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INVESTMENT APPRAISAL OF A POPLAR PLANTATION AGED 42 YEARS

Abstract: Commercial profitability of poplar cultivation was analysed in an artificial poplar plantation in Serbia. The aim of this study was to validate the invested financial means in the artificial poplar plantation, on the basis of the analysis of costs and receipts during a 42-year rotation, on alluvial semigley, at a discount rate of 12%. Methods of dynamic investment calculation (net present value - *NPV*, internal rate of return – *IRR*, benefit-cost method – *B/C* and payback period - *PBP*) were used. The investigated plantations were established from *Populus* x *euramericana* cl. *I-214,* with a planting spacing of 6 x 3 *m*.

At the calculation discount rate of 12%, the project for the production cycle of 42 years was not cost-effective from the economic aspect. The discount rate of 6% can be accepted in the studied plot because of the better site (alluvial semigley), but the oldness of the stand is unfavourable. For the studied sample plot, *IRR* was 5.51 %. *B/C* at *r*=12% in the study compartment was 0.24. The analysis shows that *PBP* is practically unacceptable for the investor at the discount rate of 6%.

In practice, it is necessary to improve the position of producers in getting financial means for investment in poplar cultivation, so as to stimulate the establishment of artificial poplar plantations, especially in the private sector (on private land).

Key words: investment appraisal, poplar plantation, commercial profitability, costs, revenues

ПРОЦЕНА ИНВЕСТИЦИЈА У ПЛАНТАЖИ ТОПОЛЕ СТАРОСТИ 42 ГОДИНЕ

Извод: У раду је приказана анализа комерцијалне исплативости узгоја топола, на примеру плантаже старости 42 године. Циљ истраживања је да се на основу анализе трошкова и прихода у периоду од 42 године, коришћењем метода динамичке анализе, провери оправданост уложених финансијских средстава у вештачке тополине засаде. Прорачун је вршен за дисконтну стопу

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од 12%. Плантажа се налази на земљишту алувијални семиглеј, *Populus* x *euramericana* cl. *I-214*, размака садње 6 x 3 *m*.

При дисконтној стопи од 12%, пројекат је за трајање производног циклуса од 42 године неисплатив. Интерна стопа приноса је 5,51%, што је знатно испод калкулативне дисконтне стопе од 12%, па би финансирање пројекта помоћу неког кредитног аранжмана било практично немогуће под овим условима. Однос корист-трошак је 0,24, а анализом резултат рока повраћаја новца дошло се до закључка да је практично неприхватљиво финансирати састојину на овај начин примењујући дисконтну стопу од 6%.

Кључне речи: плантаже топола, комерцијална исплативост, трошак, добит

1. INTRODUCTION

Wood production in short-rotation poplar plantations has been studied since the mid-1950s in the Former Yugoslavia. The information and results gained from these trials are presented, particularly with respect to operations, productivity and costs. Current methods for site selection, establishment, management practice, pests and diseases, harvesting and storage of poplar plantations are described and discussed. Consequently, managing forests for a single purpose only (timber production) may lead to socially inefficient management of woodlands. The financial aspect of growing hybrid poplar is a subject that has been studied by many for years all around the world (Tabbush, Parfitt, 1996, Van Kooten *et al.*, 1993, Mitchell *et al.*, 1997, Jain, Singn, 2000, Petraš *et al.*, 2008, Keča *et al.*, 2011, Keča *et al.*, 2012).

Costs considered in this analysis include: afforestation, maintenance, harvesting, and opportunity costs of land. Afforestation costs consist of site preparation, transportation and installation of the bedding plants, fertilization, fencing and wheel track set up. Maintenance costs include transportation and installation of new bedding plants to replace dead plants, cultivation care, irrigation, and form pruning. Afforestation and maintenance costs differ according to the type of plantation considered (Keča, 2010b). Maintenance costs are considered only for the first 6 years (Phototable 1). In this analysis, costs incurred after the sixth year are not taken into account, because it is assumed that expenses incurred for the management of woodland equal revenue obtained from the sale of trees (thinning operations).

