THE NET PRESENT VALUE OF INVESTMENTS IN RAISING AND EXPLOITING WALNUT PLANTATIONS

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ABSTRACT

The subject of the research is the application of the net present value and methods based on it for the assessment of the economic justification of raising walnut plantations of Sejnovo variety on 3 and 10 ha, with same cultivation form and planting system. The research was conducted on the basis of data collected during the period 2022-2024. in Western Serbia. For a plantation of 3 ha, indicators of economic effectiveness per unit area are lower than indicators for a plantation of 10 ha, i.e. 53,378 €/ha<8,375 €/ha (net present value) and 69,204 €/ha<73,089 €/ha (capitalised value). Pay-back period for a 10 ha is shorter than a 3 ha i.e. 9.24 years<9.64 years and internal rate of return for a 10 ha is higea than a 3 ha by 0.57%, i.e. 37.92%>37.35%. It is concluded that investing in establishing and exploiting walnut plantations on an area of 10 ha is more economically efficient than an area of 3 ha.

Introduction

The areas under walnut plantations in the world cover 1.1 million hectares, and the production of walnuts in shell in the world is around 3.5 million tons. The world's largest producers are: China, the United States of America and Iran. The area under walnut plantations in Europe occupies 169,000 ha, and the volume of production is about 386,853 tons (FAO, 2024; Nađ et al., 2024). The largest European producers are Ukraine, Greece and Romania. In Serbia, walnuts are grown on 3,307 ha (SORS, 2024). Serbia ranks 25th in the world in terms of the production of in-shell walnuts, accounting for only 0.2% of the total produced quantities. According to the total production of

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walnuts in Europe, Serbia is in ninth place (Dobrescu, 2019). Some of the most famous varieties of walnuts are: Čendler, Tehama, Šampion and Džinovski, while the high quality of the fruits is characteristic of the following walnut varieties: Jupiter, Sava, Šejnovo and Plovdiv walnut (Cerović et al., 2014). Production in perennial plantations, and therefore also in orchards, is highly dependent on natural conditions and is conditioned by numerous risks, such as: founding, cultivation, production, market, financial and other risks (Sredojević, 1998). For walnut production, it is important that it is characterized by modest costs for the care and maintenance of plantations, which, along with small losses in fruit quality after harvest, ranks it among the most successful fruit productions (Inobatov, Ziyadullaev, 2023). The production of walnuts of 2 t/ha in Hungary enables coverage of the total production costs (Apati, 2014). Turk & Rozman (2001) are stating that positive economic results are achieved in the integral production of walnuts. Positive economic effects are achieved in the system of organic walnut production (Očić et al., 2019; Petković et al., 2024; Popa et al., 2023). A comparative analysis of investments in the production of walnuts in the shell and walnut kernels showed that the production of walnuts in the shell is economically unjustified and that for a quick return on investment and profitable production it is necessary to sell shelled and dry walnuts (Apáti et al., 2018). On the farms in Turkey, a profit of over 4,000 €/ha was recorded in the years during the full crop yield (Unakitan, Inan, 2020; Neševski & Bojičić, 2024; Aşkan, 2021). So far, profitability has also been established at different production intensities on farms in Mexico (Fernández-Chávez et al., 2021). Research into the quality of 20 walnut varieties present in the continental part of Montenegro determined intervals of different fruit weights (Jaćimović et al., 2020). Based on the analysis of activities in production technology, supply and demand for walnuts in shell and kernel, different levels of productivity in walnut production have been determined (Bakhshinejad, 2016; Aşkan, 2021; Rakhmonova, 2022).

Economic results in the production of walnuts are to a lesser extent conditioned by agroecological conditions, but they significantly depend on the selected variety, cultivation form and soil quality during the entire period of plantation exploitation. (Janković, Janković, 2014). The success of fruit production is also determined by numerous non-production factors, such as the development of the product market, the availability of professional staff, traffic conditions, the level of economic development and others (Kljajić et al., 2017). The analysis of investments in raising and exploiting walnut plantations in the Republic of Serbia shows more favorable economic effects compared to the results in other countries. This is explained by the fact that the selling price of walnuts is relatively high (Bogdanović, Hadžić, 2019). Research on the movement of the market price of walnut kernels on green markets in the Republic of Serbia indicated that the highest price will be reached at the end of 2023 and the beginning of 2024, in the amount of 9.7 €/kg (Ostojić et al., 2024). The price of walnuts in the shell is lower and is about 1/3 of the price of walnuts in the kernel. The yield per hectare is higher in plantations with a larger number of trees, but the profitability of this system, as a consequence of the increase in investment in raising plantations and

the total costs of care, protection and exploitation, is lower compared to the production system with a lower density (Fernández-Chávez et al., 2021). The number of walnut trees per hectare on the farms analyzed in some studies ranged from 120 to 204 (Očić et al., 2019; Milošević & Stankov, 2023; Fernández-Chávez et al., 2021).

