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Full Length Research Paper

Decision making analysis of walnut seedling production on a small family farm in Serbia

Branka Kalanović–Bulatović[1], Bojan Dimitrijević[1]*, Zorica Vasiljević[1], Zoran Rajić[1], Nebojša Ralević[1] and Mladen Grbović[2]

[1]Faculty of Agriculture, University of Belgrade, Belgrade, Serbia.
[2]University of Tennessee, Knoxville, USA.

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The wide range of walnut application makes it one of the most appreciated fruit species. In 2008, Serbian government started providing subsidies for every planted walnut seedling. These incentives have already increased the interest in this type of seedlings on the market. One of the main objectives of each farm is to maximize economic results. For a family farm, there are many alternatives on how to accomplish this objective. The decision making analysis has been done on the basis of the case study for the typical small family farm that produces walnut seedlings, located in the central part of Serbia. One of the options for the farm is to proceed to use current technology, while the other possibility is to be reduced some of production operations. A third alternative is to give up the seedlings production and to put that money in the bank as savings. The decision has to be made between those three alternatives aiming at achievement of optimal/best economic result for the family farm. Summarizing results obtained from the decision tree, simulation and sensitivity analysis, the optimal solution for the family farm should be to continue production of walnut seedlings with technology it is currently using.

Key words: Decision making analysis, family farm, seedling production, walnut, Serbia.

INTRODUCTION

The wide range of walnut application in nutrition, medicine and food, timber and leather industry makes it one of the most appreciated fruit species. Its tree is considered valuable material for furniture production. Currently, there are 1,966,000 walnut trees in Serbia with 1,703,000 bearing trees (Statistical Office of Serbia, 2008). The annual production is 24,800 tones with average yield of 14.2 kg per tree (Statistical Office of Serbia 2008). In 2008, the Government started to provide subsidies for every planted walnut seedling by 1,200 RSD (Dinar, Official Currency in the Republic of Serbia) per seedling (Ministry of Agriculture, Forestry and Water Management of Republic of Serbia – MAFW, 2008). These incentives have already increased the interest for this type of seedlings on the market.

The seedling production in general is very complex and specialized field of fruit production, with many different production lines which timely supervene on each other (Milic et al., 1993). Because of that, the seedling production requires complete synchronization and concurrent completion of different operations. Some specificities of work organization in the seedling nursery are the following: cultivation on the small land area, yearlong activities so there is no marked seasonality of work, a need for qualified labor, personal responsibilities of workers, no hard work required (Milic et al., 1993). More also, economical efficiency of seedling production depends on: complex production with high costs per capacity unit, a high plant concentration on the small area and a high share of human labor (Andric, 1998).

The analyzed farm in this study was located in the central part of Serbia, a region well known for its fruit production. The plum production has the greatest share, followed by peach, apple, apricot and pear. Majority of producers produce more than one fruit specimen. Walnut production does not constitute considerable share in this region. The owner of the farm has inherited this production

*Corresponding author. E-mail: dimitrijedi@yahoo.com. Tel: + 381 64 22 48 076. Fax: + 381 11 316 17 30.

Table 1. Land structure on the farm in 2007.

Type of land use	Soil class	Acreage (ha)	Current usage (ha)
Fruit growing	-	0.70	-
Nursery	1	0.10	0.06
Peach orchard	4	0.22	0.22
Mother plantation 1	1	0.11	0.11
Mother plantation 2	3	0.20	0.20
Cherry orchard	3	0.07	0.07
Uncultivated	4	0.056	0.056
Total	-	0.756	0.716

Source: Grbovic et al., 2008.

from his father who was a well known seedling producer in ex-Yugoslavia. With M.Sc. degree in Crop Protection Science, his father had achieved very good results and reputation for this farm and passed his knowledge onto his son. His mother and sister help him operate the farm. Qualified labor was hired from The Fruit Research Institute for the most important operations such as grafting (Fruit Research institute Cacak, 2009). Moreover, the farm location enables a good connection with buyers that purchase seedlings directly on the farm, thus releasing the farm from the transportation costs to the market.

Given the annual production in Serbia (less than 25,000 of walnut seedlings), the fact that there are only 3 producers of this type of seedlings in this region with increased demand; the farm has no problem marketing its product. In the last couple of years, the farm is cooperating with a big buyer of seedlings which exports them in neighboring countries (Croatia, Bosnia and Herzegovina and FYRO Macedonia). Thus, all produced seedlings are being sold to them. The owner of the farm, however, wants to know how reduction of some operations would influence his costs and net revenue. For reduced technology he considers no usage of own field tiller, no-tillage for mother plantations, 50% less treatment with fungicide (once a month instead of twice), no regulated conditions for keeping grafting branches, and no insurance of production and wooden pillars instead of concrete ones. This reduction would considerably reduce his total costs, but the number of produced seedlings would significantly decrease, especially the number of the 1st class seedlings (Kalanovic et al., 2010).