Yield classes in hybrid poplar plantations (*P.* x *euramericana* cl. *I-214)* are high in Serbia. But, the economic cost-effectiveness of the poplar plantations is debatable. The reasons for this are numerous: high costs encountered at the stage of plantation establishment and non-existence of income until the end of rotation that is influenced by different biological, climatic, technical and technological aspects, etc. (Holopainen *et al.*, 2010, Keča *et al.*, 2011). The largest poplar plantation areas are intended for the production of veneer, peeling and cutting logs. All of that wood, about 350 000 *m³* of roundwood year[1], is processed in Serbia (Keča *et al.*, 2012). It is used in the production of: packaging, veneer, pallets, various types of boards, etc.
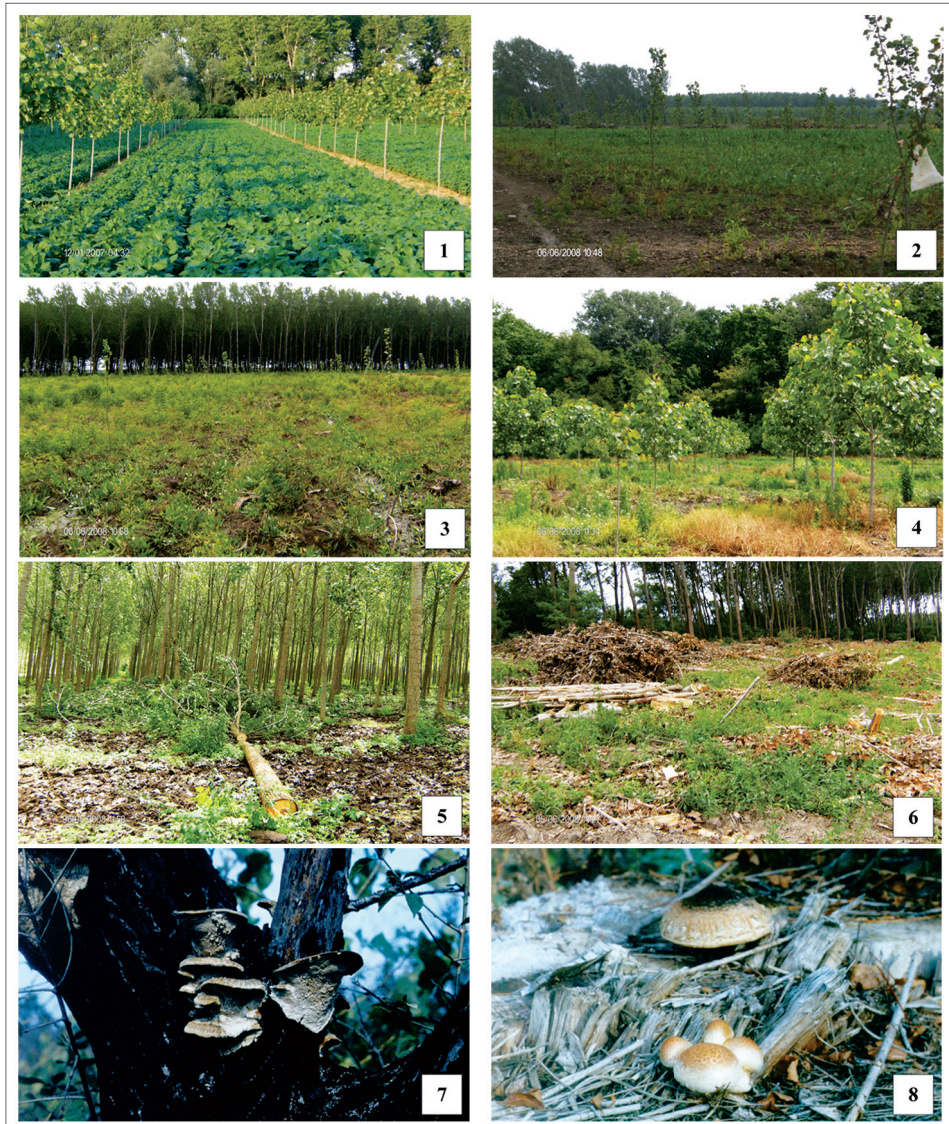
Phototable / Фототабела: 1. two-years old plantation with soybean/две године стар засад соје; **2.** hybrid poplar plantation with maize (photo Pajić S.)/засад хибридне тополе са кукурузом (фото Пајић С.); **3.** ground and soil preparation (photo Pajić S.)/припрема земљишта и земље (фото Пајић С.); **4.** plantation with different tree age/засад са дрвећем различите старости; **5.** schematic thinning in 9 year old hybrid poplar plantation/шематска прореда у деветогодишњем засаду хибридне тополе; **6.** clear cut at the end of rotation/чиста сеча на крају опходње; **7.** *Trametes suaveolens*-sporophores (foto Karadžić D.); **8.** *Pholiota populnea*-fruit bodies on stump/*pholita populnea*-плодоносна тела на пању.