The period of raising walnut plantations lasts from five to seven years, when it is expected that the annual value of the production of walnut fruit will exceed the costs of care and protection of the plantations (Unakıtan, İnan, 2019; Inobatov, 2024). Investing in raising and exploiting perennial plantations is a complex and responsible business. Mistakes made during planting cannot be corrected during their exploitation (Sredojević, 1998). Therefore, the subject of research in this paper is the economic analysis of raising and exploiting walnut plantations. The aim of the research is to determine the assessment of economic justification of investing in raising and exploiting walnut plantations of different areas, for the same variety, cultivation form and the number of seedlings per unit area, using the net present value and other methods based on it.

Materials and methods

Investments for the establishment and raising of plantations of walnuts of the Šejnovo variety were determined on the basis of a survey conducted in the three-year period 2022-2024 on selected seven family holdings in Western Serbia, where walnut production is realized. For certain natural inputs, care and protection during planting, as well as work processes and technology of regular walnut production, data from the documentation of internal records on the farms, as well as professional literature, were used. For the analysis of areas and yields of walnut production in the world and in the Republic of Serbia, statistical data bases were used, namely: Food and Agriculture Organization (FAO) and Statistical Office of the Republic of Serbia (SORS). Economic indicators based on the collected data were determined using statistical and calculative methods. Based on the amount of parameters of the economic flow, the net present value of plantations of 3 ha and 10 ha was calculated, and based on it: yield value of plantations; investment pay-back period and internal interest rate. According to the defined criteria for each of the mentioned indicators (Andrić, 1998; Andrić et al., 2005), appropriate ratings were determined, based on which a fairly reliable picture of the efficiency and economic evaluation of the justification of the analyzed walnut plantations as an investment was given.

Investment in raising (growing) plantations (A_0) was determined as:

$$A_0 = (a_0 \times r^m + a_1 \times r^{m-1} + a_2 \times r^{m-2} + \ldots + a_{m-1} \times r + a_m) - (b_{h-1} \times r + b_h) \quad [1]$$

$a_1, a_2, a_3 \ldots a_{m-1}, a_m$ - financial payments per m years of planting;

i – rate of interest;

r – interest factor (r = 1+i);

m – period of raising (growing) plantations (years);

h – period (years) of receiving financial income during the raising of plantations

The economic benefit per year of exploitation of walnut plantations was determined as the difference between the amount of annual cash receipts from the exploitation of plantations and the amount of annual monetary payments for the maintenance and exploitation of plantations. The final value of plantations is determined as the difference between the estimated value of the wood mass at the end of the period of exploitation (receipt) and the costs of clearing plantations, which was determined by the discounting procedure at the beginning of the period of exploitation of plantations (Sredojević, 1998). The net present (or capital) value of plantations (NPV_0) is obtained when the initial investment is subtracted from the sum of the discounted net annual benefits from the exploitation of walnut plantations and the final value of the wood mass, and it is calculated from the form:

$$NPV_0 = \left[\sum_{i=1}^{n} \left(\frac{b_i - a_i}{r^i} \right) + \frac{B_n}{r^n} \right] - A_0 \qquad [2]$$

a_i - financial payments for the maintenance and use of plantations (i = 1, 2, 3, ... n);

b_i - financial income from walnut plantations in certain years (i = 1, 2, 3, … n);

B_n – financial income from wood pulp at the end of the n^{th} year;

n – period of walnut plantations exploitation (years)

If the net present (capital) value is positive, i.e. $NPV_0 > 0$, the investment is economically justified, and vice versa. The largest amount of money that can be invested in raising walnut plantations so that it is economically justified at a given interest rate and in the planned period is determined by calculating the capitalized value of the plantations (CV_0) according to the form:

$$CV_0 = \sum_{i=1}^{n} \frac{b_i - a_i}{r^i} + \frac{B_n}{r^n} \qquad [3]$$

If the capitalized value is currently higher than the amount of investments in its construction, i.e. $CV_0 > A_0$, investment is economically justified, and vice versa. For the return period of invested capital (t) are also used the terms pay-off, pay-back or pay-out method. It is the moment when the capital value is equal to zero ($NPV_0=0$), and is calculated as follows:

$$t = t_1 - \frac{NPV_0[t_1]}{NPV_0[t_2] - NPV_0[t_1]} \qquad [4]$$

If the return period is shorter than the planting period, i.e. t < n, investing in raising plantations is economically justified, and vice versa. In order to get an answer to the question: At what level of interest can the capital invested in the investment is returned, that is, repaid, the internal interest rate (i_e) was determined. Essentially, it is the rate at which the net present value equals zero ($NPV_0 = 0$). Using linear interpolation, the internal interest rate (i_e) was determined from the formula:

$$i_e = i_1 - NPV_{01} \frac{i_2 - i_1}{NPV_{02} - NPV_{01}} \quad [5]$$

If the internal interest rate is higher than the assumed calculative one, i.e., $i_c > i$, investing is economically justified, and vice versa.