The farm’s main objective is to maximize economic results. To accomplish this goal, profit needs to be maximized through minimizing costs and maximizing the number of seedlings produced, especially the 1st class seedlings. Hence, the farmer is considering reduction of some operations from his production in order to minimize the costs. He is aware that this reduction will influence the number of produced seedlings as well as the share of the 1st, 2nd and 3rd class seedlings. He wants to know if it would be more profitable to continue using current production technology or switch to the reduced-cost technology. The third alternative he is considering is depositing money in the bank instead of dealing with the seedling production.

MATERIALS AND METHODS

The paper has been done on the basis of the case study for typical small family farm located in the central part of Serbia, a region well known for its fruit production, where the average size of a farm is 2.10 ha (Muncan and Bozic, 2006). The farm operates on total area of 0.756 ha including cherry and peach orchards with 0.07 and 0.22 ha, respectively (Table 1). The production of walnut seedlings is performed on the area of 0.41 ha with seedling nursery, mother plantation 1 and mother plantation 2 using 0.10, 0.22 and 0.20 ha, respectively. The nursery and mother plantation 1 are situated on the 1st class soil for agricultural production (according to the classification of the MAFW).

The farm owns necessary machinery for successful seedling production except a large tractor which is being rented for the necessary operations. The farm also has the following objects for seedling production: room for keeping graft branches, room for keeping bud cuttings, storage and office. Moreover, the following cultivars of walnut are being produced on the farm: Champion, Sejnovo, Late fruitful, Srem, Rasna, Tisa, Jupiter, Geisenheim 139, Ibar and Late bunchy; all of which are grafted on the Juglans Regia L. rootstock.

The current technology of production on the farm includes the following operations: seeding and rootstock production, soil preparation for seedling nursery, rootstock seeding in to the nursery, rootstock care till grafting, grafting, the seedling raising in nursery, picking, pitting and sale of seedlings. Seeding and rootstock production includes tractor plowing and tillage before seeding and hoeing of seeded land later on. Seeding is performed manually with walnut seed being put in the channel made by hoe. Every year 3,000 walnuts seed are put in the soil (30 kg of seed) on the surface of 0.02 ha, with 1.1 m row space and 5 cm between seeds. Before seeding, seeds are being treated by fungicide (BENFUGIN 500 g/kg; Galenika) and kept 2 days. This operation also includes fertilizing by NPK (8:5:24) and KAN (27% of Nitrogen) fertilizers. Fertilizing is performed manually (20 kg of fertilizer). In October, between 2,600 and 2,800 rootstocks are usually picked up by subsoil tractor plough cutting the root, thus enabling workers to pick them out, and then the classification and pitting of produced rootstock are performed

Furthermore, soil preparation for nursery includes: cultivation, fertilizing, plowing (30 to 50 cm), soil breaking and surface plotting (Grbovic et al., 2008). The farm is using grafting branches from its own mother plantation. Only the one-year old and healthy branches

Table 2. Average number of seedlings produced with current technology (1999 to 2008).

Number of seedlings produced	Average
1st class	1,231
2nd class	586
3rd class	94
Total	1,911

Table 3. Average number of seedlings produced with reduced technology (1999 to 2008).

Number of seedlings produced	Average
1st class	492
2nd class	762
3rd class	188
Total	1,442

Table 4. Share of different seedling classes in total number of seedlings.

Parameter	Seedling share (%)	
	Current technology	Reduced technology
1st class	64.42	34.14
2nd class	30.67	52.82
3rd class	4.91	13.04
Total	100.00	100.00

are being used. The branch cutting is performed in December. The farm keeps grafting branches in the regulated temperature and humidity conditions till grafting. The type of grafting used is called the applied grafting, and requires that both branch and rootstock are of the same thickness. Preparation of rootstock and branches is being performed before grafting (March). After grafting, bud cutting is being held in the room with regulated temperature conditions (30 to 32°C). In April, rootstock is being seeded in the nursery. The growing of seedlings in the nursery includes: shoot removal from rootstock, nursery cultivation, lateral shoot removal, seedling tying (concrete pillars used), seedling fertilization, irrigation (3 L per seedling in April and 4 to 5 L in June, July and August in draught conditions) and their protection from plant diseases and pests (12 times annually) (Grbovic et al., 2008).

