.38%, thus it can further decrease by 6.23% to reach the turning point of the investment's economic viability.

The value of critical selling price without investment subsidies in case of payback of the walnut plantation is 408.70 HUF/kg, which means that 3.20% increase compared to the baseline price would be necessitated for the NPV of the investment to reach zero. In the combination of walnut plantation and postharvest facility this value is 739.20 HUF/kg, which is lower than the baseline value by 19.40%. By utilizing investment subsidies in raw walnut production the critical selling price is 383.51 HUF/kg while this value for dried walnut is 688.36 HUF/kg.

Table 13. Critical values of factors affecting income with and without investment subsidies (NPV = 0)

Name	**Critical value**		**Baseline value**		**Difference**	
	Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
Yield level without subsidies (%)	103.20	82.61	100.00	100.00	+3.20%	-17.39%
Yield level with subsidies (%)	96.70	76.38	100.00	100.00	-3.30%	-23.62%
Selling price without subsidies (HUF/kg)	408.70	739.20	396.30	882.80	+3.04%	-19.40%
Selling price with subsidies (HUF/kg)	383.51	688.36	396.30	882.80	-3.23%	-28.24%

Source: own editing

Scenario analysis

In case of the main affecting factors we used exactly the same pessimistic and optimistic values than in Table 7. The following results were obtained with simultaneous consideration of affecting factors (Table 14). When utilizing 100% own sources the realistic scenario shows the analysis detailed above, which is the base scenario.

In the pessimistic scenario in case of the establishment of the orchard without a drying facility the net present value remains negative, and the values of internal rate of return, profitability index and dynamic discount period significantly deteriorate, and even the utilization of the 50% investment subsidy cannot significantly improve these values. If a drying facility is built along with the walnut plantation, then in pessimistic case the net present value decreases to 1,252,700 HUF/ha from the 3,047,170 HUF/ha baseline value. The value of IRR decreases to 4.55% but even in this case it is going to exceed the realistic 3% value of discount rate. The value of profitability index exceeds 1, and the investment pays back in Year 25. If we utilize the 50% investment subsidy, the value of NPV almost doubles and the IRR and PI remains favourable, and the payback period decreases to 21 years.

Table 14. Results of scenario analysis with 100% own source and 50% investment subsidy

100% own source							
Name	**Unit**	**Pessimistic**		**Realistic**		**Optimistic**	
		Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
NPV	thHUF/ha	-1,716.80	1,252.70	-408.71	3,047.17	2,625.30	7,718.19
IRR	%	-0.17	4.55	2.35	6.40	6.37	9.70
PI	-	0.00	1.24	0.73	1.99	2.43	3.72
DPP	year	>30	25	>30	19	20	16
50% investment subsidy							
Name	**Unit**	**Pessimistic**		**Realistic**		**Optimistic**	
		Raw	*Dried*	*Raw*	*Dried*	*Raw*	*Dried*
NPV	thHUF/ha	-834.40	2,284.51	441.31	4,129.64	3,427.33	8,262.15
IRR	%	1.17	6.37	3.84	8.48	8.25	12.18
PI	-	0.04	2.54	1.40	4.03	4.58	7.36
DPP	year	>30	21	27	18	18	15

Source: own editing

In the optimistic scenario in case of 100% own source, production of raw walnut results in 2,625,300 HUF/ha NPV at the end of the useful lifespan of the investment, which means that the value of NPV changes to positive compared to that in the realistic case. The value of internal rate of return reaches and exceeds discount rate and the investment pays back in 20 years. With the utilization of 50% investment subsidy the investment would pay back in Year 18 along with significant improvement of the value of the indicators. In case of selling of dried walnuts, the net present value is 7,718,190 HUF/ha at the end of the investment period along with 9,70% IRR a 3.72% PI, and the investment pays back in Year 16 if the producer utilizes 100% own sources. If we consider the utilization of 50% investment subsidy, the investment pays back in Year 15 along with improvement of the values of the indicators.

As a summary it can be stated that in the pessimistic scenario selling of raw walnut along with decreasing yields and selling prices, increasing input material prices and utilization of 100% own financial sources the investment proves to be uneconomical, while values of dried walnut production decrease a bit compared to the realistic case, but still remain positive. According to the results of the optimistic scenario, both investments are going to pay back in the useful lifespan.

Cross-table analysis

Cross-table analysis determines the return of the plantation at the end of its useful lifespan by considering the selling price and yield combination with the highest values from elasticity calculations. The selling price of raw walnut ranges from 250.00 HUF/kg and 500.00 HUF/kg, while the lower range of yield is 1.00 t/ha and its highest value is 4.00 t/ha in raw weight. The internal rate of return in this case ranges from -

12.74% to 13.52%. It can be seen that below 2.00 t/ha average yield there is no such a selling price that would make the investment profitable in the useful lifespan of 30 years. At 2.00 t/ha average yield at least 500.00 HUF/kg selling price is necessitated for the walnut plantation to pay back, however, the value of the IRR still does not reach the value of discount rate. At 4.00 t/ha average yield IRR shifts to positive range at any level of selling price, but it will exceed the value of discount rate at 300.00 HUF/kg *(Table 15)*.