Results and discussion

On the basis of the data collected by the survey on the consumption of materials, the labor work and machines during the planting period, as well as the production costs and yield by individual years of exploitation of the plantations, the starting parameters for the economic analysis were determined. The data served as the basis for defining two plantations of walnuts, variety Šejnovo, of the same cultivation system, on two different areas. The data obtained from the internal records of the producers on the surveyed farms served as a basis for the formation of analytical calculations of walnut production, according to which the annual cash receipts and issuances were determined, that is, the net annual benefit for individual years of exploitation.

The starting assumptions for the analysis are:

- plantations are raised at the same time on areas of 3 ha and 10 ha;
- before planting, the land was not used for growing agricultural crops;
- land preparation, i.e. agro-mechanized works are carried out before the beginning of planting, in the so-called "year zero";
- investment dynamics are given in accordance with real investments in practice, whereby investments that are made once do not occur only at the beginning, but in all years of planting;
- the period of raising is five years;
- "small yield" is achieved in the fifth year;
- the exploitation period lasts 30 years;
- at the end of the exploitation period, the final (liquidation) value of the plantation is reached, which represents the difference between the value of the wood mass of the tree and the costs of grubbing;
- calculative rate of interest is 8%;
- the average walnut yield is 3.2 t/ha, the market price of walnuts is 0.3 €/kg, and the price of the wood mass of de-rooted walnut is 300 €/m^3.

Walnut planting is a long-term investment that requires high financial investments at the time of establishment, and compared to other fruit species, it is characterized by a longer cultivation period and a relatively long period of exploitation (Sredojević et al.,

2024). On the basis of economic parameters determined by processing data from the field collected by the survey, as well as technical and technological norms, along with previous analytical calculations, the amounts of investment investments were determined.

The calculation procedures of the amount of financial investments according to individual work processes, from the execution of agro-mechanized works, land preparation, planting, procurement of machinery and care for each year of cultivation of crops are calculated, and according to the dynamics of the investment and with the calculated intercalary interest are given in tables 1 and 2.

Table 1. Investments for raising 3 ha of walnut plantations, 120 seedlings/ha

Purpose	Monetary amounts per m years of plantation cultivation (€)						Sum (€)
	0[1)]	1	2	3	4	5	
Agro-mechanized operations	1,300	850	700	650	600	650	4,750
Labor cost	300	1,500	980	940	870	1,030	5,620
Material[2)]	200	4,600	930	950	1,050	1,120	8,850
Procurement of machinery	-	3,200	3,200	-	-	-	6,400
Roads in the plantation	-	800	800		-	-	1,600
Irrigation system	-	1,100	1,100	-	-	-	2,200
Installing a fence	-	800	850	-	-	-	1,650
Project, supervision and control	1,100	700	400	400	400	400	3,400
Permanent working capital	-	-	-	1,600	1,600	-	3,200
Investments by year:	2,900	13,550	8,960	4,540	4,520	3,200	37,670
The value of a "small yield"[3)]	-	-	-	-	-	2,050	2,050
Corrected investments	2,900	13,550	8,960	4,540	4,520	1,150	35,620
Correction factor (1,08^m)	1.4693	1.3605	1.2597	1.1664	1.0800	1.0000	-
Total investments:	**4,261**	**18,435**	**11,287**	**5,295**	**4,882**	**1,150**	**45,310**
Share by age (%)	**9.40**	**40.69**	**24.91**	**11.69**	**10.77**	**2.54**	**100.00**

Source: Authors' calculation

[1)] *Included investments in the preparation of land for planting*

[2)] *Seedlings, mineral fertilizers, means of protection, etc.*

[3)] *The value of the yield during the planting period minus the harvest costs*

Table 2. Investments for raising 10 ha of walnut plantations, 120 seedlings/ha

Purpose	Monetary amounts per m years of plantation cultivation (€)						Sum (€)
	0 [1)]	1	2	3	4	5	
Agro-mechanized operations	3,800	2,300	1,900	1,800	1,700	1,900	13,400
Labor cost	1,080	4,200	2,750	2,800	2,580	1,200	14,610
Material[2)]	680	15,480	2,900	3,100	3,400	3,800	29,360
Procurement of machinery	-	10,700	10,700	-	-	-	21,400
Roads in the plantation	-	2,100	2,100	-	-	-	4,200
Irrigation system	-	3,700	3,700	-	-	-	7,400
Installing a fence	-	2,300	2,300	-	-	-	4,600
Project, supervision and control	3,500	2,200	1,350	1,350	1,350	1,350	11,100