Production of high quality poplar timber can be threatened by different factors like windstorm, windthrow and snow break, but also insects, mammals, diseases, etc. (C e l-l e r i n o, G e n n a r o, 1999, R o y l e, O s t r y 1995). Among them, decaying fungi play an important role, because they can destroy a significant amount of timber. The range of damages is in direct correlation with the age of a plantation or we can say that younger plantations aged up to 25 years have minor damages (1-5%), while damage in over-aged plantations reaches up to 20% of the total wood volume (N. Keča, unpublished). The most common species, causing decay, in hybrid poplar plantations are *Trametes suaveolens* (L.) Fr., *Fomes fomentarius* (L.) Fr., *Trametes versicolor* (L. ex Fr.) Quel., *Pholiota populnea* (Pers.:Fr.) Kuyper & Tjallingii-Beukers (K e č a, 2004).

The goals of the work reported in this paper were: (i) to examine the financial effects of different discount rates on the cost-efficiency values of a poplar plantation, based on an analysis of the present value of costs and revenues over 42 years, (ii) to test the sensitivity of these values to possible changes in the levels of costs and revenues on the example of one compartment/section aged 42 years.

2. MATERIAL AND METHOD

2.1 Methods of investment appraisal

The deficit of wood production in meeting the demand is increasing in many countries. Establishment of plantations with poplar, salix and other fast growing forest tree species is one of the most effective ways to meet the growing demand for wood.

The subject of research has been a poplar plantation of clone *I-214* aged 42 years, with a planting spacing of 6 x 3 *m* (555 trees per *ha*), for technical wood production, on alluvial semigley soil type, management class 10.453.83, with an area of 6.62 *ha,* on a plain terrain. It is a well managed stand, even aged, with full forest cover (0.7), medium maintained. The study was carried out in a plantation of poplar trees in the North-western part of Serbia, in the area of the Sava River, in the period 2002 – 2012 (Figure 1).

The data used in this study were collected from the archives of the forest enterprise that managed the studied plantations - Public Forest Enterprise "Vojvodinašume" (secondary data). Cash outflow is present in the first 5 years, and cash inflow from schematic thinning in the 6th year and at the end of the rotation (in this case, at the age of 42, during the final cutting from the income of F–veneer and L–peeling logs, timber wood class I and II, and pulpwood) (Table 1, 2). Data related to the
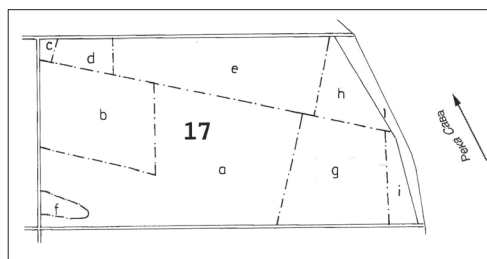

Figure 1. Map of the study plot
Слика 1. Мапа истраживане површине

final cutting were collected directly in the field and controlled in the official documentation of the forest enterprise. The costs are expressed per unit area of *1 ha* at the prices in force in January 2010, converted into euro *(€)*. Since all the studied stands are state-owned and managed by the Public Forest Enterprise "Vojvodinašume", the value (cost) of land rent was not entered into the calculations (Keča, 2011/a).

