AN OPTIMIZATION MODEL FOR THE DELIVERY OF PLANTS TO NURSERIES

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Abstract

The purpose of the development is to present an option for reducing costs in the delivery of ornamental plants to nurseries. The nursery is located in the town of Parvomai and is located in the eastern part of the Plovdiv region, in the Thracian plain, at about 134 meters above sea level. Different varieties of flowers are produced in it – petunias, violets, verbena, tagetis, sakezets and other species. The nursery stocks and delivers goods to 5 small sites in the surrounding area To achieve the goal, the following tasks must be solved: to characterize the used vehicles; to optimize transport costs by solving a transport task under certain conditions. By using MS Excel Solver, proposed algorithm for describing a transport task and its subsequent solution, significantly speeds up the calculation procedures and helps to reduce costs when making deliveries.

Key words: optimization model, transport task, Solver.

INTRODUCTION

Decorative plants are one of the main details of the interior of the house or the landscape of the garden. The beginning of the nursery production of decorative planting materials in our country is connected with the construction of the parks at the residences Evksinograd - Varna, Krichim and Vrana - Sofia. The creation of green systems in cities and other settlements, the landscaping of various objects (enterprises, schools, hospitals, etc.), knowledge of the stages in the production and cultivation of ornamental trees and shrubs in nurseries, planting in the green areas and their successful further cultivation are the main tasks for specialists in this field.

The cultivation of ornamental plants falls under floriculture, which is a major branch of horticulture. They are seen not so much for practical purposes as for decoration and comfort. Decorative indoor plants perfect house design. The assortment of plants is large. Ornamental plants have quite exotic species. A nursery is a place where plants are propagated and grown to the desired size. Some nurseries specialize in certain areas. Nurseries can also specialize in one type of plant.

Some produce stock seasonally, ready in the spring for export to colder regions where breeding could not begin as early, or to regions where seasonal pests prevent early season cultivation. (Dobrevska G. et al., 2015). Nurseries grow plants outdoors, in container fields, tunnels and greenhouses. There should be a minimum time gap between removing the material from the nursery and planting in the desired location. To avoid exposure to the sun, the planting material should be removed from the nursery in the evening and planted the next day.

The aim of the development is to load more sites with minimal fuel costs. To achieve it, the following task must be solved: to optimize transport costs by solving a transport task under certain conditions. Such an approach was developed in the publication (Dallev, 2021) to optimize the transport costs of fertilizing on a farmer's farm. Thus, we have already created a program for optimization problem solving. This approach was use in the research study of (Ivanova et al., 2018; Marinov, 2016; Atanasov et al., 2020; Blagoeva et al., 2021; Georgieva et al., 2019; Yordanova et al., 2020).

MATERIALS AND METHODS

The nursery is located in the town of Parvomai and is located in the eastern part of the Plovdiv region, in the Thracian plain, at about 134 meters above sea level. The terrain is predominantly hilly and flat. The climate is transitional-continental with pronounced

temperature contrasts. The soils are chernozem (smolny, cinnamon-forest, meadow-alluvial). (Dobrevska et al., 2015). Different varieties of flowers are produced in it – petunias, violets, verbena, tagetis, sakezets and other species (Figure 1).

The nursery supplies and delivers goods to 5 small sites in the vicinity. The first site is located in the village of Gradina, the distance is 6 km from our base. The second object is located again in the village of Gradina, but it is at a distance of 8 km. Object 1 and object 2 are at a distance of 2 km from each other. Site three is located in the village of Byala Reka and is 10 km away from the nursery. Site four is located in the village of Dragoynovo and is 15 km away. The two sites are 5 km away from each other. The last site we charge is located in the village of Patriarch Evtimovo and is 20 km away from the nursery.

From the calculations, it can be seen that the sites are not close to the nursery.

The transport is carried out with two vehicles, each of which has an additional construction made of shelves in order to maximize the use of space and ensure a larger delivery of goods. We have the following equipment:

Fiat Scudo 2005-

Characteristics: Length - 4,805 m, Width -1,895 m, Height -1,980 m

Fuel consumption - urban 8.4/100 km, extra-urban 6.8/100 km, combined - 7.2/100 km.

Fuel type - diesel

We load the sites with seedlings in trays, dimensions of the trays - 48 nests, length 52.5 cm, width 37.5 cm. The number of boards in the Renault Master with the additional 3 shelves is:

Width includes 55 pcs. boards, i.e. 55 x 3 = 165 pcs. boards, there are 13 boards in length - 13 x 3 = 39 pcs., the total capacity is 165 + 39 = 204 pcs. boards.

Which makes 204 pcs. boards with 48 nests, a total of 9792 plants.

In order to keep the fuel costs to a minimum, we proposed to site 1 and site 2 to make their delivery of plants on the same day, the delivery is made by Renault Master due to the large requests (Monday and Wednesday).