Purpose	Monetary amounts per m years of plantation cultivation (€)						Sum (€)
	0 [1)]	1	2	3	4	5	
Permanent working capital	-	-	-	5,100	5,100	-	10,200
Investments by year:	9,060	42,980	27,700	14,150	14,130	8,250	116,270
The value of a "small yield"[3)]	-	-	-	-	-	6,800	6,800
Corrected investments	9,060	42.980	27,700	14,150	14,130	1,450	109,470
Correction factor ($1{,}08^m$)	1.4693	1.3605	1.2597	1.1664	1.0800	1.0000	-
Total investments:	**13,312**	**58,474**	**34,894**	**16,504**	**15,260**	**1,450**	**139,894**
Share by age (%)	**9.52**	**41.80**	**24.94**	**11.80**	**10.90**	**1.04**	**100.00**

Source: Authors' calculation

[1)] Included investments in the preparation of land for planting

[2)] Seedlings, mineral fertilizers, means of protection, etc.

[3)] The value of the yield during the planting period minus the harvest costs

Looking at the structure of investments by year of raising (cultivation) of seedlings, the largest share is the costs in the first year 41-42%, precisely because of the costs of the seedlings. The established investment investments for the establishment of 3 ha of walnut plantations amount to 45,310 €, i.e. 15,103 €/ha, and for the establishment of 10 ha of plantations, 139,894 €, i.e. 13,989 €/ha is required, which is 8% less per unit area compared to so far of 3 ha. According to Apáti (2014), investments in raising walnut plantations in Hungary amount to around 7,500 €/ha. To raise plantations in the system of integral production in Slovenia, it is necessary to provide about 10,000 €/ha (Turk, Rozman, 2001). In the total investments in establishing and raising walnuts, one of the items is the procurement of mechanization, which due to wear and tear in certain years of plantation exploitation needs to be replaced. Investments in the replacement of mechanization assets in the 10^{th} and 20^{th} years during the exploitation of walnut plantations, according to current values in the amount of 3,200.00 € (for 3 ha) and 5,300.00 € (for 10 ha), at a discount rate of 8%, at the beginning of the exploitation period, they amount to:

In the 10^{th} year …… 3,200 € x 1.08^{-10} = 1,482 €

In the 20^{th} year …… 3,200 € x 1.08^{-20} = 686 €

Total: 2,168 € (for a 3 ha plantation)

In the 10^{th} year ….. 10,700 € x 1.08^{-10} = 4,956 €

In the 20^{th} year ….. 10,700 € x 1.08^{-20} = 2,295 €

Total: 7,251 € (for a 10 ha plantation)

Based on the established investment investments in raising plantations of 3 ha and 10 ha in tables 1 and 2, as well as the calculation of the current amount of investment in machinery that will be replaced due to wear and tear during the exploitation of the plantations, in table 3 are shown the total investments for both plantations.

Table 3. Total investments in raising plantations and in replacing worn-out mechanization during the period of exploitation of walnut plantations

Type of cost	3 ha		10 ha	
	Amount (€)	Share (%)	Amount (€)	Share (%)
Investments in planting	45,310	95.43	139,894	95.07
Investing in the replacement machinery	2,168	4.57	7,251	4.93
T o t a l:	**47,478**	**100.00**	**147,145**	**100.00**

Source: Authors' calculation

According to the amounts determined in table 3, the total investments in raising plantations and replacing worn-out machinery amount to 47,478 € (for 3 ha), i.e., 15,826 €/ha and 147,145 € (for 10 ha), i.e., 14,715 €/ha. Looking at each 1 ha, the investments for the planting of 10 ha compared to 3 ha are lower by 1,111 € (about 8%). Bogdanović and Hadžić (2019) determined the investments for raising 1 ha of walnut plantations in Serbia of about 12,900 €. However, due to the increase in input prices, this research has shown that in Serbia, larger investments are needed per 1 ha of walnut plantations.

The amounts of annual financial income were obtained by multiplying the yield of walnuts with their market prices. The final value of the plantations is the value of the wood mass of the felled plantations less the costs of felling and grubbing. This value is translated, i.e. discounted using compound interest at the moment of completion of planting. Annual financial expenses are related to the maintenance of roads and buildings in the plantation, filling of empty places, as well as for carrying out production in the plantation, compensation for the labor work and others. They are determined on the basis of the consumption of materials, the labor work and the work of mechanization according to technological maps by years of plantation exploitation. And finally, net annual benefits were calculated, as the difference between annual monetary receipts and annual monetary expenditures. Subsequent calculations of indicators of economic effectiveness, with the application of dynamic methods of investment calculation, were performed on the basis of calculation at the level of variable costs. According to the natural amounts of inputs and outputs and corresponding market prices, table 4 shows cash receipts, cash issues and economic benefit by year for the entire investment period.

