SUSTAINABLE FARMING MODEL FOR VEGETABLE CULTIVATION. CASE STUDY

MODEL DE EXPLOATARE SUSTENABILĂ PENTRU CULTURA LEGUMELOR. STUDIU DE CAZ

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Abstract.
The paper presents a case study conducted in Matca commune, Galați county, with the aim of analyzing the sustainability of a family vegetable farm. The study included the assessment of technical-agronomic, economic, and biological factors, as well as the identification of risks that may influence production stability. The farm uses modern technology, based on two crop cycles in protected areas, with drip irrigation and fertigation systems. Production is competitive, reaching 160–180 t/ha for tomatoes and 100–150 t/ha for cucumbers. The main disruptive factors are climate variations, diseases, pests, and high input and energy costs. The SWOT analysis highlighted the technological advantages and economic risks. The farm is emerging as a model of sustainable small-scale vegetable farming, where efficient management and the use of high-performance hybrids contribute to maintaining competitiveness and long-term economic viability.
Key words: sustainable vegetable farming, disruptive factors, SWOT analysis

Rezumat.
Lucrarea prezintă un studiu de caz realizat în comuna Matca, județul Galați, având ca obiectiv analiza sustenabilității unei exploatații legumicole familiale. Studiul a inclus evaluarea factorilor tehnico-agronomici, economici și biologici, precum și identificarea riscurilor ce pot influența stabilitatea producției. Ferma utilizează o tehnologie modernă, bazată pe două cicluri de cultură în spații protejate, cu sisteme de irigare prin picurare și fertirigare. Producțiile sunt competitive, atingând 160–180 t/ha la tomate și 100–150 t/ha la castraveți. Principalii factori perturbatori sunt variațiile climatice, bolile, dăunătorii și costurile ridicate ale inputurilor și energiei. Analiza SWOT a evidențiat avantajele tehnologice și riscurile economice. Ferma se conturează drept un model de legumicultură sustenabilă la scară mică, unde

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managementul eficient și utilizarea hibrizilor performanți contribuie la menținerea competitivității și viabilității economice pe termen lung.
Cuvinte cheie: legumicultură sustenabilă, factori perturbatori, analiza SWOT

INTRODUCTION

Vegetable growing is one of the most intensive agricultural activities, based on mechanization, chemicalization, irrigation, and the use of high-performance cultivars [Stan and Munteau, 2003]. The most modern methods, techniques, and technologies are used in vegetable growing [Stoian, 2005]. The technologies used must be as environmentally friendly as possible in order to avoid degradation of the vegetable growing ecosystem [Stoleru, 2008; Popa, 2010; Teliban, 2011]. These technologies must also ensure unpolluted harvests in sufficient quantities to ensure economic efficiency [Dobay, 2005; Munteanu et al., 2008].

Currently, there are several agricultural systems in Romania: the conventional system (classical or traditional, intensive or extensive), the unconventional system (with several variants: biodynamic, biological, organic, or ecological agriculture) [Stoleru, 2013]. Between these two systems lies sustainable agriculture, considered to be a compromise between conventional and unconventional agriculture [Munteanu, 1999]. Vegetable farms in Romania include all the systems mentioned above, but it is important to know the means by which these farms withstand the test of time or, more precisely, how these farms have ensured their sustainability.

In this context, the purpose of this paper is to conduct a case study that will present in concrete terms how to run family vegetable farms that are characterized by a high degree of sustainability.

MATERIAL AND METHOD

To achieve the proposed goal, namely the case study, the research protocol provided for technical and agronomic analyses of a family association, A.F. Condrache. To carry out this case study, information was collected on the model of organization of the micro-farm's activity, technical equipment, crops grown on the farm, and cultivation technologies. Factors favoring vegetable cultivation and, in particular, disruptive factors were also analyzed [Munteanu 1999]. A comprehensive analysis of the technical and agronomic factors impacting sustainability was made possible thanks to the results and statistics provided by farmers.

The case study concludes with a SWOT analysis that highlights the strengths, weaknesses, opportunities, and threats specific to family micro-farms.

RESULTS AND DISCUSSIONS

Presentation of the agricultural farm

Condrache Farm is a family-run vegetable farm located in Matca, Galați County, one of the most famous vegetable-growing areas in Romania.

