COMPARATIVE STUDY ON THE DIFFERENCES IN THE VALUE OF THE ECONOMIC EFFICIENCY OF TOMATO PRODUCTION IN A CLASSIC SYSTEM WITH CONVENTIONAL HEATING AND BASED ON THERMAL WATERS

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Abstract: *Romania's geographical location allows vegetable production to be achieved with low production costs during the summer months, due to the favorable temperature. However, summer production, correlated with the abundance of products during this season, is not sufficient to economically support the rest of the time. Both the duration of sunshine and the average temperature are naturally lower in Romania compared to some adjacent countries with horticultural traditions.*
The differences regarding the economic efficiency of greenhouses for tomato cultivation were studied, for two heating systems: a classic system that involves the purchase of the thermal agent and an unconventional system that uses thermal waters to heat the environment. The study was conducted in the plain area of western Romania in the area of the town of Lovrin. Production in the classic system was variable throughout the year, with values ranging between 27 and 37 tons/hectare. There was only one exception, the month of December with a production of 15 tons/hectare. The average production was approximately 31 tons/hectare. The minimum production in the unconventional system that ensures economically comparable values with the classic greenhouse tomato growing system is approximately 26.8 tons/hectare. The value added obtained by increasing the production by one ton/hectare in the unconventional system is approximately 7957 euros.

Key words: *economic value, tomato, conventional heating, thermal waters heating*

INTRODUCTION

Romania has a vast potential due to the presence of thermal waters, which, however, seem to be insufficiently used. Their use is mostly due to balneoclimatic tourist resorts and only isolated for other purposes. [1-3]

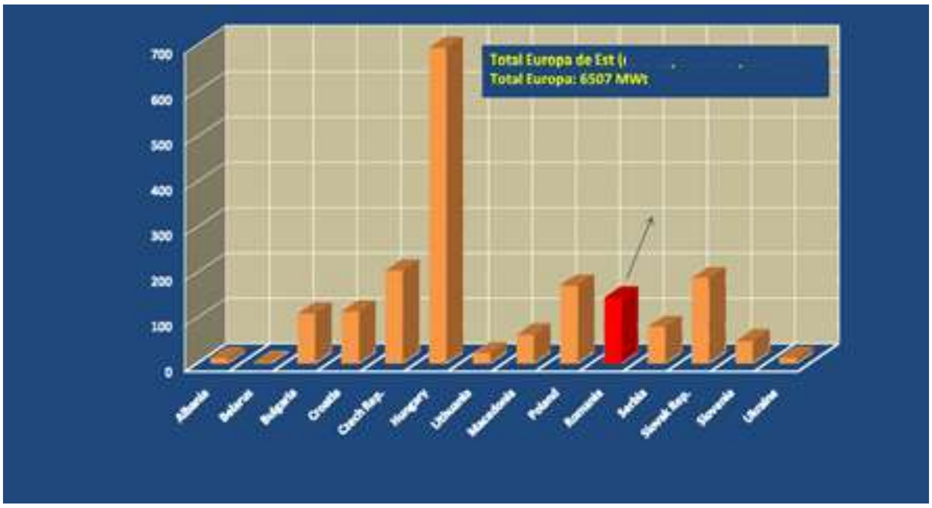

Figure 1. Non-electrical use of geothermal energy in Eastern Europe (in MWt)

The heating system based on thermal waters referred throughout the study is referred to is cold in the following unconventional system. It will be further assumed that the ambient temperature provided by the thermal waters will induce an approximately constant monthly production.