Table 4. Financial income, financial payments and cash flow during the period of exploitation of 3 ha and 10 ha walnut plantations, 120 seedlings/ha

Years of exploitation	Financial income (€)		Financial payments (€)		Cash flow by years (€)	
	3 ha	10 ha	3 ha	10 ha	3 ha	10 ha
1	8,640	30,000	3,020	9,600	5,620	20,400
2	16,320	57,600	5,710	18,430	10,610	39,170
3	24,000	73,600	8,400	23,550	15,600	50,050
4	28,800	92,800	11,520	33,400	17,280	59,400
5	30,720	105,600	12,280	38,010	18,440	67,590
6	32,640	112,000	13,050	40,320	19,590	71,680

Years of exploitation	Financial income (€)		Financial payments (€)		Cash flow by years (€)	
	3 ha	10 ha	3 ha	10 ha	3 ha	10 ha
7	34,560	118,400	13,820	42,520	20,740	75,780
8-25	36,480	121,600	14,590	48,640	21,890	72,960
26	29,760	96,000	10,410	30,720	19,350	65,280
27	22,500	76,800	7,870	24,570	14,630	52,230
28	15,360	45,000	6,250	14,400	9,110	30,600
29	11,520	41,600	4,030	13,310	7,490	28,290
30	119,840[1)]	399,000[2)]	3,020	9,210	116,820	389,790

Source: Authors' calculation

[1)] 8,640 €+ 3,200 € (PWC) + 108,000 € (wood mass value) = 119,840 €

[2)] 28,800 €+ 10,200 € (PWC) + 360,000 € (wood mass value) = 399,000 €

If average annual amounts are used to determine economic indicators, the calculation procedure is simpler, but the reliability of the indicator amounts is reduced due to changes in the ratio of input and output over a number of years (Sredojević et al., 2019; Unakıtan and İnan, 2019; Fernández-Chávez et al., 2021). In Hungary, ten years ago, with a yield of 1 t/ha on holdings and an average price of walnuts of 0.55 €/kg, the annual income from walnut plantations was determined in the amount of 850 €/ha (Apati, 2014). On the farm in Croatia, where the organic production of walnuts is realized, an income of 2,760 €/ha was established (Očić et al., 2019), and the structure is dominated by subsidies from the state (54%). On farms in Slovenia, the value of production was determined to be 4,600 €/ha, at a market price of 1.25 €/kg and a yield of around 3 t/ha. (Turk, Rozman, 2001). In Turkey, due to the significantly higher selling price of walnut kernels (over 6 €/kg), the annual value of production was recorded at around 13,000 €/ha (Unakitan, Inan, 2020; Aşkan, 2021).

Researches in Hungary, Slovenia and Croatia have recorded lower annual production costs from around 1,200 €/ha to 2,700 €/ha depending on the period during plantation exploitation (Rozman, 2001; Apáti, 2018; Turk, Očić et al., 2019). The costs of walnut production on farms in Turkey amount to 8,700 €/ha, primarily due to the different ratio of input and output prices in walnut production compared to the Republic of Serbia (Unakitan, Inan, 2020; Aşkan, 2021). In order to determine the economic justification of investment in raising and exploiting walnut plantations on areas of 3 ha and 10 ha, in table 5, the net present value for individual plantation areas was determined by a calculative procedure. For a plot of 3 ha, the net present value is 160,134 €, or 53,378 €/ha, and for a plot of 10 ha, the net present value is 583,746 €, or 58,375 €/ha. Considering that the net present values are positive, it is concluded that investing in the analyzed plantations under the mentioned conditions is economically justified, but for 4,997 €/ha, a greater economic benefit is achieved than plantations on 10 ha. In a related study, which also considered the effects of investing in raising and exploiting walnut plantations on farms in Serbia, a significantly lower net present value of 30,400 €/ha was determined (Bogdanović and Hadžić, 2019). This is explained by the fact that

in the last five years there has been a change in the ratio of input and output prices, as well as an increase in the prices of both.

The net present value of plantations depends on numerous factors, the most important of which are: the amount of total investments in raising plantations; the length of the planting period; amount and schedule of net annual benefits; conditions and method of financing plantations; amount of calculated interest rate; length of plantation exploitation period, etc. In practice, it is often recommended that when assessing the economic feasibility of raising and exploiting perennial plantations, and therefore also walnut plantations, an assessment of possible risk should also be included. One of the ways is the correction of the calculated interest rate by applying the double discounting procedure. In this research, the impact of the calculated interest rate on the net present value of plantations was analyzed. The required minimum interest rate on invested funds in walnuts as an investment is 8%, and the interest rate to cover risk and uncertainty is 25% of 8%, so the corrected calculative rate of interest is increased by 2%, i.e. is 10%. Applying a discount factor at a rate of 2%, the present value of the cash flow for both plantations was again discounted in order to include the risk, and this is given in the last two columns in table 5.