The vegetable farming activity carried out on the farm has a tradition of over a decade, with a clear focus on growing vegetables in protected areas (greenhouses). The farm exploits a total area of 35 acres of greenhouses, of which approximately 10-15 acres are dedicated to growing cucumbers, and the rest of the area is occupied by tomatoes. This division of land allows for diversification of production, but also for more efficient management of both human and technical resources.

Technical and economic resources

The greenhouse, made of wood and covered with triple-layered, UV-resistant foil, features a drip irrigation system, buffer tanks for irrigation water, and a side opening system that facilitates natural ventilation.

The family that runs the farm is directly involved in all stages of production, from sowing, maintenance, and phytosanitary treatments to harvesting and marketing, which allows for direct quality control and a significant reduction in labor costs.

The farm is equipped with the following essential technical resources: partially automated drip irrigation systems that allow for precise dosing of water and fertilizers (fertigation); buffer tanks for water (1,000 and 2,000 liters), located in the immediate vicinity of the greenhouse; heating system used for the first crop cycle (January-April); small agricultural machinery and tools suitable for working in protected areas (small motor hoes, atomizers, water pumps, alveolar trays, thermometers).

The farm also has a small greenhouse, used mainly between December and February to grow its own seedlings. This helps to reduce crop establishment costs and allows for better control over the quality of the biological material.

The farm also has a rudimentary but efficient sorting and packaging area, where tomatoes and cucumbers are prepared for sale. Packaging is done in standardised crates, and selection by quality category is done manually.

The variety of species and hybrids

The crop assortment chosen by the Condrache farm consists of high-performance hybrids adapted to local soil and climate conditions, as well as market requirements. Thus, for tomato cultivation, the Melanet F1 hybrid is used, known for its uniform fruits, exceptional taste, and high productivity. For cucumber cultivation, the Ilonara F1 hybrid is grown, a parthenocarpic variety with increased disease resistance and good yield in controlled microclimate conditions.

In 2020, the farmer cultivated only 10 acres of cucumbers and 25 acres of tomatoes, and starting in 2021, he began to increase the area cultivated with cucumbers to 15 acres, to the detriment of tomatoes. This was due to the increasing demand for cucumbers over the last two years.

Cultivation technology

A defining feature of this farm is the cultivation technology organized into two distinct cycles, adapted to climatic conditions and market requirements. The first cycle begins in December, with the sowing of seeds in seedbeds, followed by

the planting of seedlings in greenhouses starting in February. The second cultivation cycle begins in early June with the planting of seedlings, also obtained in-house. This system of successive cultivation ensures optimal use of protected areas and contributes to ensuring a constant flow of products to the market.

For the first cycle of cultivation, tomato and cucumber seeds are sown in alveolar trays, using professional peat-based substrate enriched with perlite and starter fertilizers. These are kept in a heated greenhouse at a temperature of 18-20°C, with a relative humidity of 70-80%, and germination takes place in 10-15 days.

Foliar fertilization with macro and microelements is applied after the first true leaves appear, alternating with preventive disease protection treatments (*Pythium*, *Fusarium*) at intervals of 10-14 days.

At the same time, the greenhouses are prepared for planting: plant debris is removed, the soil is disinfected (using fungicides), and then the soil is loosened by light tilling. At this stage, basic fertilization is administered using well-fermented manure (40-60 t/ha) together with chemical fertilizers, followed by the installation of a drip irrigation system.

Depending on the hybrid, the planting distances for tomatoes are 70 cm between rows and 40 cm between the two rows, and 40-45 cm between plants in a row. For cucumbers, the distances are 70 cm between rows and 40 cm between the two rows, and 30-35 cm between plants in a row. The distances between rows and between strips are designed so that both vegetables can be grown on the same area in the case of crop rotation, as far as the crop cycle allows.

Seedlings are planted in the second half of January – early February, depending on weather conditions and the stage of development of the seedlings (6-7 true leaves). Planting watering and root biostimulants are applied to stimulate plant rooting. During this period, greenhouses are carefully monitored to maintain a minimum temperature of 14-16°C for optimal development of vegetable plants in the greenhouse.