Table 1. Revenues and costs, *NPV* at a discount rate of 12% in the study plot
Табела 1. Приходи и трошкови, нето садашња вредност при дисконтној стопи од 12%

Study plot Огледна површина	Year Година	C	R	C_r	R_r	C_{rs}	R_{rs}	$\sum R_r - \sum C_r =$ NPV
Unit Јединица мере	(€·ha^{-1})							
	42	3 727,64	16 779,22	31,94	143,75	2 844,90	682,91	-2 161,99
	$\sum$			2 844,90	682,91			

Legend : C – costs; R – revenues, C_r – discounted cost, R_r –discounted revenue, C_{rs} – average relative cost (divided by age of plantation), R_{rs} – average relative revenue, *NPV* – net present value, *NPV$_s$* – average net present value (divided by age of plantation)

Table 2. Income of final cutting in the study plot
Табела 2. Приходи од главне сече на огледној површини

Assortment structure Сортиментна структура	Price Цена	Final cuttings income Приход од главне сече	
	euro	m^{-3}	euro
F - veneer	55	186,60	10 263,00
L – peeling logs	45	69,01	3 105,45
timber wood class I	35	47,01	1 669,85
timber wood class II	27,50	30,19	830,23
Pulpwood	17,14	53,15	910,99
$\sum$	/	/	16 779,52

Investment Appraisal also known as Capital Budgeting (Röhrich, 2007, Götze *et al.,* 2008) is used to asses whether capital expenditure on a particular poplar plantation will be beneficial for the entity or not. These techniques are used for evaluation both in the private and public sector in forestry. Most commonly used techniques include: Net Present Value (*NPV*), Internal Rate of Return (*IRR*), Payback Period (*PBP*) and Benefit-Cost Method (*B/C*) (Pogue, 2010), which are applied in the article (Keča *et al.*, 2012). Capital budgeting (or investment appraisal) is the planning process used to determine whether an organization's long term investment such as new machinery, replacement machinery, new plants, new products, etc. are worth pursuing. It is a budget for major capital

or investment and expenditures (Sullivan and Sheffrin, 2003). All four methods have been applied in the article (Keča *et al.*, 2011). These four methods, known as dynamic methods, are nowadays used in countries all over the world in the investment economics effectiveness appraisal and practically start with the assumption that money has its time value (Gittinger, 1972, Lumby, 1988).

The technique of **SWOT** analysis was applied in the article. The SWOT analysis headings provide a good framework for reviewing strategy, position and direction of a company or business proposition, or any other idea. A SWOT analysis is a subjective assessment of data which is organized by the SWOT format into a logical order that helps understanding, presentation, discussion and decision-making (Pahl, Richter, 2009).

The **case study** method was applied and preferred for several reasons: (i) ”how-why” questions were presented and posed in the research, (ii) the investigator has little control over events, and (iii) the research is focused on a contemporary phenomenon within a real-life context (Yin, 2009). However, the sampling of case from the chosen population is unusual when building theory from case studies. Such research relies on theoretical sampling (*i.e.,* cases are chosen for theoretical, not statistical, reasons) (Yin, 1981).

During the final cutting and on the temporary timber yard examination of the presence of decay was performed. The identification was based on the morphological characteristics of the species as described by Keča (2004). The present sporophores were identified according to the description and keys of Karadžić (2010). The estimation of damages caused by different species was according to Karadžić (1987).