Table 5. Net present value of walnut plantations for areas of 3 ha and 10 ha and its movement depending on interest rate risk

Years of exploitation (n)	Nominal amount of cash flow (€)		$\frac{1}{1.08^n}$	Present value of the cash flow (€)		Discounting to capture uncertainty (risk) 25% of 8% = 2%		
	3 ha	10 ha		3 ha	10 ha	$\frac{1}{1.02^n}$	Present value cash flow (€)	
							3 ha	10 ha
0	-47,478	- 147,145	1.0000	-47,478	-147.145	1.0000	-47,478	-147,145
1	5,620	20,400	0.9259	5,204	18,888	0.9804	5,102	18,518
2	10,610	39,170	0.8573	9,096	33,580	0.9612	8,743	32,277
3	15,600	50,050	0.7938	12,383	39,730	0.9423	11,668	37,437
4	17,280	59,400	0.7350	12,701	43,659	0.9238	11,733	40,332
5	18,440	67,590	0.6806	12,550	46,002	0.9057	11,366	41,664
6	19,590	71,680	0.6302	12,346	45,173	0.8880	10,963	40,114
7	20,740	75,780	0.5834	12,100	44,210	0.8706	10,534	38,489
8	21,890	72,960	0.5403	11,827	39,420	0.8535	10,094	33,645
9	21,890	72,960	0.5002	10,949	36,494	0.8368	9,162	30,538
10	21,890	72,960	0.4632	10,139	33,795	0.8203	8,317	27,722
11	21,890	72,960	0.4289	9,389	31,292	0.8043	7,552	25,168
12	21,890	72,960	0.3971	8,692	28,972	0.7885	6,854	22,844
13	21,890	72,960	0.3677	8,049	26,827	0.7730	6,222	20,737
14	21,890	72,960	0.3405	7,454	24,843	0.7579	5,649	18,828
15	21,890	72,960	0.3152	6,900	22,997	0.7430	5,127	17,087
16	21,890	72,960	0.2919	6,390	21,297	0.7284	4,654	15,513
17	21,890	72,960	0.2703	5,917	19,721	0.7142	4,226	14,085
18	21,890	72,960	0.2502	5,477	18,254	0.7002	3,835	12,781
19	21,890	72,960	0.2317	5,072	16,905	0.6864	3,481	11,604

Years of exploitation (n)	Nominal amount of cash flow (€)		$\frac{1}{1.08^n}$	Present value of the cash flow (€)		Discounting to capture uncertainty (risk) 25% of 8% = 2%		
	3 ha	10 ha		3 ha	10 ha	$\frac{1}{1.02^n}$	Present value cash flow (€)	
							3 ha	10 ha
20	21,890	72,960	0.2145	4,695	15,650	0.6730	3,160	10,532
21	21,890	72,960	0.1986	4,347	14,490	0.6598	2,868	9,560
22	21,890	72,960	0.1839	4,026	13,417	0.6468	2,604	8,678
23	21,890	72,960	0.1703	3,728	12,425	0.6342	2,364	7,880
24	21,890	72,960	0.1577	3,452	11,506	0.6217	2,146	7,153
25	21,890	72,960	0.1460	3,196	10,652	0.6095	1,948	6,492
26	19,350	65,280	0.1352	2,616	8,826	0.5976	1,563	5,274
27	14,630	52,230	0.1252	1,832	6,539	0.5859	1,073	3,831
28	9,110	30,600	0.1159	1,056	3,546	0.5744	606	2,037
29	7,490	28,290	0.1073	804	3,036	0.5631	453	1,710
30	116,820	389,790	0.0994	11,612	38,745	0.5521	6,411	21,391
NPV_0 ..... without risk coverage:				**+160,134**	**+583,746**	with risk:	**+105,612**	**+438,776**

Source: Authors' calculation

Including the risk and uncertainty of the calculative interest rate, assuming that it would increase by 25%, there would be a decrease in the net present value for both plantations by 35% for 3 ha, and 25% for 10 ha, which would result in extension of the return period of invested capital. That is why it is necessary, before investing, to examine possible financial risks, in order to possibly avoid them or mitigate them to a sufficient extent, thereby increasing investment security. Given that the net present value represents the basis for determining other indicators of the economic justification of investment, according to the above formula and from the determined amounts in table 5, the capitalized value was determined (Sredojević et al., 2024). For a plantation of 3 ha it amounts to 207,612 € (i.e. 62,204 €/ha), and for a plantation of 10 ha it amounts to 730,891 € (i.e. 73,089 €/ha) and these amounts represent the upper limits for investing in raising and exploiting the analyzed plantations. Given that the stated amounts are significantly above the value of the established investments for both plantings, i.e. 207,612 € > 47,478 € and 730,891 € > 147,145 €, means that it is economically justified and that it is economically more efficient to invest in raising plantations of 10 ha, i.e. 73,089 €/ha > 62,204 €/ha. On the basis of the net present value in table 6, the parameters of the test periods of the return of invested capital are given, and then the length of the period is determined analytically below.