On Monday we deliver 72 boards for Site 1 and 100 boards for Site 2.

On Wednesday we deliver 90 boards to site 1 and 110 boards to site 2.

We deliver 17,856 plants per week.

After that, we offered the same option to site 3 and 4, with which their delivery takes place (Tuesday and Friday).

Tuesday we deliver 50 boards to site 3 and 130 boards to site 4.

Friday we deliver 160 boards to site 3 and 43 boards to site 4.

A total of 9744 plants. Again, delivery is made by Renault Master.

At sites 1, 2, 3 and 4, delivery is made with a Renault Master bus, due to its large size and the possibility of more goods.

Object 5 - delivery is made (Monday and Thursday), due to the small amount of sales, delivery is made with Fiat Scudo.

We deliver 18 boards on Monday and 25 boards on Thursday.

In total for the two days we deliver 2064 plants.

Figure 1. The nursery varieties of flowers

Algorithm used for the transport problem solving via the instruments of MS Excel Solver (MS EXCEL 2010)

One of the tools in MS Excel is a module for optimization task solving called Solver (Figure 2). It can be found under the Data menu. It must be activated before its first use taking the following steps:
• launch MS Excel;
• select Options from the File menu;
• the Excel Option dialog box appears;
• click on the submenu Add-Ins (Additions) → Manage (Management) and select Excel Add-ins (additions in Excel);
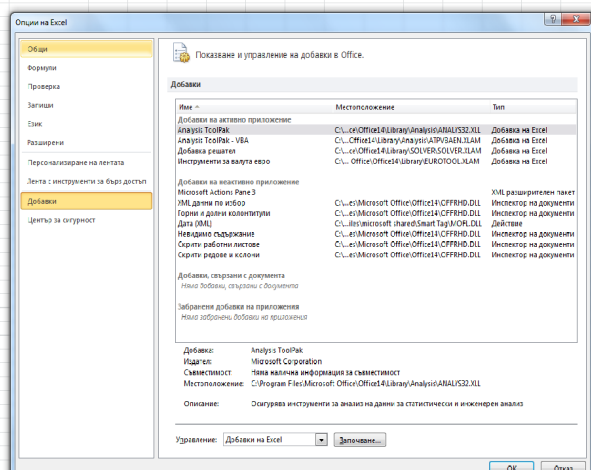• close the dialog box with OK.

Figure 2. Solver activation dialog box

In this way, we now have the program for solving optimization tasks.

The transport task is formulated as it follows:

Consider the following task. At the points $A_1, A_2, ...A_m$ (which we will call producers) is produced output in quantity, respectively a_1, $a_2, ...a_m$. Points $B_1, B_2, ...B_n$ (we will call them users) need the same output in quantities respectively b_1, $b_2, ..., b_n$. There is a balance between production and consumption i.e.

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j.$$

The transport costs per unit from point $A_i (i = 1,2,...,m)$ to point $B_j (j = 1,2,...,n)$ are c_{ij}.

To devise up a plan for the procurement of points $B_1, B_2, ...B_n$ of production from the points $A_1, A_2, ...A_m$, so that the needs of consumers are met, the goods of the producers to be disposed of and the total transport costs to be minimal.

RESULTS AND DISCUSSIONS

Assignment to optimize transportation costs for delivery to five sites:

To carry out the delivery operation with two vehicles to the following sites (Figure 3):

1. Site 1 - 162 boards at a distance of 6 km from the nursery;

2. Site 2 - 210 boards at a distance of 8 km from the nursery;

3. Site 3 - 210 boards at a distance of 10 km from the nursery;

4. Site 4 - 173 boards at a distance of 15 km from the nursery;

5. Site 5 - 43 boards at a distance of 20 km from the nursery.

The data on the average fuel consumption during transport has been determined empirically - 0.244 L/km and the calculations are made at an average fuel price of BGN 3.25.
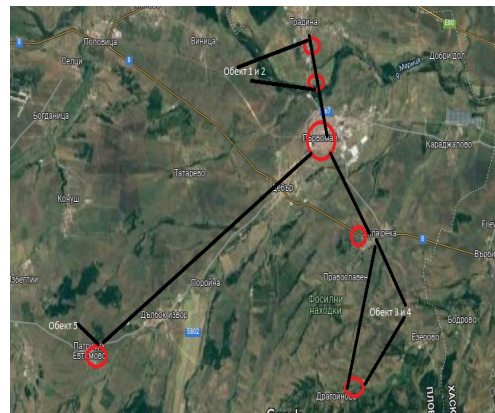

