

Modelling in 3D the olive trees cultures in order to establish the forces (interval) needed for automatic harvesting

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Abstract. The purpose of this study is to bring as much as possible, close to real situation the 3D modelling for the olive trees in order to establish the necessary forces for automatic harvesting (harvesting robots). To fulfil our goal we have at our disposal different ways to do modelling very close to the real situation. One way is to use reality capture software (its results being photos) that are converted into a real 3D model, the disadvantage of the method being a mesh model that is not accurate enough. The reasonable alternative is to develop an experiment by measuring a sample orchard of olive trees (experiment who took place in Halkidiki, Greece, measuring over 120 trees). After establishing the real dimensions, we adopted as model the media that we have measured (the height of the tree, the thickness of branches, number of branches, etc.), model which we consider closer to the reality and therefor more suitable for our simulation.

1. Theoretical considerations

Common automatic harvesting is based on vibration forces to shake the trees [1]. We can establish this vibration forces with empiric mathematical calculation or we can determine this forces by 3D modelling, with specific software. In the first case, the problem is that after the calculation we need to create a real prototype for testing the forces in real conditions. In the second case, we must create a real 3D model of tree, with real dimensions and real wood characteristics.

In this situation, in order to create a 3D tree model, we can use two methods. In one method, we can create the 3D tree model from photos and the result is a 3D mesh model. In the other method, we can create the 3D tree model by measurements and drawing the tree body in CAD software. In this second case, we use the average diameter dimensions and the average density of olive tree wood in raw condition [2-5].

2. Experimental conditions

In this experiment, we were traveling in Northern Greece, in Central Macedonia, in the Region of Halkidiki where there is an olive orchard that was designed to involve planting trees.

The dimensions of this olive orchard are about 6.000 square metres with about 134 olive trees, Figure 1.





Figure 1. Olive orchard in peninsula Kassandra of Halkidiki

2.1. Creating a 3D tree model from photos

In this case we examine all the trees from orchard and we choose, for this experiment, a tree with the middle dimensions. After that we took photos in 360-degree around the olive tree, Figure 2.



Figure 2. Olive in 360-degree photo

After that we use a dedicated software for reverse engineering that can create 3D models from photos. The software is the ReMake from Autodesk and we converted the reality captured with photos into high-definition 3D meshes, Figure 3. These meshes are edited and scaled and the final result will be a 3D olive tree meshed model in 3D solid cad extensions (dwg, sat or obj), Figure 4.