Table 6. Calculating the pay-back period of funds invested in raising and exploiting walnut plantations and replacing worn-out machinery

Years of exploitation (n)	Nominal amount of cash flow (€)		Present value of net income for 3 ha (€)		Present value of net income for 10 ha (€)	
	3 ha	10 ha	4 year	5 year	4 year	5 year
0	-47,478	- 147,145	-47,478	-47,478	- 147,145	- 147,145
1	5,620	20,400	5,204	5,204	18,888	18,888
2	10,610	39,170	9,096	9,096	33,580	33,580
3	15,600	50,050	12,383	12,383	39,730	39,730
4	17,280	59,400	12,701	12,701	43,659	43,659
5	18,440	67,590	.....	12,550	.....	46,002
6	19,590	71,680	.....	.....	.....	.....
7	20,740	75,780	.....	.....	.....	.....
8-25	21,890	72,960	.....	.....	.....	.....
26	19,350	65,280	.....	.....	.....	.....
27	14,630	52,230	.....	.....	.....	.....
28	9,110	30,600	.....	.....	.....	.....
29	7,490	28,290	.....	.....	.....	.....
30	116,820	389,790	.....	.....	.....	.....
		T o t a l:	**-8,094**	**4,456**	**-11,288**	**34,714**

Source: Authors' calculation

According to the amounts determined in table 6, the interpolation procedure determined the shortest period of time for which the investments in raising plantations and replacing worn-out machinery during the exploitation of plantations will be returned, and it amounts to:

$$t = 4\text{ year} - \frac{(-8{,}094\ €)}{(+4{,}456\ €) - (-8{,}094\ €)}$$ = 4.64 years from the period of exploitation, i.e.9.64 year from the century of planting (for 3 ha)

$$t = 4\text{ year} - \frac{(-11{,}288\ €)}{(+34{,}714\ €) - (-11{,}288\ €)}$$ = 4.24 years from the period of exploitation, i.e. 9.24 year from the century of planting (for 10 ha)

The calculated pay-back periods of individual plantings are shorter than their life span, i.e. 9.64 years < 35 years and 9.24 years < 35 years, that is, shorter than the longest period for which the funds should be returned so that the investment would be economically justified.

Therefore, investment investments for a plantation of 10 ha will be returned in the first quarter and for 3 ha in the last quarter during the 10th year of the life of the plantation after planting. Therefore, considering that the determined periods are shorter than the planned life spans of the plantations, this indicator leads to the conclusion that investing in raising both analyzed walnut plantations is economically justified. By comparing

the established periods, the evaluations obtained based on the previous indicators are confirmed that it is more economically advantageous to invest in raising plantations of 10 ha, because the capital return period is shorter, i.e. 9.24 years < 9.64 years.

Based on the amount of net present value calculated in a tabular manner similar to the pay-back period at trial interest rates of 35% and 40%, by the interpolation process, according to the above-mentioned form, the internal interest rate was determined for both areas of walnut plantations, namely:

$$i_{e(3ha)} = 0.35 - 24 \in \frac{0.40 - 0.35}{-27 \in -24 \in} = 0.3735 = 37.35\%$$

$$i_{e(10ha)} = 0.35 - 18{,}970 \in \frac{0.40 - 0.35}{-13{,}470 \in -18{,}970 \in} = 0.3792 = 37.92\%$$

The calculated internal rate of return of 37.35% and 37.92% are over four times higher than the assumed calculative interest rate (8%), which means that according to this indicator, investing in both plantations is economically justified, but investing in a plantation of 10 ha is more economically advantageous, that is 37.92% > 37.35%.

The parameters of the investment calculation of raising and exploiting the analyzed walnut plantations, on the basis of which the indicators of economic effectiveness were determined, are given in table 7.

Table 7. Parameters of investment calculation of raising and exploitation 3 ha and 10 ha of walnut plantations

Parameters of investment calculation	Amount	
	3 ha	10 ha
m - period of raising (growing) plantations	5 years	5 years
n - period of exploitation of walnut plantations	35 years	35 years
i - rate of interest	8 %	8 %
A_0 - total investments	47,478 €	147,145 €
b_i - financial income by years of exploitation	Table 4	Table 4
a_i - financial payments by years of exploitation	Table 4	Table 4
k_i - cash flow by years of exploitation	Table 4	Table 4
B_n - final (liquidation) value of walnut plantations	111,200 €	370,200 €

Source: Authors' calculation

Looking at the unit area, investments for a 3 ha plantation are higher than investments for a 10 ha plantation by 1,112 €/ha, i.e. 15,826 €/ha > 14,714 €/ha. In order to make a comparative analysis of the economic effectiveness of the analyzed plantations, in Table 8 are shown the amounts of individual indicators and the fulfillment of the criteria for making an assessment.