Picking up, pitting and sale of seedlings is being performed in October. Tractor plow is used; after picking up, the seedlings are being classified and sold or pitted. If pitting is performed on the farm, 40 to 50 cm deep trenches are made and poisonous lure is put around the seedling root, and then covered with the soil. When a buyer comes for seedlings, they are being put in the bags (10 seedlings/ bag) and sold. Usually, seedlings are being sold during the fall. The data about number of seedlings produced on the farm were obtained from the farm's records (Grbovic et al., 2008) for the 1999 to 2008 periods.

Estimation of experimental data

All seedlings were classified in three groups: the 1st class, 2nd class and 3rd class ones. They are classified by the look of the stem, leaf, height and root (Stancevic and Bugarcic, 1994). The averages for the produced seedlings with full technology were calculated using the farm's historical data (Table 2). The number of seedlings produced with reduced technology was calculated as a percentage of those produced with current technology, using estimations from previous researches (Korac et al., 1997). Those estimates ranged from 50 to 70% decrease in number of the 1st class seedlings, and between 20 to 35 and 100% increase in the 2nd and 3rd classes, respectively. For the sake of this study however, 60% decrease in the 1st class, 30% increase for the 2nd and 100% increase for the 3rd class was used to enable calculation of the total and average number of seedlings produced with reduced technology (Tables 3 and 4).

The market prices for walnut seedlings are determined annually for each class by the Association for production, processing and marketing of fruit, vegetables and forestry products and fruit seedlings. Those prices are usually higher than prices on the farm, primarily because if the products are selling on the farm, there are no transportation and marketing costs. Another reason is that farm is usually selling all its production to one large buyer, which gets a patronage discount. For that reason, in this analysis it was used the average farm's historical selling prices for the 2003-2008 period. The prices are determined by classes and they are highest for the 1st class and lowest for the 3rd class. Three different price levels (low, high and average) were used for different market conditions and these were used for calculations of the Expected monetary value (EMV) and Expected utility (EU). The prices were normally distributed using BestFit program and integrated into the decision tree chance nodes for both alternatives and each class of seedling (Palisade decision tools). The profit for each alternative and each class and price level was calculated per seedling by using the following formula:

Profit (Alternative 1, 2) = (selling price for seedling of the 1st, 2nd and 3rd class) – costs/seedling.