3. RESULTS

3.1 Investment appraisal

The value of plot establishment and management costs between the ages of 0 and 6 years is 3 727.64 € *ha⁻¹* for the observed sample plot. The income from thinning is 1 064.20 € *ha⁻¹*. At the end of rotation in the 42nd year, the revenues were 16 779 € *ha⁻¹*. The values for *NPV* at a discount rate of *r*=12% were negative in the studied plot –2 161.99 € *ha⁻¹* (Table 1). The value of 12% was chosen as the base discount rate, which is about the average of the 10-15% range (IMF, 2005) recommended for the evaluation of economic investment in transition countries (Neumann and Zimmermann 2000).

The financial effects for the plantations were also estimated using the discount rates of 8%, 6% and 4%, under the condition that the costs and revenues are equal *(C$_r$ = R$_p$)* (Table 3). For discount rates of 12, 8, 6%, the *NPV* values were negative for the study plot. A positive *NPV* value for *p*= 4% was observed, with a maximum of 3100 *€ ha⁻¹* (Table 3).

The internal rate of return *(IRR)* for the studied plot is 5.51%. Assuming all stands require the same amount of upfront investment, the stand with the highest *IRR* would be considered the best and undertaken first.

Table 3. Sensitivity of *NPV (€ ha⁻¹)* compared to the relative changes C_r and R (p = 4-12%)
Табела 3. Сензитивна анализа нето садашње вредности *(€ ha⁻¹)* у поређењу са релативним променама прихода и трошкова при различитим дисконтним стопама (p = 4-12%)

Study plot Огледна површина	Soil Type Врста земљишта	Age старост	p = 12%		p = 8%		p = 6%		p = 4%	
			C_r	R_r	C_r	R_r	C_r	R_r	C_r	R_r
		Year година	$€·10^{-3}$							
1.	ASG	42	-2,16	-2,16	-1,73	-1,73	-1,10	-1,10	0,31	0,31

Legend / Легенда : ASG-Aluvial semigley / алувијални семиглеј

The application of the payback period (*PBP*) calculation can greatly affect the reliability of predicting the degree of economic effectiveness of investments, and also the potential risks for the investor in his decisions on the investments in poplar cultivation (Keča *et al*., 2012). The most favourable situation is the discount rate of 2%, where the period is 20 years. The payback period for the discount rate of 6% is 80 years, which is unacceptable from the economic standpoint.

The cost-benefit analysis shows that in the case of this stand *B/C*=0.24 at a discount rate of 12%. That practically means that the costs of the project are three times higher than the receipts, and each euro of investment creates 0.24 euro of profit *i.e.* 0.76 euro of loss. Therefore, it can be claimed that it is economically unacceptable to invest in such a stand, but just when *p* = 12%.

Table 4. Payback period for the studied plot (*p*=6%, 4% and 2%)
Табела 4. Рок поврћаја новца за анализирану огледну површину

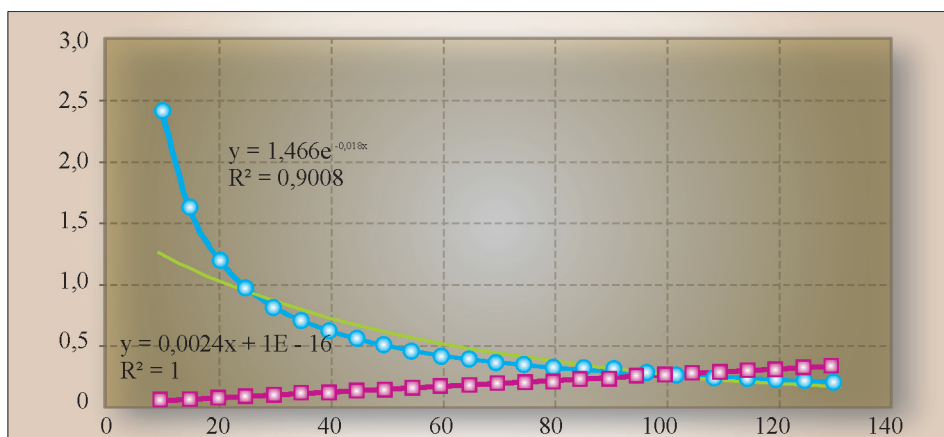| Study plot p(%)	PBP year
6	80
4	38
2	20