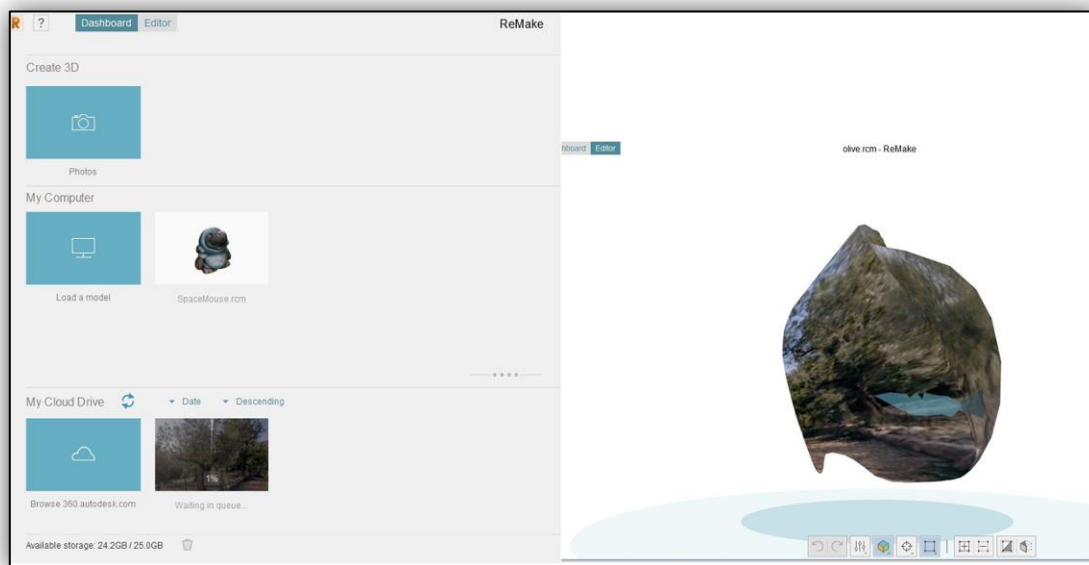


Figure 3. Olive tree mesh created from photos

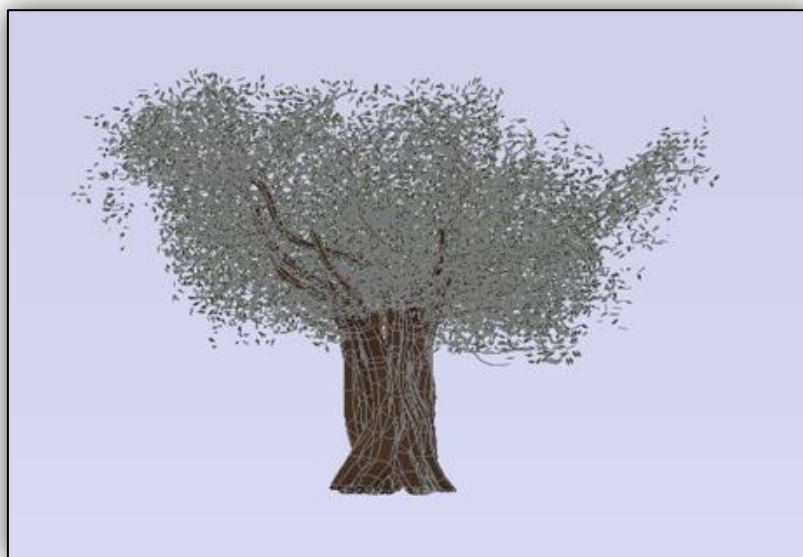


Figure 4. Olive tree mesh 3D model in Autodesk Inventor

The inconvenience of the method is that the accuracy is not good, because:

- we have transformed the leaves in 3D objects with the same mass characteristic of the olive wood [6];
- it is very difficult to delete or edit every leaves;
- the tree body has different dimensions from the real one because the software has approximate dimensions;

At least one of the biggest problems is the mesh file because it isn't a real 3D object, and for this reason we can't edit the characteristics of the materials, wood density, and we cannot add the vibrating forces to see if these forces are enough or if these forces will affect the olive tree [7], [8].

2.2. Creating a 3D tree model from measurements

In this case we took measurements of all the trees from orchard. The measurements we took were the height, the thickness, the perimeter and the numbers of branches of olive trees, Figure 5 [2], [9].

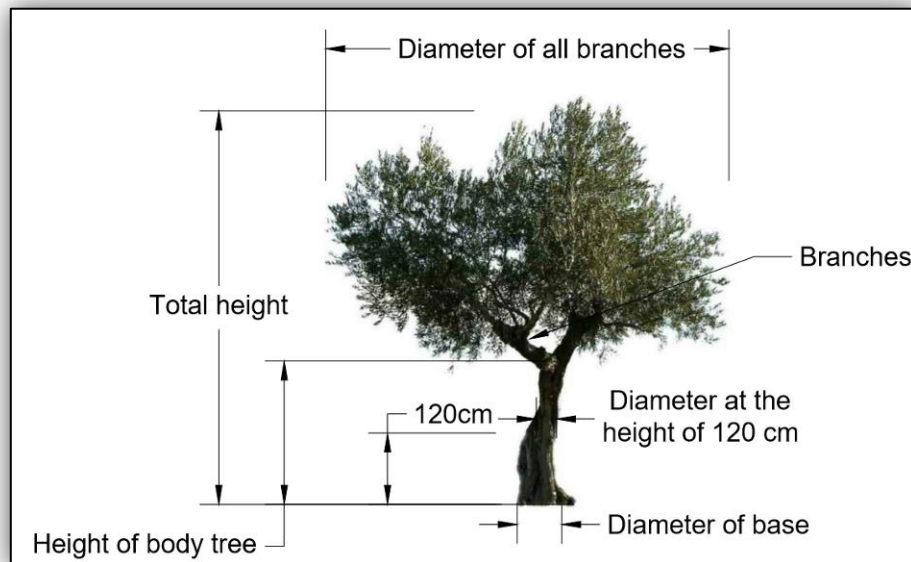


Figure 5. Olive tree measurements

All the data from the measurements was centralized in a table for processing, where the most useful data for creating the 3D model is the height of the olive and of the body tree, the perimeter of the body in different heights and the crown size of the tree.