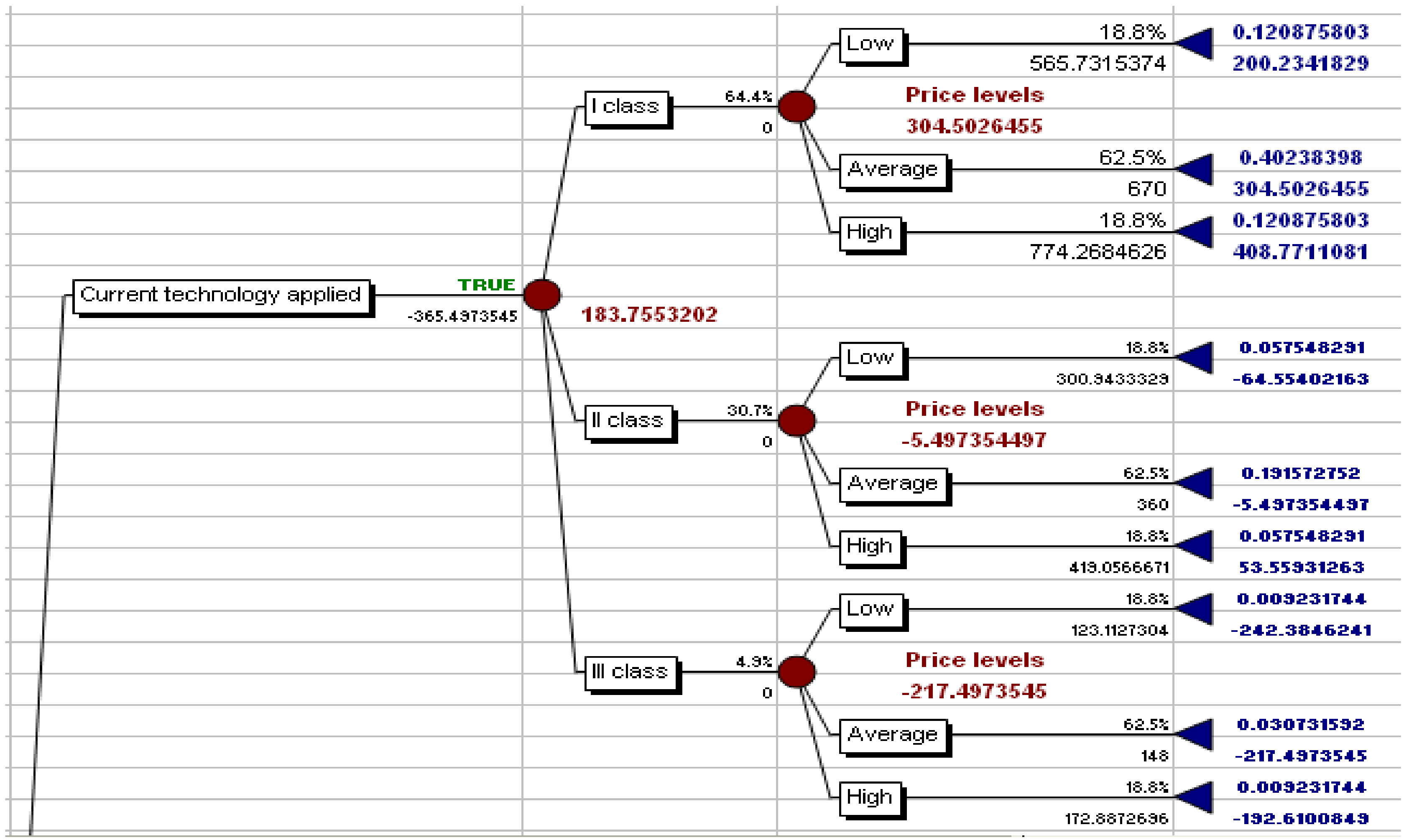

Figure 1. EMV for current technology of production (per seedling).

Calculated profits are shown in the decision tree (Figures 1 and 2).

After calculations of profits, EMV for each class of seedling was calculated by multiplying of profits with corresponding probabilities (Figures 1 and 2):

EMV (class) = Profit (low) * Probability (low) + Profit (average) * Probability (average) + Profit (high) * Probability (high).

Multiplying computed EMV for classes with respective probabilities, EMV for each alternative was calculated using decision tree (Palisade decision tools).

EMV (Alternative 1, 2) = ∑ EMV (class 1st, 2nd, 3rd) * Probability (class 1st, 2nd, 3rd).