Table 8. Indicators of the economic justification of raising and exploitation 3 ha and 10 ha of walnut plantations

Indicators of economic justification of walnut plantations	Amount and fulfillment of criteria	
	3 ha	10 ha
NPV_0 - net present value of walnut plantations	160,134 € > 0	583,746 € > 0
CV_0 – capitalised value of walnut plantations	207,612 € > 47,478 €	730,891 € > 147,145 €
t – pay-back period	9.64 years < 35 years	9.24 years < 35 years
i_e - internal rate of return	37.35 % > 8 %	37.92 % > 8 %

Source: Authors' calculation

The calculated indicators of economic justification show that, under the assumed organizational and economic conditions, investing in raising both analyzed walnut plantations would be expedient, that is, economically justified. For a plantation of 3 ha, indicators of economic effectiveness per unit area are lower than indicators for a plantation of 10 ha, i.e. 53,378 €/ha < 58,375 €/ha (net present value) and 69,204 €/ha < 73,089 €/ha (capitalised value). Then, the return period of investment investments for a 10 ha plantation is shorter compared to a 3 ha plantation, i.e. 9.24 years < 9.64 years and the rate of capital return for a 10 ha plantation is more favorable than a 3 ha plantation by 0.57%, i.e. 37.92% > 37.35%. Based on the net present value and other indicators determined on its basis, it can be concluded that investing in raising and exploiting walnut plantations on an area of 10 ha is economically more efficient than investing in raising and exploiting plantations on an area of 3 ha.

In order to be able to compare investments in raising walnut plantations of different areas, a relative indicator was also determined from the ratio of the net present value of plantations and the present value of investments, i.e.: 160,134 € / 47,478 € = 3.37 (for 3 ha) and 583,746 € / 147,145 € = 3.98. For each euro of investments, 3.37 € (for 3 ha) and 3.98 € (for 10 ha) of accumulation are realized, where 3.98 > 3.37, which means that the investment in raising and exploiting a plantation of 10 ha is more profitable compared to the current 3 ha.

Conclusions

By applying the net present value and methods based on it, in this research, the evaluation of the economic justification of raising walnut plantations was determined, as well as the choice between areas of 3 ha and 10 ha, the Šejnovo variety, the same cultivation form and planting system. The total investments in raising plantations and replacing worn-out machinery amount to 47,478 € (for 3 ha), i.e. 15,826 €/ha and 147,145 € (for 10 ha), i.e. 14,715 €/ha. Looking at 1 ha, investments for planting 10 ha are lower compared to 3 ha, by 1,111 € (about 8%).

At a calculated interest rate of 8%, a net present value of 160,134 € (for 3 ha) and 583,746 € (for 10 ha) is achieved. Including the risk and uncertainty of the calculative interest rate, provided that it is increased by 25%, there would be a decrease in the net present

value for both plantations, namely by 35% for 3 ha, and 25% for 10 ha, which would extend the return period of the investment capital. According to the yield value, the upper limit of investment investments is 207,612 € (for 3 ha) and 730,891 € (for 10 ha), and considering that this value is higher than the total investment investments of individual plantations, the investment is economically acceptable. The planned investments would be recovered during the 10th year, which is a much shorter period of time than the period of use of plantations, i.e. 9.24 years < 35 years and 9.64 years < 35 years. The calculated internal interest rates of 37.35% and 37.92% are higher than the calculated 8%, which means that investing in raising both plantations is economically expedient.

Looking at the unit area, investments for a 3 ha plantation are higher than investments for a 10 ha plantation by 1,112 €/ha, i.e. 15,826 €/ha >14,714 €/ha. The calculated indicators of economic justification show that, under the assumed organizational and economic conditions, investing in raising both analyzed walnut plantations would be expedient, that is, economically justified. For a plantation of 3 ha, indicators of economic effectiveness per unit area are lower than indicators for a plantation of 10 ha, i.e. 53,378 €/ha < 58,375 €/ha (net present value) and 69,204 €/ha < 73,089 €/ha (capitalised value). Then, the return period of investment investments for a 10 ha plantation is shorter compared to a 3 ha plantation, i.e. 9.24 years < 9.64 years and the rate of capital return for a 10 ha plantation is more favorable than a 3 ha plantation by 0.57%, i.e. 37.92% > 37.35%. For each euro of investments, 3.37 € (for 3 ha) and 3.98 € (for 10 ha) of accumulation are realized, where 3.98 > 3.37, which means that the investment in raising and exploiting a plantation of 10 ha is more profitable compared to the current 3 ha.

Based on the net present value and other indicators determined on its basis, it can be concluded that investing in the raising and exploitation of walnut plantations on an area of 10 ha is more economically efficient and sustainable than plantations on an area of 3 ha.

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Conflict of interests

The authors declare no conflict of interest.

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