Table 1. Measurements of olive trees

| Olive tree | Height of olive tree (cm) | Height of body tree | Perimeter of olive tree (cm) on base | Perimeter of olive tree (cm) at high of 120 cm from sol | Number of principal branches | Diameter of crown |
|--------------------|---------------------------|---------------------|--------------------------------------|---|------------------------------|-------------------|
| 1 | 351 | 195 | 94,2 | 72,2 | 5 | 380 |
| 2 | 327 | 210 | 100,5 | 81,5 | 7 | 410 |
| 3 | 373 | 235 | 141,3 | 119,2 | 15 | 570 |
| 4 | 342 | 205 | 113,1 | 91,1 | 9 | 380 |
| 5 | 335 | 245 | 138,2 | 113,1 | 16 | 560 |
| 6 | 341 | 225 | 131,9 | 106,8 | 14 | 520 |
| 7 | 368 | 235 | 141,3 | 116,2 | 19 | 590 |
| 8 | 379 | 255 | 144,5 | 109,9 | 23 | 620 |
| 9 | 333 | 235 | 157,1 | 128,8 | 15 | 490 |
| ... | ... | ... | ... | ... | ... | ... |
| 132 | 345 | 210 | 153,9 | 128,8 | 12 | 440 |
| 133 | 361 | 205 | 144,5 | 119,3 | 11 | 420 |
| 134 | 352 | 200 | 119,3 | 106,8 | 14 | 430 |
| Average dimensions | 365 | 225 | 119,4 | 100,5 | 11 | 485 |
| Minimum dimensions | 310 | 175 | 81,6 | 62,8 | 4 | 350 |

We used all the data from Table 1 to create a 3D model of a olive tree in Autodesk Inventor. We started to create a 3D model of olive tree, Figure 6 and we are scaling in the average and minimum dimensions.

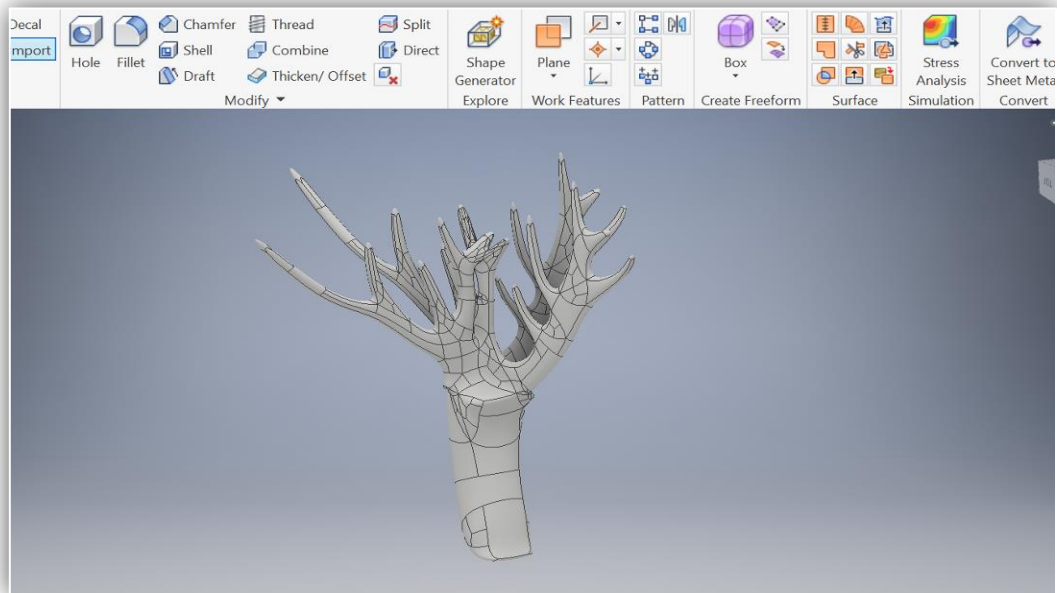


Figure 6. 3D Olive tree in Autodesk Inventor

In the next step we used the stress analysis study firm Autodesk Inventor and we simulated different vibration forces, Figure 7. The vibration forces were simulated on 3D olive model at a height of 120 cm from the ground at the positions of the shaking system [6-9].