Maintenance work at the Condrache microfarm includes:

- Pruning tomato and cucumber plants;
- Tomatoes and cucumbers are staked using clips on a single string**;**
- Pruning plants is an operation performed on tomatoes in order to remove the growing tip of the main stem after 5-6 clusters, thus redirecting all the plant's energy to the fruits, accelerating their development and ripening;
- Defoliation of plants is carried out for better aeration and illumination of the vegetative mass;
- Drip irrigation is performed daily or every two days, followed by fertigation with balanced formulas (NPK + microelements) depending on the plant's stage of development. Fertigation is applied separately to tomatoes and cucumbers, usually on different days;
- Integrated phytosanitary treatments are applied according to biological pressure: alternating biological insecticides with selective chemicals;

• Daily ventilation of greenhouses to control humidity and prevent fungal diseases in spring; in summer, keep the greenhouse windows open at all times for ventilation;

• The greenhouse usually gets too hot at the start of summer when it's really warm outside, and the plants in the greenhouse start to suffer.

The first fruits are harvested from mid-March for cucumbers, continuing until mid-May, and for tomatoes from the second half of April until June.

The produce is harvested by hand, sorted, and sold immediately. In favorable years, each harvest can yield 100–150 kg of tomatoes and 500–600 kg of cucumbers.

The second crop cycle at the Condrache farm is carried out under the same conditions as the first crop cycle, with the same preparation of the greenhouse and crop maintenance work. The difference lies in the sowing period, which begins in late May-early June, in order to ensure summer-autumn production. This cycle is characterized by more intensive use of natural resources (heat, light), but it is also more vulnerable to extreme weather conditions. Germination occurs more quickly, in 8-15 days, due to high ambient temperatures. Seedlings are kept under shade cloth or diffused foil to avoid sunburn.

Planting in greenhouses takes place between June 25 and July 5, depending on the speed of plant development and weather conditions. The seedlings are of superior quality, with a well-developed root system, which allows for rapid establishment and vigorous regrowth.

The other greenhouse preparation work, namely crop care and harvesting, is carried out in the same way as in the first crop cycle and under the same conditions.

The products obtained are sold wholesale on the local market in Matca or are taken over by intermediaries who supply fresh vegetables to supermarkets and wholesale warehouses in Bucharest or abroad.

We can say that the Condrache farm is a model of a small but efficient vegetable farm, with management adapted to the current needs of sustainable vegetable growing. Crop diversification, the use of high-quality hybrids, and customized technology have led to increased yields and strengthened the farm's position in the regional vegetable market.

Disruptive factors in tomato and cucumber crops

The agricultural activity carried out at the Condrache farm in Matca is not without challenges and disruptive factors that negatively affect production, economic efficiency, and long-term stability. Identifying and analyzing these risks is an essential step in strengthening the farm's sustainability and adapting crop technology.

Natural factors

One of the main disruptive factors in the 2020-2022 period was marked climate variability. Although crops are protected in greenhouses, they remain exposed to the indirect influence of weather conditions:

• very cold winters or long periods of overcast skies, which limit seedling development in cycle I;

• strong winds (especially in March and April), which can damage the structure of greenhouses;

• scorching temperatures in July–August, which affect cycle II, causing heat stress, flower abortion, and reduced fruit quality;

• high atmospheric humidity, which favors the development of fungal diseases such as rot and powdery mildew.

Biological factors

The last two years have been characterized by increased phytosanitary intensification, especially in the case of pests such as the greenhouse whitefly (*Trialeurodes vaporariorum*), thrips (*Frankliniella occidentalis*), red spider mites (*Tetranychus urticae*) – common in cycle II, but also pathogens such as fusarium or verticillium wilt, especially in tomatoes, as a result of monoculture or inadequate crop rotation.

To combat these problems, integrated measures were applied: partial crop rotation, treatments with systemic and contact products, and the introduction of natural predators (especially to combat thrips and whiteflies).

Economic factors

In 2022, the farm faced significant increases in production costs, driven by higher electricity prices (used to heat greenhouses in winter), higher input prices (seeds, fertilizers, plant protection products), and additional costs for seasonal labor during peak season.

At the same time, market volatility, especially during peak production months, created difficulties in optimizing product sales. During some periods, prices fell below production costs, especially for cucumbers.