Diagram 1. Changes in *B/C* in relation to relative changes in C_r and R_r (*p*=12%) in the studied plot
Графикон 1. Промена односа „корист-трошак" на релативне промене трошкова и прихода

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It is also observed that the changes of *B/C* dependent upon costs are described by an exponential function. On the other hand, the changes of *B/C* dependent on changes of receipts are described by a linear function (Diagram 1).

Statistical significance is verified by the t-test, correlation coefficient, determination coefficient, and Fisher's statistics for changing of costs and receipts. It can be concluded that the connection of relative and independent variable is very high R≥0.95. The ratio between explained and total variations in the regression is very high R^2≥0.9. The fisher test confirmed *i.e.* tested the precision of the calculated correlation coefficient. That value is also very high. Therefore, it is proved that we can have confidence in the calculated coefficient of correlation. Using the t-test the precision of the calculated parameters was established and it is proven that the parameters are very precisely calculated in all examples (Table 5).

Table 5. Statistical analysis for *B/C*
Табела 5. Statistička analiza za odnos "korist-trošak"

Changes in C	Value	Changes in R	Value
R	0,949	*R*	1
R^2	0,9007	R^2	1
F-statistics	208,8	F-statistics	1,44E+33
t-statistics	3,89	t-statistics	5,587
$y = 1{,}466 \cdot e^{-0{,}0181x}$		$y = 0{,}002x - 2{,}77 \cdot 10^{-17}$	

According to the SWOT analysis, it can be concluded that the focus in poplar production is actually in the economic, production, market, ecologic and social aspects of this field (Table 6).

Table 6. SWOT analysis of the research
Табела 6. SWOT анализа истраживања

Strengths:	*Weaknesses*:
• *"intercrop" production* • *decrease the costs of establishment of the plantations* • *focus to "commissioned production"* • *expand the pallet of products of poplar wood* • *"consuming of CO_2"* • *erosion control* • *establishing of shelterbelts* • *biomass production*	• *costly establishment of the plantation* • *inefficient legislation in poplar production* • *inefficient fertilization and pruning* • *high amounts of "payback"* • *inadequate pricing of poplar wood* • *adverse credit developmental policy* • *unfavourable tariff policy* • *lack of economic information on poplar production* • *presence of various schemes: risks of wrong (unproductive investments in certification)*

Opportunities:	*Threats*:
• *decrease rotation in poplar plantations* • *establish real amount of ceteris paribus in poplar plantations* • *improve techniques of classification of assortments* • *discover new segments of the market (new products)* • *establish capacities for cellulose production* • *increase the investment in stands on good habitats* • *introduce the auctions for selling the wood and develop e-market* • *establish clusters of SME$_s$ of poplar production* • *branding of products made of polar wood*	• *poplar production on unattractive soil for poplar production* • *competition of sawmill yards* • *decrease the costs of soil preparation* • *monopoly of public enterprises* • *„dumping" prices of poplar wood* • *unregulated ownership structure of polar stand* • *prejudice on poplar wood* • *lower prices of poplar wood in the countries in the region*

The **WO** strategy (**MIN/MAX**), which is characterised by minimizing of weaknesses and maximising of the use of external opportunities, is presented as the most favourable alternative in this case.