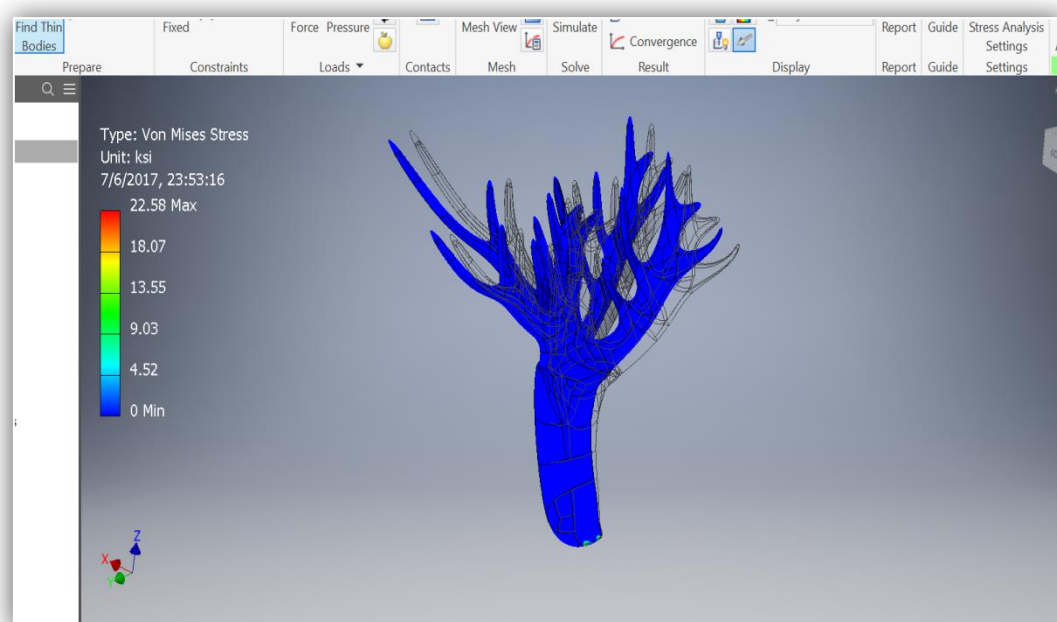


Figure 7. 3D Olive tree in Autodesk Inventor in stress analysis

3. Results and discussion

In order to determine the necessary vibration forces we can use certain software such as Inventor or Solidworks, where we can create the 3D model and simulate the forces. In this case, we used Autodesk Inventor with different vibration forces and static force, Table 2.

Table 2. Resume of Autodesk Inventor simulated study

| Nucleus | Reaction Moment | | Reaction Moment | |
|------------------|-----------------|-------------------|-----------------|-------------------|
| | Magnitude | Component (X,Y,Z) | Magnitude | Component (X,Y,Z) |
| Fixed Constraint | 112.045 N | -112.045 N | 96.153 N m | 0 N m |
| | | 0 N | | -96.153 N m |
| | | 0 N | | 0 N m |
| Fixed Constraint | 223.345 N | -223.345 N | 197.133 N m | 0 N m |
| | | 0 N | | -197.133 N m |
| | | 0 N | | 0 N m |
| Fixed Constraint | 435.265 N | -435.265 N | 301.223 N m | 0 N m |
| | | 0 N | | -301.223 N m |
| | | 0 N | | 0 N m |

All results were satisfactory on highest forces without breaking the olive tree body or any branches. We apply these forces in x displacement (Figure 8), y displacement (Figure 9) and z displacement (Figure 10).