EUs were also calculated using the Palisade Decision

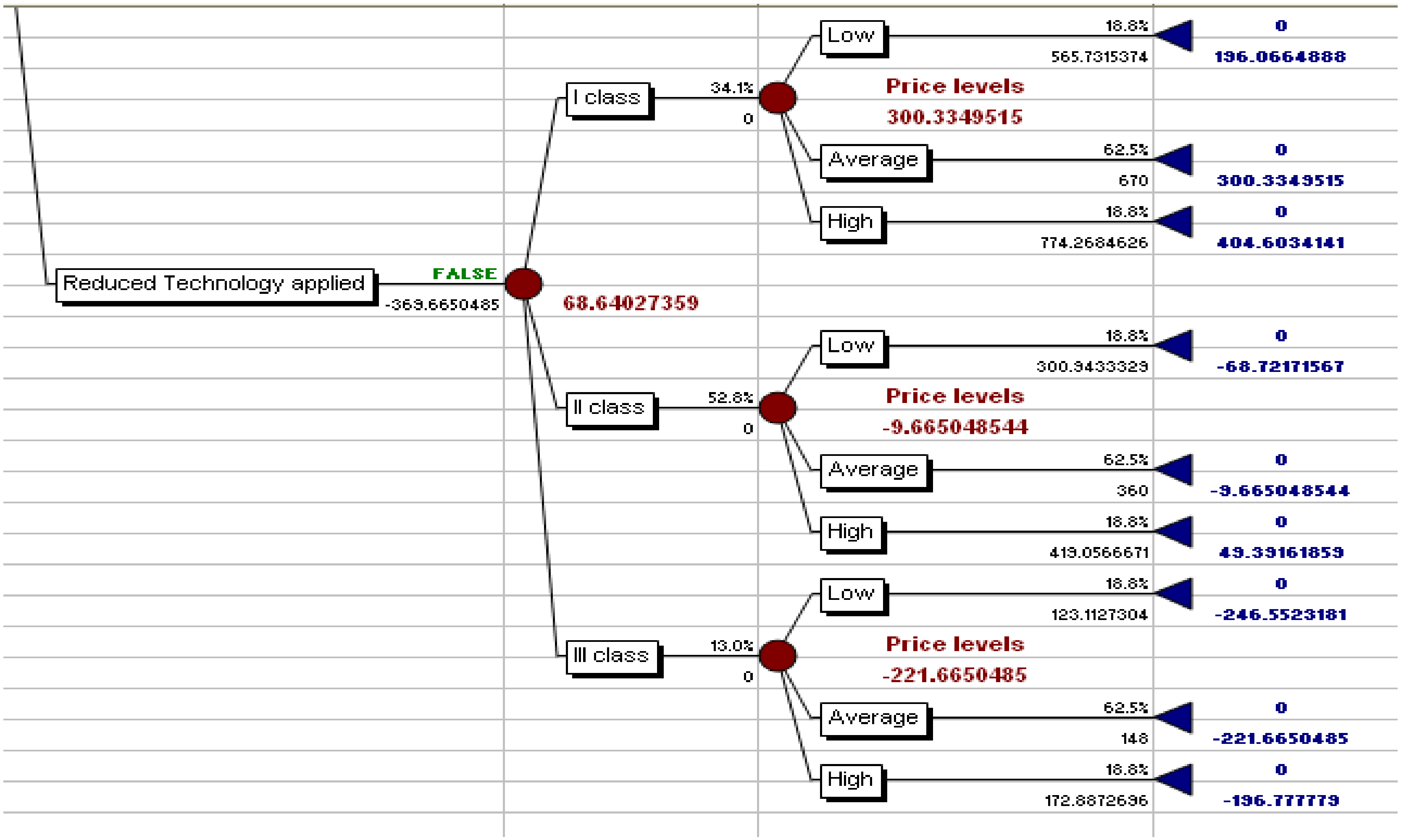

Figure 2. EMV for reduced technology of production (per seedling).

Tools Precision Tree program (Palisade decision tools) (Figures 3 and 4).

Exponential utility function was used, assuming farmers Risk tolerance coefficient of 100. Profits, costs, EMV and EU for each alternative were calculated per seedling.

In addition, the EMV and EU for the alternative of depositing money in the bank were calculated assuming amount of money that would be deposited is equal to annual costs of production, excluding the costs of depreciation for the assets that would have to be paid anyway – fixed costs (Figure 3). Current effective interest rate (EIR) of 12% for twelve month fixed-term deposits was used for computations. The EIR is equal to nominal annual rate (Agrobanka - Belgrade, 2009). There is no income tax for the RSD deposits in Serbia at the moment (National Bank of Serbia). Thus, computed value was divided by the average number of seedlings produced with both reduced