4. DISSCUSION

The analysed characteristics, including the type of soil and age of stands are visible directions in which solutions for raising of poplar plantations in Vojvodina could be found. Moreover, they could be efficient and profitably acceptable at the discount rate which is the upper limit for investment in *populiculture* and that is 6%. S c h a f e r (1969), S i n d e n (1976) and v a n O o s t e n (2006) conducted similar researches. Profitable rotations in the future have the effect of shortening the optimal rotation period, because an investment in standing timber causes opportunity costs by delaying the establishment of the next generation of plantations (M o o g , B o r c h e r t, 2001). Plantations are very efficient in CO_2 consumption, as shelterbelts, in flood control (table 5), etc. Therefore, the state can stimulate forest owners to invest in poplar production on river banks in the future. The plantations grown on higher quality soil types such as alluvial semigley are more profitable (K e č a *et. al.*, 2012).

The length of rotation is a highly questionable parameter, because it depends on the purpose of production (bio-fuel, cellulose, technical wood, protection of rivers, crops, etc.) (Phototable 1), site class and markets. On the other hand, shorter production cycles have better financial parameters (R a e *et al*., 2004, J a i n , S i n g h, 2000, U p d e g r a f f *et al*., 2004).

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The costs of logging and assortment production make a significant expense item. Therefore, it is necessary to reduce costs in the felling and preparation of assortments and also in the first phase of transport (Cremer *et. al.*, 1982, Eriksson *et. al.*, 2002, Zhu *et al.*, 1998).

Regarding *IRR*, the results clearly show an inverse proportion between the discount rate and the age of the plantation. Also, a direct proportion with soil type is present *i.e.* discount rates are higher for plantations that are grown on stands suitable for poplar production (alluvial semigley) and for shorter rotations and *vice versa* (Keča, 2010b). In this case the stand is over-matured.

Different authors have analyzed different *PBP* for poplar plantations depending on the soil type, age of stand, plant density and climate (Dhillon *et. al.*, 2001, Latif *et.al.*, 2003, McKenney *et.al.*, 2011).

The benefit-cost ratio varies ranging from 0.4-2.8 in poplar plantations depending on the area of research (Siddiqui, Khan, 1991, Lust 1998).

Only the application of all four dynamic methods gives solutions to investment issues in poplar plantations in general and it is recommended for use in all investment analyses.

Losses from pests and pathogens in hybrid poplar plantations are almost avoidable (Minghao, Yanzhon, 2005). Environmental conditions of some years can speed up inoculum production and cause an epidemic (Marković, Karadžić, 2006). On the other hand, there are many factors that affect losses which can be controlled by managers. Wounding of trees during among row treatment, thinning, undergrowth removal and branch pruning must be reduced to a minimum. Rotation length is prescribed, but sometimes has to be extended, because of other factors such as timber demand, economic crises and so on. Managers have to be aware that longer rotation can increase development of decaying fungi and cause a reduction of incomes.

5. CONCLUSIONS

From the previous analysis it can be concluded that:

While the discount rate is 12%, the project is unprofitable for a period of 42 years, because the loss of about 2 160€·ha⁻¹ can be noticed. The above mentioned unprofitability is acknowledged by *IRR*, which is 5.51%, significantly less than the calculative discount rate of 12%. Therefore, financing of such stands is very problematic and difficult. Positive financial effects can be reached by lowering the costs of establishing a plantation. A decrease in costs influences the financial effect of production more than an increase in incomes in this case. The costs can be reduced by finding a solution in the field of soil preparation for afforestation, *i.e.* working operations which will show a higher level of economic efficiency in the future. The most favourable situation is at the discount rate of 2%, where the period is 20 years for *PBP*. The cost benefit analyses shows that in the case of this stand *B/C* = 0.24. According to the SWOT analysis, WO strategy (MIN/MAX) is accepted as the most favourable alternative.

The observed damages are acceptable for extensive production, but the amount of destroyed wood volume of 3% cannot be neglected. Species like *Trametes suaveolens*, *Fomes fomentarius* and *Pholiota populnea* (phototable 1, pictures 7,8), which are present in the plantations and surrounding forests, cannot be eliminated, but good plantation management, without a needless wounding of trees can reduce damages to a minimum.