Figure 3. The sites

Task. To solve the following transport problem

B_j / A_i	B_1	B_2	B_3	B_4	B_5	a_i
A_1	0.05	0.12	0.05	0	0.1	755
A_2	0.02	0	0	0.02	0	43
b_j	162	210	210	173	43	798

Solution. The transportation problem is closed because a balance between production and consumption is observed, i.e.

$$\sum_{i=1}^{2} a_i = \sum_{j=1}^{4} b_j = 798$$

MS Excel (Solver) is used for solving the resulting closed (balanced) transport problem. Figure 4 presents a spreadsheet with the mathematical model of the specified task.
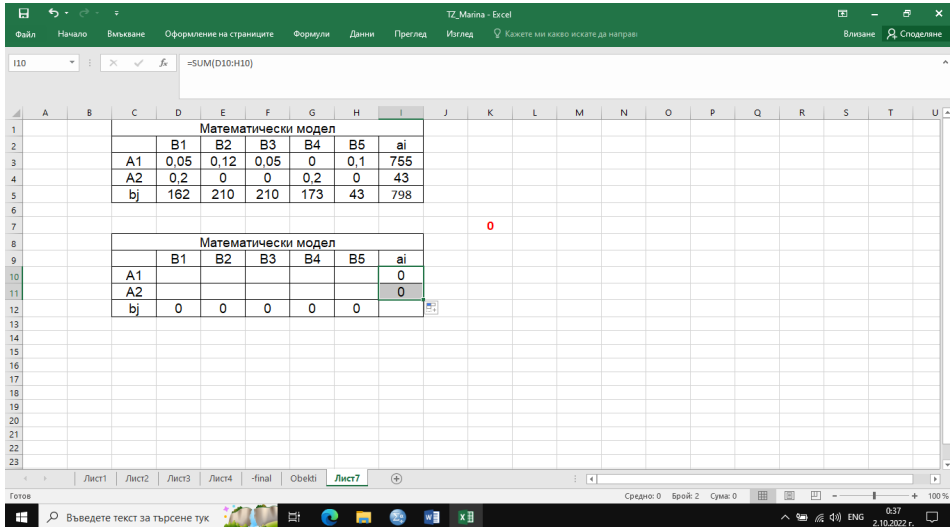

Figure 4. Task model spreadsheet

Completing the worksheet:

1. In cells $D$3:$H$4 we enter the values of transport costs, in cells $I$3:$I$4 - the constants from matrix A(ai), and in cells $D$5:$H$5 - the constants from matrix B (bi).

2. In cell $K$7, we enter the formula used for calculating the value of the objective function, i.e. = SUM PRODUCT(D3:H4; D109:H11).

3. In the second table, in cell $C$11, formula = SUM (D10:D11) is entered and zero appears after clicking the mouse.

And then it is copied to the remaining cells $D$12:$F$12. A null value also comes out.

In the same way, a formula is entered for cell $I$10 and copied to cell I 11.

When composing the formula, one can use absolute addressing of the cells that contain the variables of the task (the $ sign is placed in front of the column name and/or row number).

When solving large-scale problems, it is suitable to use the built-in function, SUMPRODUCT, which calculates the scalar product of two vectors of the same dimension.

We enter the input data and activate the formula from the menu Data (Data) → Solver, after that

We open an empty dialog box named Solver Parameters, which shows the formula for the value of the objective function (Figure 5).

It is recommended that before calling Solver, the cell with the target function should be current - in this case, cell $K$7.

With Equal To, select the radio button corresponding to the criteria of the model, in the specific task, select Min.

The By Changing Cells box shows the entered cells, which contain the values of the problem`s variables. In the present task, these cells are $D$12:$H$12 on which the objective function is minimized.

When we click on the Subject to the Constraints field, we use the buttons next to it in order to enter the restrictive conditions - in this case we can add, or change using the Change button and delete existing constraints using the Delete button. After the entry of the current limit is finished, we select the Add button if we must enter a new limit, or the OK button if the entry is completed.