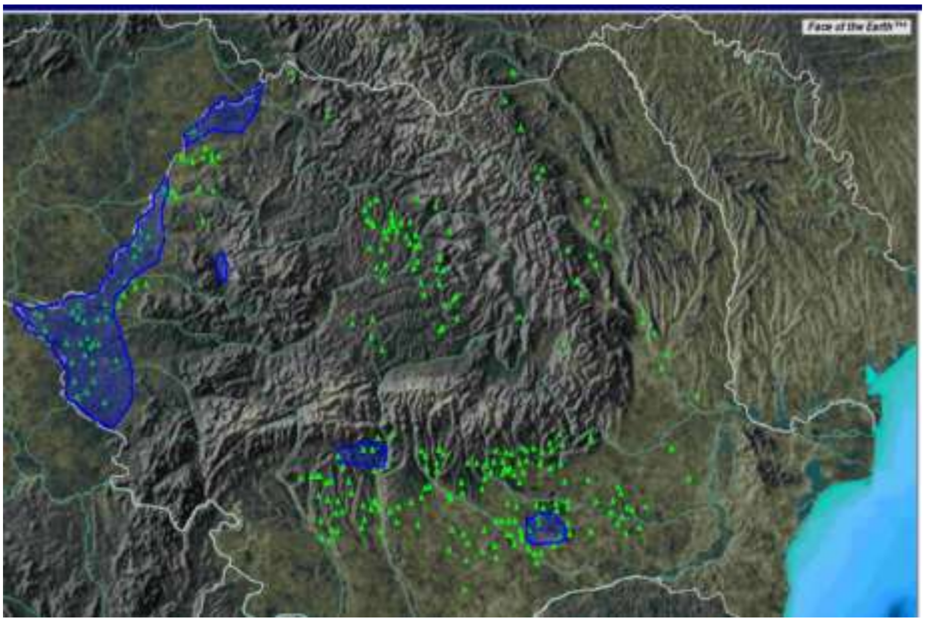

Figure 2. Location of the main hydro geothermal areas in Romania

Romania's geographical positioning allows vegetable production to be obtained with low production costs during the summer months, due to the favorable temperature. However, summer production, correlated with the abundance of products in this season, is not sufficient to economically support the rest of the time. Both the duration of sunshine and the average temperature are naturally lower in Romania compared to some adjacent countries with horticultural traditions. [4-7]

The quality of vegetables obtained in protected cultivation, in greenhouses or solariums, can be maintained in the producer-consumer circuit only by applying technological operations, which consider, on the one hand, the biological requirements of the crops and, on the other hand, the technical and economic possibilities of performing these operations. [8,10,11]

According to the DEX, a greenhouse is a specially designed construction, with walls and a roof made of glass or transparent plastic, built for growing vegetables, fruits or flowers under controlled temperature and humidity conditions. Greenhouses must be equipped with appropriate natural ventilation, ensuring a minimum ventilation area of 15-20% of the total covered area, as well as appropriate air recirculation. For the proper functioning of the greenhouse, the climatic needs of the crops will be considered, including the needs for temperature, relative humidity and light intensity. In conditions of high temperature and relatively low humidity, the plants will suffer, even compromising the crop. Regarding the location of the greenhouse, often the inclination, the slope of the land, decides its orientation. On flat soils it is important to take into account the direction of the prevailing winds, having to be oriented towards the one that presents less resistance. The most common is the north-south direction to take better advantage of sunlight, and to avoid shadows. The greenhouse will need to be equipped with electricity, in order to guarantee adequate management and control of: irrigation, fertigation and climate control.

MATERIALS AND METHODS

The purpose of the paper is to carry out a comparative study to highlight the value differences that characterize the economic efficiency in the case of the classic tomato production system in greenhouses equipped with conventional heating and those that use a heating system based on thermal waters.

RESEARCH RESULTS

Proposed greenhouse model for growing vegetables

The analyzed greenhouse can be located in Arad County and is a multi-tunnel type, made up of modules. Each module has a width of 9.6m, a length of 100 ml, a minimum height of 4.5 m and a maximum of 9.5 m. The modules are arranged side by side, parallel, resulting in a compact space with the total area occupied depending on the number of modules used. [12]

The entire technological process in the greenhouse is automated, the vegetable greenhouse being equipped with the following installations:

- irrigation installations (underground system and sprinklers);
- rainwater collection installations;
- sanitary treatment and humidification installations;
- thermal screens;
- anti-freeze micro-sprinkler system;
- central heating installation based on briquettes.

The zenithal ventilation is composed of 11 units of 1/3 zenithal windows in the 11 modules. Their commissioning is carried out by means of a gear motor, controlled from the electrical panel.

The greenhouse is covered (sides, front and ceiling) with a double layer of high-transparent polyethylene. The inner layer is treated with anti-condensation (to prevent condensation drops from falling on the plants), UV treatment and offers very good thermal insulation.

The installed thermal screen regulates the climate inside the greenhouse, retaining a maximum amount of heat with minimal light loss. This is ideal during the cold period of the year.

Figure 3. Greenhouse modules for vegetables

The technological flow required by greenhouse vegetable cultivation takes into account several essential phases:

- preparing the land for planting;
- planting seedlings according to the crop's growing season;
- crop maintenance;
- harvesting, sorting, packaging and transporting vegetables to the point of sale.

The general flow of vegetables from producer to consumer is: harvesting, sorting, grading, packaging, short-term storage, transport, delivery, marketing.

Protecting vegetables is of particular importance for maintaining quality, taking into account the fact that vegetable harvesting is mostly done during hot and dry periods of the year, when the maximum daily temperature on the ground can exceed 45^0C and in the air 35^0C or vice versa during very cold periods.