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ПРОЦЕНА ИНВЕСТИЦИЈА У ПЛАНТАЖИ ТОПОЛЕ СТАРОСТИ 42 ГОДИНЕ

Р е з и м е

Дужина производног циклуса у тополиним плантажама може се релативно једноставно усклађивати према циљевима производње. У поређењу са другим врстама дрвећа, која имају дужу опходњу брже се враћају уложена финансијска средства. Такође, постоји и могућност примене бројних агротехничких мера у сврху повећања продуктивности.

У раду је приказана анализа комерцијалне исплативости узгоја топола, на примеру плантаже старости 42 године. Циљ истраживања је да се на основу анализе трошкова и прихода у периоду од 42 године, коришћењем метода динамичке анализе (нето садашња

вредност, интерна стопа приноса, рок повраћаја новца и однос „корист-трошак"), провери оправданост уложених финансијских средстава у вештачке тополине засаде. Прорачун је вршен за дисконтну стопу од 12%.

Плантажа се налази на земљишту алувијални семиглеј, *Populus* x *euramericana* cl. *I-214*, размака садње 6 x 3 *m*. Ради се о једнодобној и очуваној састојини, потпуног склопа (0,7), која је средње негована. Типолошка припадност је шума тополе на алувијалном семиглеју. основна намена састојине је производња техничког дрвета.

При дисконтној стопи од 12%, пројекат је за трајање производног циклуса од 42 године неисплатив и бележи губитак од –2 161.99 € *ha⁻¹*. Позитиван ефекат се бележи тек применом дисконтне стопе од 4% и то 3 100 € *ha⁻¹*.

Интерна стопа приноса је 5,51%, што је знатно испод калкулативне дисконтне стопе од 12%, па би финансирање пројекта помоћу неког кредитног аранжмана било практично немогуће под овим условима. Интерна стопа приноса је виша за засаде који су подигнути на стаништима која више одговарају тополама (алувијални семиглеј), као и за краће опходње и обрнуто.

Однос корист-трошак је 0,24, а анализом резултат рока повраћаја новца дошло се до закључка да је практично неприхватљиво финансирати састојину на овај начин примењујући дисконтну стопу од 6%. једини прихватљив сценарио представља употреба дисконтне стопе од 2%, када рок повраћаја новца износи 20 година. Може се тврдити да је економски неоправдано улагати у пројектоване састојине, али само у случају када је друштвена цена капитала 12%.

Примећено је да се промена *B/C* у зависности од промена трошкова, одвија по експоненцијалној функцији, а промена В/С у зависности од промена прихода по линеарној функцији.

Може закључити да је повезаност зависне и независне променљиве јако висока $R \geq 0{,}95$, да је однос објашњених и укупних варијација у датим регресијама јако висок $R^2 \geq 0{,}9$. Фишеровим тестом (F-статистиком) потврђује се, тј. тестира прецизност израчунатог коефицијента корелације и тај број је јако висок, што доказује чињеницу да се може имати поверења у израчунати коефицијент корелације (R). Т-тестом је утврђена прецизност израчунатих параметара и доказано је да су параметри прецизно израчунат.

Анализа исплативости за четири тестирана фактора показала је да постоји доста правилна зависност између промене квалитета станишта, дужине опходње и величине тестираних *NPV*, *IRR*, R и *PBP*. Засади подигнути на квалитетнијим земљиштима, као што су алувијални семиглеј били су финансијски исплативији у односу на оне подигнуте на земљиштима која нису тополина, као нпр. α/β глеј и црнице.

На посматраном локалитету уочене су: *Trametes suaveolens*, *Fomes fomentarius* and *Pholiota populnea,* које узрокују највеће штете (на 3% од дрвне запремине) и на тај начин умањују квалитет дрвета и трајно оштећују највредније делове стабла.