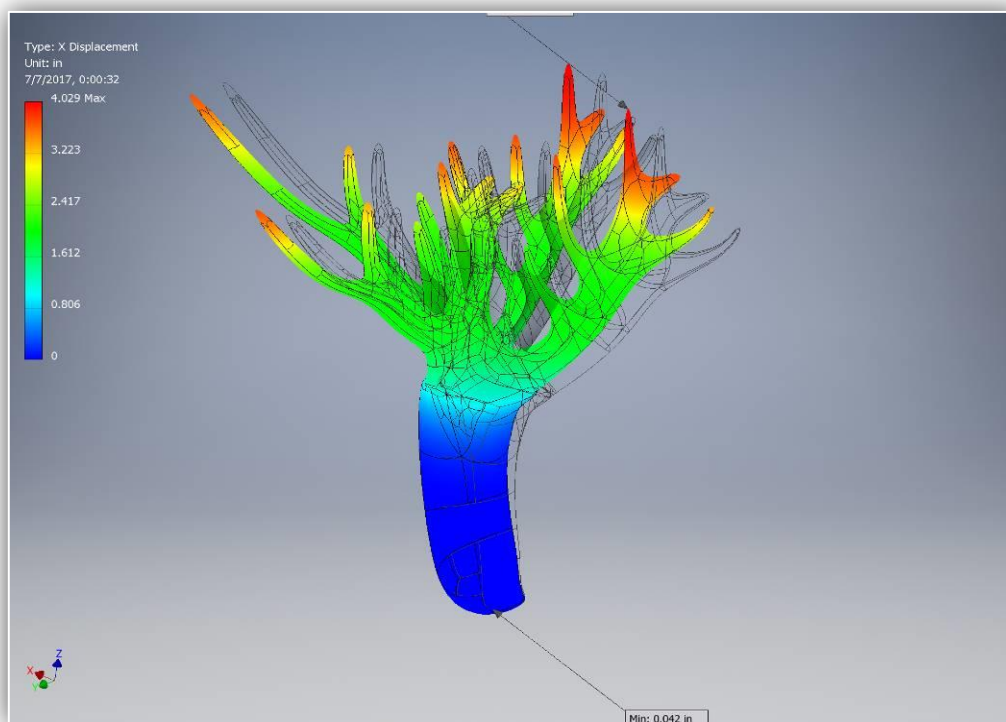


Figure 8. 3D Olive tree with forces distribute in x displacement

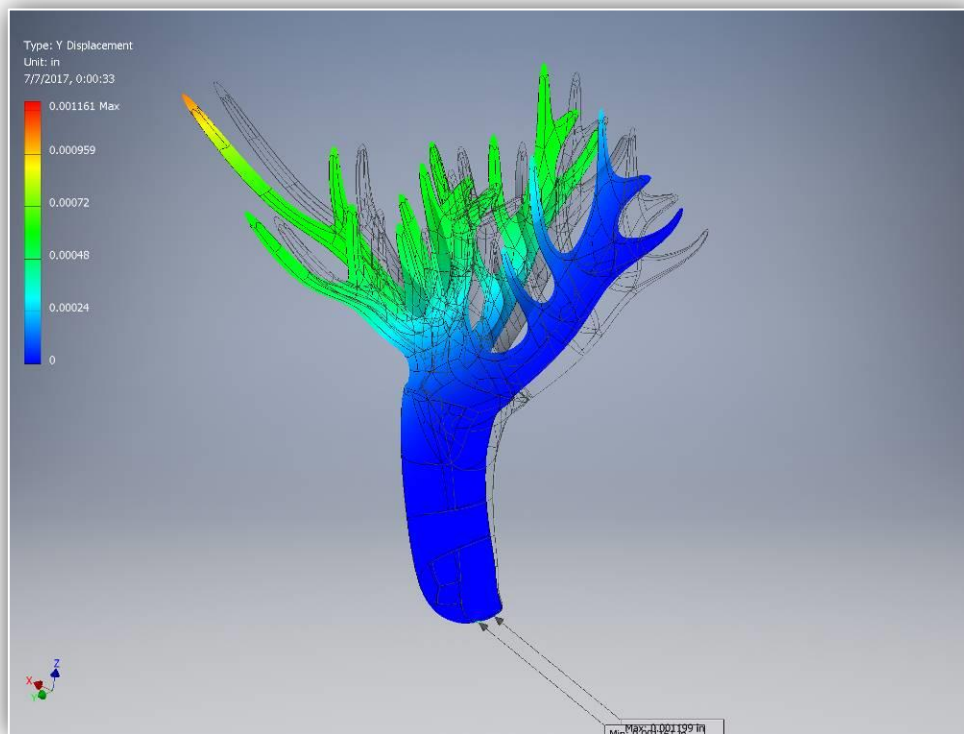


Figure 9. 3D Olive tree with forces distribute in y displacement

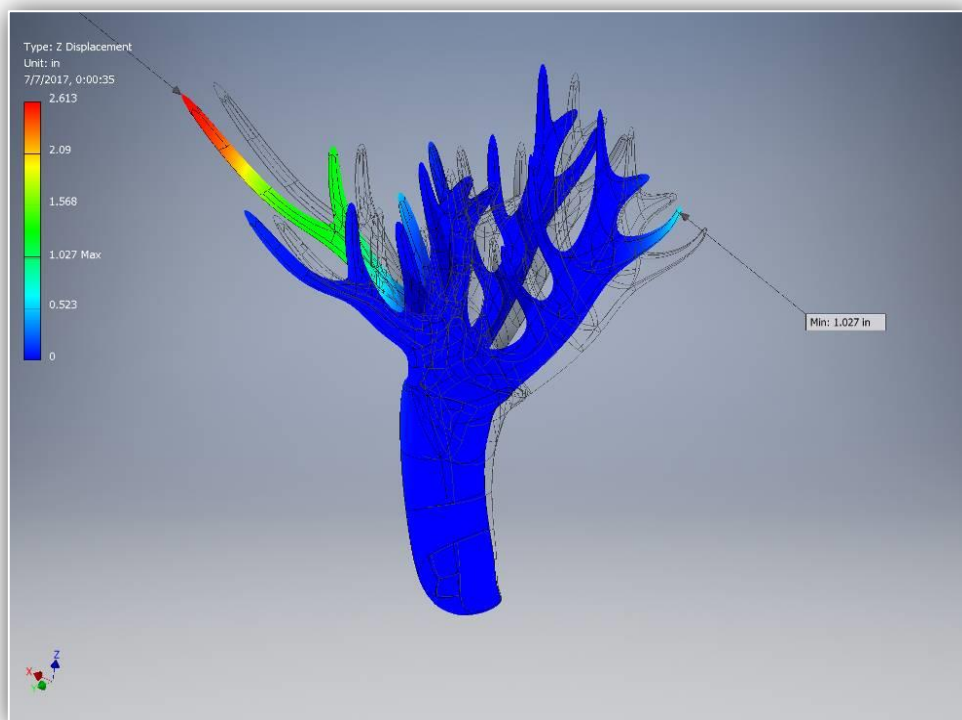


Figure 10. 3D Olive tree with forces distribute in z displacement

With this we can take a conclusion that there are more methods to create a 3D model of an olive tree, but the best solution are to create step by step the 3D model with real dimensions and with real olive wood characteristics. After we finished this 3D modelling we can use our 3D model in Inventor or in Solidworks to establish the shaking forces for automating harvesting.

References

- [1] El Attar M Z, El Awady M N, Rashwan M and Genaidy M A I 2004 *Physical properties effects on shaker-model harvesting of olive-trees*, 10th MSAE conference
- [2] Peri C 2014 *Olive handling, storage and transportation*, Wiley-Blackwell, Italy
- [3] Tucu D, Golimba A and Mnerie D 2010 *Grippers design integrated in handling systems destined to agriculture mechanization*, Actual tasks on agricultural engineering, proceedings. Book Series: Actual Tasks on Agricultural Engineering-Zagreb, **38**, pp 447-454