Technical and organizational factors

Although the farm is adequately equipped, certain limitations remain: lack of an automated climate control and shading system, which limits control over the microclimate during the summer; insufficient storage space, which reduces the capacity to store the harvest in the short term; limited access to alternative energy sources (e.g., solar panels), which maintains dependence on the conventional electricity grid.

The farm relies mainly on family labor, which ensures good control of the technological process, but during peak periods (harvesting, planting), it is necessary to hire temporary workers. In recent years, there has been a declining availability of local agricultural workers, which has led to increased labor *costs.*

Economic analysis and farm sustainability

The agricultural activity carried out on the Condrache farm has generated consistent and profitable yields in recent years, reflecting the efficiency of the technology applied and the farm's ability to adapt to climatic conditions and the market. Analysis of the yields obtained and economic parameters reveals a number of trends and factors that are decisive for the economic sustainability of the farm.

During the three years analyzed, 2020, 2021, and 2022, the farm cultivated tomatoes annually on an area of approximately 20-25 acres and cucumbers on 10-

15 acres. The crops were divided into two technological cycles, which allowed for harvesting in two stages and maximizing the marketability period.

The Melanet F1 tomato hybrid has an average yield per cycle of between 8,000 and 10,000 kg/1,000 m², with an annual productivity of between 16,000 and 18,000 kg for 20 acres.

The Ilonara F1 cucumber hybrid has an average yield per cycle of between 10,000 and 12,000 kg/1,000 m², with an annual productivity of between 10,000 and 15,000 kg for 15 acres.

To assess economic efficiency, the following key indicators were considered: production costs, revenues, and net profit. Costs include expenses for seeds, seedlings, greenhouse plastic, irrigation, phytosanitary treatments, labor, and electricity.

Estimated production costs (RON/cycle): Melanet F1 tomatoes: ~ 20,000–25,000 RON; Ilonara F1 cucumbers: ~ 17,000–20,000 RON.

Revenue (RON/cycle): Tomatoes: 36,000–45,000 RON (average selling price: 2.5–3.5 RON/kg); Cucumbers: 30,000–37,000 RON (average selling price: 1.5–2.0 RON/kg)

Estimated net profit/cycle: Tomatoes: between 16,000 and 20,000 RON; Cucumbers: between 13,000 and 17,000 RON

The total annual profit (both cycles and crops) varies between 55,000 and 75,000 RON, depending on the year, market prices, and direct costs incurred.

The rate of return frequently exceeds 40-45%, which places the farm in the high profitability zone for a small-scale operation. This performance is supported by the choice of high-quality hybrids, marketing during periods of high prices (May-June, August-October), and cost reduction through the direct involvement of the family in the production process.

During the period analyzed, 2020 was the most favorable year, with both high yields and good prices, especially for tomatoes. The year 2021 was affected by extreme weather events (strong winds, sudden temperature variations), which reduced cucumber production. In contrast, 2022 was marked by high input costs, but high market prices offset potential losses.

The main strengths, weaknesses, opportunities, and threats identified are summarized in Table 1:

Table 1

SWOT Analysis of the Condrache Farm

Strengths	Weaknesses
- two-cycle cultivation technology - alternating tomato and cucumber crops reduces economic risk - high-yield hybrids - location in a recognized vegetable-growing area - irrigation systems and controlled microclimate	- relatively small total surface area - high costs for maintaining multiple cycles - sensitivity to temperature fluctuations - lack of own brand on the market

Opportunities	Threats
- increased demand for vegetables in the off-season - implementation of smart technologies for climate control - direct sales to HoReCa chains	- new diseases and pests affecting tomatoes/cucumbers - fierce competition on the Matca market - high energy and heating costs - dependence on market conditions in the off-season

CONCLUSIONS

The main advantage of the Condrache farm is its rigorous technological organization: starting cycle I in December allows for early harvest and market access at a favorable time in terms of prices.

Cycle II, with sowing at the beginning of June, makes efficient use of natural light and temperature resources, but involves greater climatic risks, particularly in terms of heat stress during the summer.

The Condrache farm is an example of good small-scale agricultural practices, where combining technological knowledge with practical experience leads to better use of available resources.

To strengthen long-term sustainability, additional investments are needed in automation, energy efficiency, and diversification of marketing channels, including through digitization and direct marketing.

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