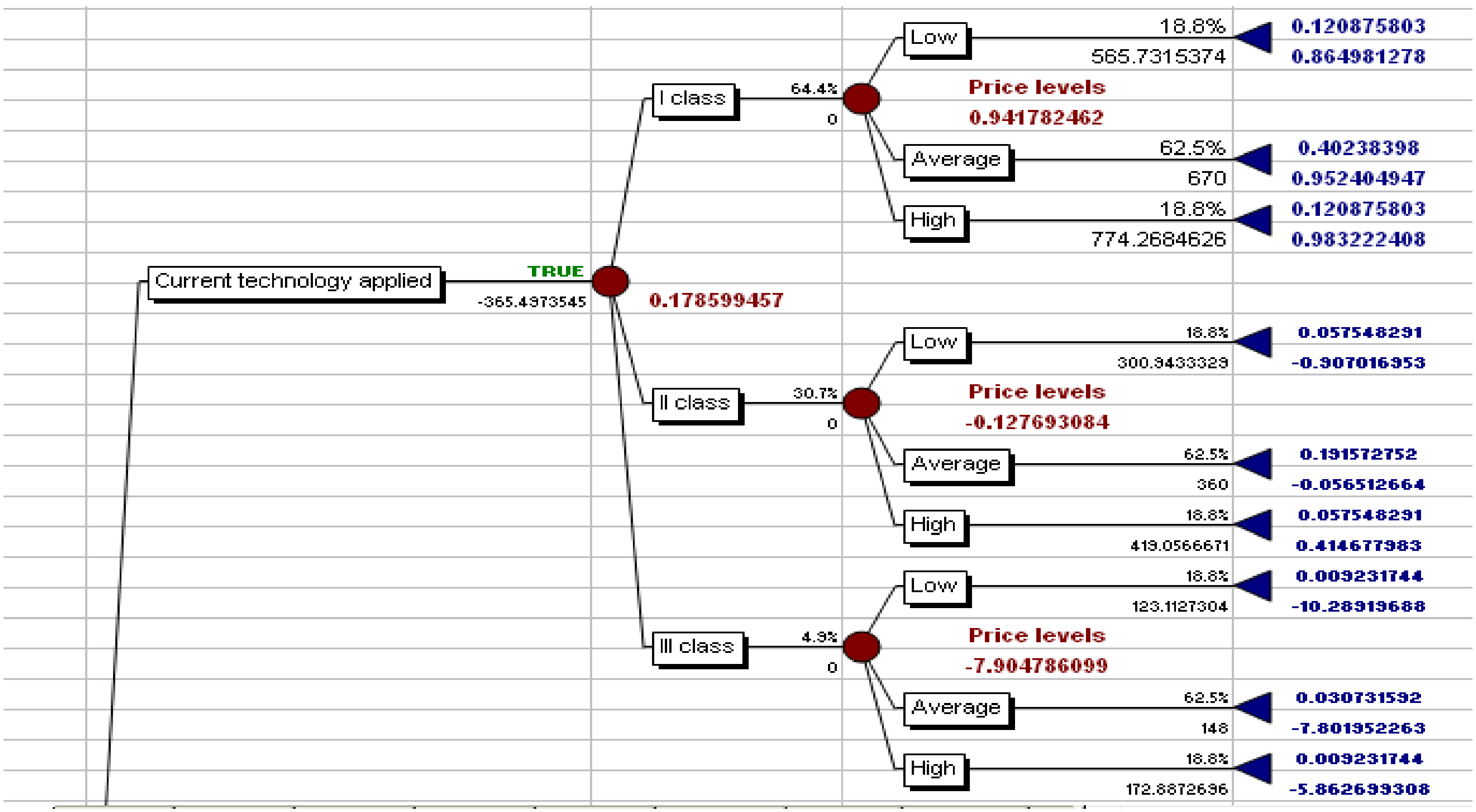

Figure 3. EU for current technology of production (per seedling).

and current technology to get expected values per seedling. EU for this decision was calculated using the exponential function.

Production costs for current technology of production were obtained from previous mentioned research (Grbovic et al., 2008) and they include: material costs, ancillary production costs, labor costs, general expenses, non-material costs, depreciation costs and insurance premium. Then, the calculated costs were divided by the number of produced seedlings for the same year as costs and integrated as a cost per seedling into the decision tree. All costs are calculated in the Serbian national currency (RSD) for the year of 2008 (Table 5). Labor costs constitute the biggest share (53.2%) followed by the costs of insurance (12.7%).

Moreover, the costs for reduced technology of production were calculated by subtracting the costs for the operations and material which would not be used: 50% less costs for chemicals because chemical treatments will be cut on half; no costs for fuel and lubricants because own field tiller would not be used; 25% less seedling produced (estimates), so 25% less costs for declarations; maintenance costs for field tiller and temperature regulator in the room for grafting branches storage during the winter; tillage and rototilling service fee for mother plantation; labor costs for the deducted operations and related nutrition costs; electricity costs for temperature regulation; depreciation costs for field tiller and concrete pillars and insurance costs. Reduced technology costs are given in the Table 6.