Tomato harvesting depends primarily on the period of establishment of the crop. Tomato fruits are sorted, graded, packaged (in crates) and then sold on the market.

The tomato harvesting period is carried out over a long period of time (9 months).

Table 1.

The main phases of greenhouse production

Land preparation for planting
Purchase of planting material
Planting seedlings
Filling gaps
Installing supporting wires for plant support
Palisade
Pillowing
Installing support clips
Additional pollination
Chiseling inflorescences
Defoliation
Slicing
Harvesting
Sorting, packaging, weighing
Transportation
Marketing
Crop maintenance operations
Disease and pest control
Fertigation (drip irrigation system)
Heating

Source: own proposal

Sorting is an important stage in the production process. Vegetables are sorted by grade and placed in 5 kg or 8 kg crates. They are placed on europallets, loaded and transported to the place of sale.

The transport of vegetables is also an important link in the valorization process and can greatly influence the quality of the products and the possibilities of maintaining their quality. In the valorization circuit, the loading - unloading - transport operations intervene in several phases of the producer-consumer circuit

The valorization of production must be done immediately after they have been harvested, to avoid damage to the fruits, on wholesale markets, public markets, supermarkets, own store, etc.

Different varieties must be chosen as planting material for experimental purposes in the first year of production (in order to choose the most effective variety in terms of disease resistance, shape, taste and fruit size in the next production cycle).

The selection of good quality varieties will be achieved through collaboration with a company that offers a complete range of products for field crops, greenhouses and solariums. The variety or hybrid that will be chosen must have increased resistance to diseases and pests and increased productivity. Hybrids or varieties that are best suited to the specific conditions of the technological cultivation area will be chosen.

The production costs, respectively the expenses represented by the establishment of the crop and its maintenance, are represented by:

- Production or purchase of seedlings;
- transport, fuels;
- greenhouse heating;
- irrigation (water cost);
- labor (for planting and maintaining the crop)
- natural pollination (cost of bumblebees)
- packaging (boxes)
- other expenses.

Before presenting the technology for the crop, it is important to highlight the cost of the elements that overlap for the crop in question, forming a common trunk: greenhouse heating and labor.

Growing tomatoes in greenhouses and defining production cycles are strictly dependent on ensuring the necessary energy consumption, the gradual reduction of which for economic and financial reasons and for making the crop profitable, has led to new concepts regarding this crop.

Heating the greenhouse is important in terms of fuel consumption and electricity consumed for classic ones. When using geothermal waters, the cost of fuel is eliminated, the geothermal water coming hot from the ground.

Tomatoes develop at different temperatures, depending on the vegetation phenophase.

Table 2.

Plant temperature requirements depending on phenophase, in tomato cultivation

Specification	Temperature ^{0} C		
	night	Cloudy days	Clear days
Seedling phase			
7-8 days after emergence	10-12	12-13	14-15
Until planting	14-16	18	20-22
After planting			
After tying the plants for 12-14 days	18-20	20-22	22-24
Until the first 2-3 inflorescences are tied	16-18	20-22	22-24
Until the end of the growing season	16-18	20-22	24-26

Source: data processed from various sources [12]

Depending on the thermal preferences of the crop, a certain temperature must be ensured in the greenhouse, which varies depending on the physiological stage of the plant. These variations imply different operating capacities of the heating system, with different consumption of electricity and sawdust (solid fuel) for classic greenhouses.

In the table below are presented the average monthly values of the market prices of tomatoes, the monthly production in the conventional system as well as an example for a scheduled production in the unconventional system of 31 tons. This value was taken into account because it approximates the average production obtained over a period of one year, for one hectare, in the classical system.

Table 3.

Average monthly values of the market prices of tomatoes, monthly production in a conventional system such as-example of a classic system-constant production system

Month	Average price (euro/tonne)	Classic system production (t/ha)	Constant system production (t/ha)	Classic system production, value (euro)	Constant system production, value (euro)	Value differences (euro)
IV	1074,468	27	31	29010,64	33308,51	4297,872
V	946,8085	33	31	31244,68	29351,06	-1893,62
VI	957,4468	35	31	33510,64	29680,85	-3829,79
VII	691,4894	37	31	25585,11	21436,17	-4148,94
VIII	627,6596	36	31	22595,74	19457,45	-3138,3
IX	595,7447	34	31	20255,32	18468,09	-1787,23
X	893,617	31	31	27702,13	27702,13	0
XI	1021,277	28	31	28595,74	31659,57	3063,83
XII	1148,936	15	31	17234,04	35617,02	18382,98
Total	**7957,447**			**235734**	**246680,9**	**10946,81**