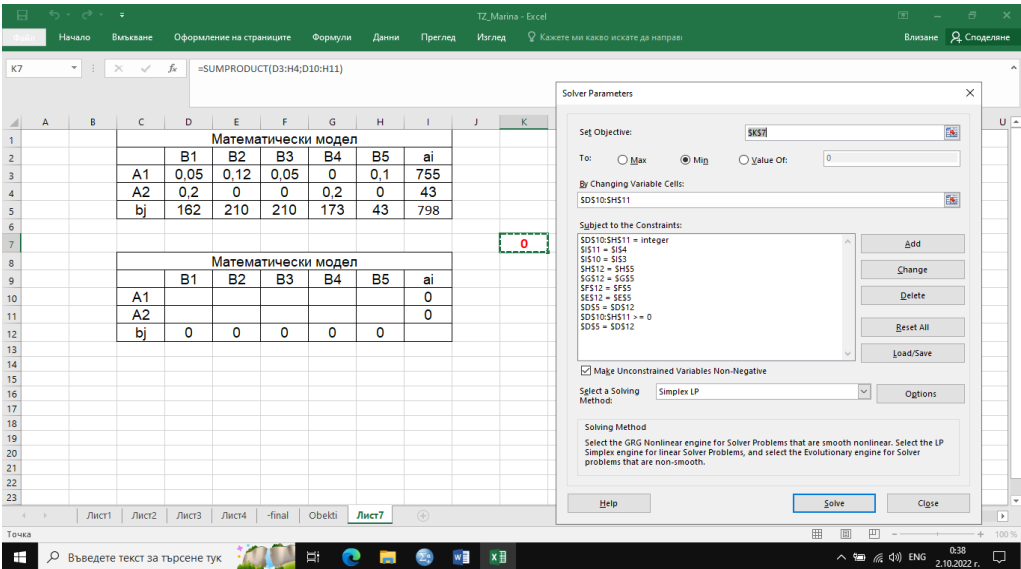The Make Unconstrained Variables Non-Negative option is checked.

Figure 5. "Solver Parameters" dialog box

The other items in the dialog box are not recommended for a change. Finally, when we click the OK button, we return to the Solver Parameters dialog box.

Figure 5 shows the Solver Parameters dialog box. The Solver button is selected from the Solver Parameters dialog box to solve the problem. The solution is presented in Figure 6.
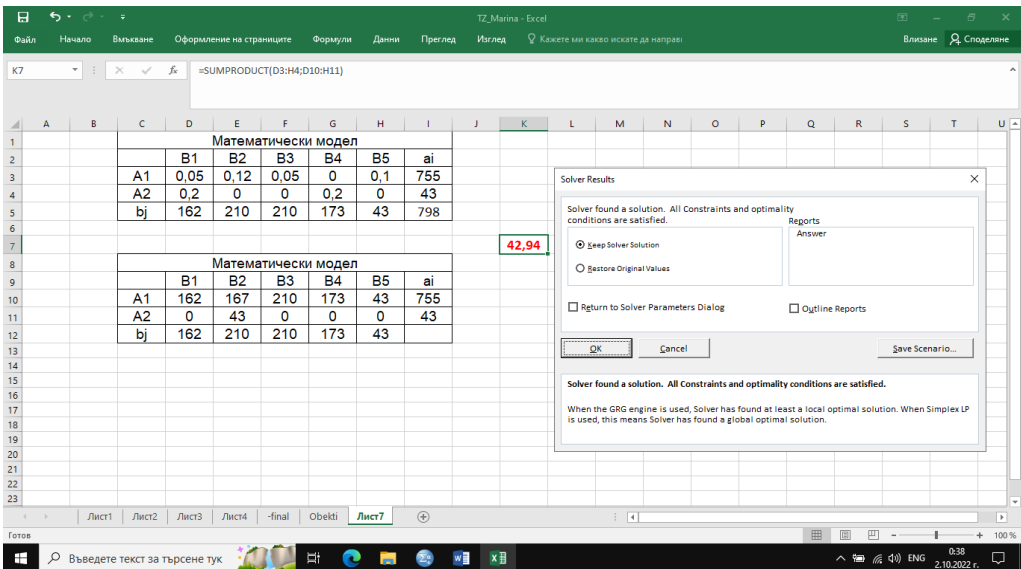

Figure 6. The spreadsheet and dialog box

Solver Results
The results obtained by the performed optimization are provided in the Solver Results dialog box. In the specific case, it is established

that all restrictive conditions and conditions for optimality are satisfied regarding the given solution. Cells $D$10:$H$11 show the optimal solutions and an optimal plan is obtained.

We can save the found optimal solution in the Solver Results dialog box (clicking the Keep Solver Solution button) or we can restore the original worksheet (clicking the Restore Original Values radio button).

It is possible to make a reference to the problem`s solution from this dialog box (Answer Report).

Taking into account the proposed description, as well as the presented solution of a transport problem in MS Excel environment using the capabilities of the MS Excel Solver, we can conclude the following:

The proposed algorithm is easily applicable regarding the description of a transport task and its subsequent solution using MS Excel Solver;

Software applications use significantly quickens the calculation procedures;

"Solver" add-on tool is established as a functional one as it can be used both, for transport-type problems, as well as for problems in other areas.

The model of the transported problem is suitable for the correct and optimal solution of the problem under consideration.

CONCLUSIONS

The following conclusions can be drawn from the present research study:

• The used algorithm proposed for describing a transport problem and its subsequent solution by means of software applications significantly accelerates the calculation procedures and is an easily applicable optimization method.

• Thanks to the optimization, the transport costs for charging 5 objects have been minimized to BGN 42.94.

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