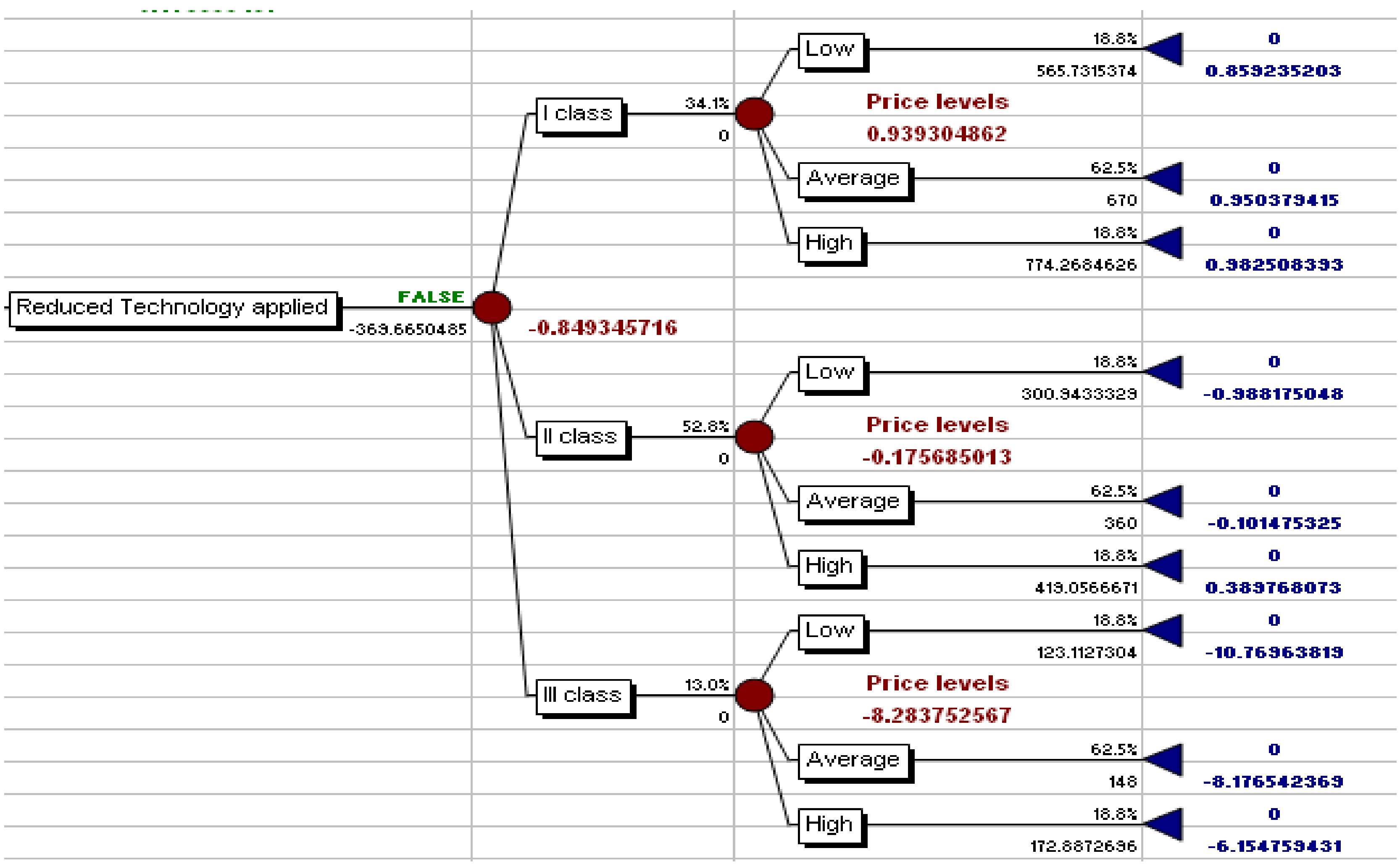

Figure 4. EU for reduced technology of production (per seedling).

Monte Carlo simulation (@risk) was used to determine expected profit for both alternatives (Vose, 2000). The following formula was used:

Expected profit = Number of seedling (1st class) * Price (1st class) + Number of seedling (2nd class) * Price (2nd class) + Number of seedling (3rd class) * Price (3rd class)

- Variable costs - Fixed costs

Each class and price of seedling was normally distributed in @risk using calculated means and standard deviations from BestFit, while variable and fixed costs were distributed using uniform and triangular distributions respectively. Uniform distribution allows setting a minimum and maxi-mum value for variable costs, while triangular distribution, with most likely, minimum and maximum values was set. Variable costs include: material costs, ancillary production costs, labor costs (excluding farmer's contribution payments). Fixed costs include: general expenses, non-material costs, depreciation costs,

Table 5. Costs of production for current technology.

Cost type	Total	%
I Material costs	**58,599**	**8.48**
Fertilizers	9,620	1.39
Chemicals	7,700	1.11
Water for irrigation	2,879	0.42
Containers	8,000	1.16
Fuel and lubricants	5,400	0.78
Small inventory	0	0
Declarations and labels	5,000	0.72
Seed for rootstock	8,000	1.16
Sawdust costs	12,000	1.74
II Ancillary production cost	**41,225**	**5.97**
Maintenance cost	32,000	4.63
Rototilling and plowing service fee	9,225	1.34
III Labor cost	**367,300**	**53.20**
Temporary labor force	142,100	20.60
Labor’s food	81,200	11.80
Farmers contribution payment	144,000	20.80
IV General expenses (fixed costs)	**65,050**	**9.42**
Office stationery	1,300	0.19
Electrical power	48,410	7.01
Post, fax and telephone	15,340	2.22
V Non-material costs	**16,216**	**2.35**
Property tax	1,216	0.18
Seedlings inspection	15,000	2.17
VI Depreciation	**54,400**	**7.88**
VII Insurance premium	**88,000**	**12.70**
VIII Total costs (RSD)	**690,790**	**100**

Subtracted costs are highlighted. Source: Grbovic et al. (2008).

insurance costs and farmer’s contribution payment (Rodic, 1997). Hundred simulations were performed for expected profits.