- [4] Mnerie D, Tucu D, Anghel G V and Slavici T 2008 *Study about integration capacity of systems for agro-food production*, Actual tasks on agricultural engineering, proceedings, Book Series: Actual Tasks on Agricultural Engineering-Zagreb, **36**, pp 617-622
- [5] Tucu D 2011 *Analyze of opportunities for willow's culture as biomass resources in banat region*, Actual tasks on agricultural engineering, proceedings, Book Series: Actual Tasks on Agricultural Engineering-Zagreb, **39**, pp 171-178
- [6] Tucu D 2014 *The behavior of willow stems by cutting in nurseries*, Actual tasks on agricultural engineering, proceedings, Book Series: Actual Tasks on Agricultural Engineering-Zagreb, **42**, pp 405-413
- [7] Tucu D, Golimba A and Slavici T 2010 *Fuzzy methods in renewable energy optimization investments*, Actual tasks on agricultural engineering, proceedings, Book Series: Actual Tasks on Agricultural Engineering-Zagreb, **38**, pp 455-462
- [8] Peri C 2014 *The extra virgin Olive Oil Handbook*, Wiley-Blackwell, Italy
- [9] Tucu D 2012 *Application of life cycle cost method for willow production machinery*, Actual tasks on agricultural engineering, proceedings, Book Series: Actual Tasks on Agricultural Engineering-Zagreb, **40**, pp 549-556