In the combination of the walnut plantation and postharvest facility the lower range of yield is 0.70 t/ha and the upper range is 3.20 t/ha in dry weight. The selling price ranges from 700.00 HUF/kg and 950.00 HUF/kg. To reach a positive internal rate of return, at least 1.70 t/ha average yield and 750.00 HUF/kg selling price is necessary. However, to realize the investment IRR shall reach (or exceed) the discount rate. This expectation is met by the combination of at least 1.70 t/ha yield and 800.00 HUF/kg selling price *(Table 16)*.

Table 15. Internal rate of return (IRR) of the production of raw walnut as a function of average price and yield

Name		Price of product (HUF/kg)					
		250.00	300.00	350.00	400.00	450.00	500.00
Yield (t/ha)	1.00	-	-	-	-	-	-
	1.50	-	-	-	-	-	-8.47%
	2.00	-	-	-	-5.40%	-1.07%	1.66%
	2.50	-	-10.91%	-2.29%	1.45%	4.02%	6.04%
	3.00	-12.74%	-1.72%	2.36%	5.13%	7.29%	9.09%
	3.50	-3.07%	2.16%	5.39%	7.82%	9.80%	11.50%
	4.00	0.74%	4.84%	7.71%	9.97%	11.87%	13.52%

Source: Own editing

Table 16. Internal rate of return (IRR) of the production of dried walnut as a function of average price and yield

Name		Price of product (HUF/kg)					
		700.00	750.00	800.00	850.00	900.00	950.00
Yield (t/ha)	0.70	-	-	-	-	-	-
	1.20	-	-12.31%	-6.78%	-3.95%	-1.97%	-0.43%
	1.70	-0.12%	1.66%	3.10%	4.32%	5.38%	6.33%
	2.20	5.29%	6.56%	7.66%	8.64%	9.52%	10.33%
	2.70	8.84%	9.94%	10.91%	11.79%	12.60%	13.34%
	3.20	11.48%	12.49%	13.40%	14.22%	14.99%	15.69%

Source: Own editing

Conclusions

The main objective of the study was to determine, whether walnut production is an economically viable activity in the domestic natural and economic environment, and whether the production of raw walnut or dried walnut with postharvest activity is more efficient. As a conclusion it can be stated that walnut production is a profitable activity in an average year both when selling raw and dried walnuts. If the producer sells walnut right after harvest in a raw bulk, total production costs in productive years reaches 974,011 HUF/ha. Attainable yield is 2.63 t/ha with 396.30 HUF/kg selling price, therefore the profit is 138,258 HUF/ha with 14.19% cost-related profitability. In case of fruit orchards these are quite unfavourable indicators (even arable farming is able to realize more favourable values), and the sensitivity of profitability is shown by the fact that even a 21.68% decrease in average yield and a 21.76% decrease in the selling price may cause loss. If the producer sells dried shelled walnut, the production cost is only 25% higher due to the cos of drying, the yield is 1.84 t/ha in dry weight, but the average selling price is 882.84 HUF/kg, thus the profit is 475,496 HUF and the cost-related profitability is 39.01%, and these are considered as favourable values. Thus it can be stated that walnut production in an average year may be profitable even without postharvest activity, but efficiency is improved significantly when the producer sells the products dried. Walnut production proved to be efficient and economically viable on a long term with postharvest investment. If the producer establishes a walnut plantation and sells the raw product, the investment does not pay back in the the useful lifespan of the orchard (30 years). On a comparison, if we calculate with the establishment of a walnut orchard and a drying facility, NPV reaches 3,047,170 HUF/ha at the end of Year 30, the investment pays back in Year 21, and IRR exceeds the value of the discount rate. With the postharvest activity along with 11.5% higher baseline capital requirement 7.5 times higher NPV, 2.7 times higher IRR and 2.7 times higher PI can be achieved, thus this version shows more favourable indicators in terms of capital-related profitability indicators and income generating capacity as well. As a result, it can be stated that without building a drying facility and selling raw walnuts the walnut production is economically not viable. This result can be slightly improved if the producer utilizes 50% investment subsidy, but not in a significant manner. As a recommendation it can be stated that since the combination of a walnut plantation and a drying facility results in more efficient production, it is worth to prepare for the full production process. Profitability can be improved with higher yields or with the utilization of investment subsidy above direct subsidies.

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