RESULTS AND DISCUSSION

Computed EMV per seedling and EU for all alternatives showed that EMV for current technology of production is higher than expected values for reduced technology of production or investing money in the bank (Table 7). EMV for Bank deposit alternative and calculated EU for bank deposit decision are shown in the Tables 8 and 9. EU for depositing money in the bank is higher than EU of other two alternatives and this is because it is the least risky alternative which gains sure 78,000 dinars (RSD).

Monte Carlo simulation showed that expected profit for reduced technology did not exceed those one obtained from current technology in any of hundred simulations. The results from the simulation are shown in the Table 10. More also, the minimum expected profit value for current technology was RSD 199,834.47, and probability that it will fall below that value is 1.07%. Probability that profit will be greater than 350,000 for current technology is 60.5%. The probability that profit will be negative for reduced technology was 3.37% and probability that it will be greater than 200,000 was only 2.72%. Sensitivity analysis therefore showed that in order to make farmer indifferent between using a reduced or current technology, average number of seedlings produced with reduced technology would have to increase to 2095. This means that all external conditions of production like weather, disease and pest occurrence would have to be optimal, which is a less likely scenario according to the farmer′s experience. Other situation which would make him

Table 6. Costs of production for reduced technology.

Cost type	Total	%
I Material costs	**48,099**	**6.96**
Fertilizers	9,620	1.39
Chemicals	3,850	0.56
Water for irrigation	2,879	0.42
Containers	8,000	1.16
Fuel and lubricants	0	0
Small inventory	0	0
Declarations and labels	3,750	0.54
Seed for rootstock	8,000	1.16
Sawdust costs	12,000	1.74
II Ancillary production costs	**18,625**	**2.70**
Maintenance costs	17,000	2.46
Rototilling and plowing service fee	1,625	0.24
III Labor costs	**347,400**	**50.30**
Temporary labor force	129,200	18.70
Labor’s food	74,200	10.70
Farmers contribution payment	144,000	20.80
IV General expenses (fixed costs)	**50,527**	**7.31**
Office stationery	1,300	0.19
Electrical power	33,887	4.91
Post, fax and telephone	15,340	2.22
V Non-material costs	**16,216**	**2.35**
Property tax	1,216	0.18
Seedlings inspection	15,000	2.17
VI Depreciation	**52,190**	**7.56**
VII Insurance premium	**0**	**0**
VIII Total Costs (RSD)	**533,057**	**77.20**

Subtracted costs are highlighted. Source: Grbovic et al. (2008).

Table 7. EMV and EU for both alternatives.

Alternative	EMV	EU
Current technology	RSD 183.75	0.18
Reduced technology	RSD 68.64	- 0.84

Table 8. EMV for bank deposit alternative (per seedling).

Alternative	Bank deposit
EMV	RSD 78,000
Average number of seedling (current t.)	1,911
Average number of seedling (reduced t.)	1,442
EMV per seedling (current t.)	RSD 40.82
EMV per seedling (reduced t.)	RSD 54.01

Table 9. Calculated EU for bank deposit decision.

Alternative	Bank deposit
Profit	RSD 78,000
Profit per seedling (current t.)	RSD 40.82
Profit per seedling (reduced t.)	RSD 54.1
EU per seedling (current t.)	0.33
EU per seedling (reduced t.)	0.42

Table 10. Minimum, mean and maximum values of expected profits for both alternatives.

Parameter	Current technology	Reduced technology
Minimum	199,834.47	- 18,693.383
Maximum	653,477.25	235,593.375
Mean	377,596.55	103,886.575

indifferent would be if farm produces only 1,435 seedlings with current technology.

Conclusion

Summarizing results from the decision tree, simulation and sensitivity analysis, the optimal solution for the farmer would be to continue production of walnut seedlings with the technology currently in use, with attempt to increase the number of the 1st class seedlings in total production. In order for reduced technology to the optimal level, the producer would need to increase the number of produced seedlings, which would be very hard without an increase of costs. The producer should also consider an increase of land under seedling production, having in a mind an increasing demand for this product on the Balkans market especially because the free trade agreement (CEFTA) has been signed recently between all countries in the region (Croatia, Bosnia and Herzegovina, Montenegro, Serbia, FYRO Macedonia and Albania).

The producer might also choose not to produce seedlings anymore, put money on savings and thus remove any uncertainty about profit. This would enable producer to look for the employment in the field he is currently majoring in as another source of income. However, that solution is not very realistic one, primarily because of the long family farm tradition in production of the walnut seedlings. Therefore, the analyzed methods could be very useful tools for the farmers in any other production line as well, particularly for the small and medium ones, in their decision making process when they are going to evaluate their organizational and production options and changes.

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