Source: own calculation

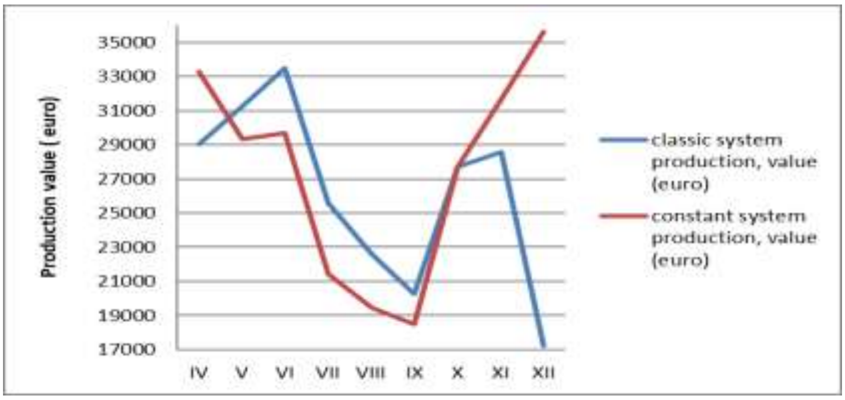

Figure 4. Monthly production value in conventional system such as-example classic system-constant production system

The graphical representation of the polynomial regression function (degree 4) determined for the data in the table, in the case of the production value in the classical system, is shown below.

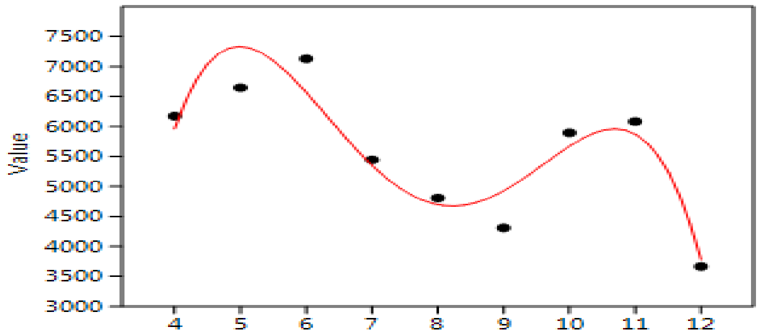

Figure 5. Graphical representation of the polynomial regression function (of degree 4) determined for the data in the table

The constant production throughout the production process (Q_0), which ensures equality with the total value of production in the classical system (T_C), disregarding the expenses for the thermal agent, is determined from the relationship:

$$Q_0 \times \sum_i p_i = T_C$$

where p_i represents the monthly production capitalization prices. In this case, we have $\sum_i p_i$ =7957.4 and T_C= 235734. Therefore, we obtain: Q_0 =29.6 tonnes/ha. This indicator is useful for observing and calculating the value added that is obtained for a constant production increasing by one tonnes:

$$(Q_0 + 1) \times \sum_i p_i - T_C = \sum_i p_i$$

So the value of this increase is 7957.4 euros. Except for heating expenses, which in the classic system were approximately c_T =22500 euro/year, if we consider that there are no changes in the other types of expenses, the expression of the difference between the profit obtained in the two systems is:

$$D = c_T + Q_C \times \sum_i p_i - T_C$$

where Q_C represents the constant scheduled production in the unconventional system. To determine the lowest value of the scheduled production in the unconventional system ($Q_{\min}$) which ensures a higher efficiency than that of the classical system, the equation given by is solved D=0, namely:

$$c_T + Q_{\min} \times \sum_i p_i - T_C = 0 .$$

It is therefore obtained $Q_{\min} = \frac{T_C - c_T}{\sum_i p_i}$. In this case we have: $Q_{\min} = 26.8$ tonnes.

CONCLUSIONS

Tomatoes present a particular economic importance, due to the large productions that are achieved and the related incomes by capitalizing on the fruits mainly on the domestic market in fresh or dehydrated form, a situation in which they can be easily capitalized for export.

Heating the environment using thermal waters is a widely used method that often has a high efficiency. It is effectively used for heating homes, industrial spaces, in agriculture, etc. However, local elements related to the climate, the temperature of the thermal water, the depth of the groundwater level, aspects regarding the possibility of drilling or even the local legislation in force, require studies carried out in a particular setting. [9,13-15]

Referring to the production value achieved in the classical system, we note in the period April-June a value increase due to the increase in production on a background characterized by a reduced variability of prices. The significant decrease in the market price of tomato production occurs in the months of July-September, a period that coincides with a downward trajectory of the production value. Starting with September, the market price shows significant increases, again implying an increasing trend in the production value. Even if in December the price is maximum, the very low production nevertheless implies a new trend of decreasing the production value.

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