SUMMARY OF PhD THESIS

Research on the optimization of some agrotechnical measures applied in carrot crops technology, in the pedoclimatic conditions of Verești commune, Suceava county

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INTRODUCTION

In the last decade, the public debate has shifted towards the quality of agricultural products. The quality of an agricultural product can be influenced by various factors, including cultivation technology. Cultivation technology represents the totality of methods and processes applied in an agricultural crop to obtain an agricultural product.

Thus, for this thesis, three important experimental factors within the carrot cultivation technology were studied to observe their influence on the quality and quantity of agricultural production. These factors are: fertilization, seedbed preparation and sowing scheme.

The aim of this study was to determine the influence of seedbed preparation and the applied sowing scheme on production, and the influence of fertilization on the chemical composition of carrot roots. Depending on the type of fertilizer applied, the qualitative and quantitative evolution of carrot roots could be observed.

The study was conducted over three years (2016, 2017, 2018), considering the pedo-climatic conditions in the village of Verești, Suceava county. The goal was to develop an innovative technology that enhances production without neglecting quality.

The study examined the influence of two types of fertilizers, NPK and organic fertilizer (cattle manure), on the composition of carrot roots. The intention was to provide information and solutions for the application of an innovative cultivation technology with an indirect influence on individuals' health, as in recent years, the health benefits of consuming carrots have been demonstrated.

STRUCTURE OF THE THESIS

The doctoral thesis is based on the research theme “Research on the optimization of some agrotechnical measures applied in carrot cultivation technology, under the pedo-climatic conditions of the village Verești, Suceava county.” It is structured into two parts and 7 chapters.

In the first 3 chapters of the first part of the thesis, the current state of research regarding carrot cultivation, the requirements for environmental factors, and the cultivation technology for this species are studied. The second part highlights the personal contribution to the addressed theme and consists of 4 chapters. These chapters include the study objectives, materials and methods, results and discussions, conclusions and recommendations, and the final chapter addresses the originality of the thesis and innovative contributions.

1. THE EVOLUTION OF RESEARCH ON CARROT CULTIVATION TECHNOLOGY

Research on the beneficial effects of carrots on cancer has shown that they have a preventive effect on cancerous diseases. Carrots are a well-known root vegetable for their high nutritional content and health benefits. Philip Brown and Alistair Grace published a report in 2000 after completing studies from the project titled “Factors Influencing Carrot Size and Shape”. Following experiments conducted at the Tasmanian Institute of Agricultural Research, claims emerged that the size of carrot roots is highly dependent on the timing of planting. Another factor they identified as important for the weight increase of carrot roots is planting density.

In Romania, in recent years, and especially at U.A.S.V.M. Cluj-Napoca, various studies have been conducted to improve carrot cultivation technology by engineer Bota Tincuța Marta, over a period of three years.

2. BIOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF CARROTS

The systematic characteristics of carrots and their environmental requirements are presented in two subchapters.

Carrots are biennial plants, although they are cultivated as annuals. In the first year of growth, they form leaves arranged in a rosette shape. The leaves are petiolate, 2-3 times pinnately divided, with pinnatifid lobes and fine pubescence. The root system is well-developed and can reach depths of up to 200 cm in loose soils. It consists of the main root and secondary roots that grow in four rows from the tuberous root. Flowering stems appear in the second year of growth after a period of vernalization. These stems are branched, striated, hollow, and pubescent and their height can exceed 1 meter, depending on pedoclimatic factors, cultivation technology, and the variety or hybrid. The flowers are white, often with pinkish shades, pentamerous, hermaphroditic, and entomophilous. Approximately 50-60 days after planting, the mother plants begin flowering, and the fruits reach maturity after 120-150 days.

Temperature Requirements: Carrots are not sensitive to temperature and grow well in temperate climates. The germination process can begin at a temperature of 3°C. Growth is favoured by average temperatures between 18 and 20°C. Temperatures exceeding 30°C encourage the growth of flowering stems in the first year of growth, while roots grow best at optimal temperatures of 18-22°C, which influence the root-to-leaf ratio. As biennial plants, carrots need to undergo vernalization to produce fruit, a process that occurs at temperatures between 5-10°C over approximately 70 days.

Light and Humidity Requirements: Studies have shown that carrot plants exposed to light conditions of more than 13 hours per day during the vegetative stage under long-day conditions are more productive compared to plants that did not have extended light exposure. In terms of humidity, carrot plants are directly influenced during germination, leaf formation and root thickening. Carrot plants develop normally with a humidity level of 65-75% of field capacity in the initial growth stage. In the subsequent growth stages, especially during root thickening, humidity should increase to around 75-80%.

Soil and Nutrient Requirements: High-quality and high-yield production is achieved in sandy, medium-textured, light soils with high permeability, depth, and a humus content of 4-5%. Carrot cultivation prefers medium or light soils with high permeability, depth, a humus content of 4 - 5%, and a neutral reaction. Carrots have a high and differentiated nutrient consumption. For a production of one ton of roots, the following nutrients are extracted from the soil: 2.2-4.7 kg of nitrogen; 0.9-1.5 kg of phosphorus; 6.2-8 kg of potassium; 1.5-2 kg of calcium; 0.5 kg of magnesium (BRUMĂ SEBASTIAN, 2004).

3. CULTIVATION TECHNOLOGY OF CARROT CROPS

This chapter will present two cultivation technologies: field cultivation of carrots and cultivation of carrots in protected spaces.

Field cultivation of carrots is not very difficult, but there are a few stages that require special attention. Crop rotation for carrots is very important, and it is recommended to rotate crops for a minimum of 3 years. Land preparation begins immediately after the plot is cleared of the previous crop. In the fall, deep plowing is performed at 28-30 cm. Since carrots are sensitive to soil compaction, it is recommended to also perform subsoiling at a depth of over 50 cm, where the land allows.

Carrots are a crop that should be sown early because there are some peculiarities regarding seedbed preparation, and the minimum germination temperature is around 4°C. It is recommended to avoid soil preparation with a disc harrow and instead use a combinator, rotary harrow or rotavator. The rotavator has the ability to shape the soil in a single pass, creating trapezoidal beds or ridges.

Sowing schemes differ depending on the method of seedbed preparation, whether sown in unshaped or shaped soil. The sowing schemes are as follows: 50+25+25+25+25 cm or 60+30+30+30 cm (unshaped land) and 66+28+28+28 cm (shaped land), etc.

Sowing depth: On medium and light soils, sow at a depth of 3 cm; on heavier soils, sow at 2.5 cm. The seeding rate to establish one hectare of carrots is between 5-6 kg for early crops and 3.5-4 kg/ha.

The next stage in the cultivation technology includes maintenance work, weed control, fertilization, irrigation, and pest and disease control. The optimal time for harvesting is determined based on the crop's stage, its intended use (fresh consumption, processing or storage for the cold season), the area's climatic conditions, and the variety's maturity (early, semi-early, semi-late or late varieties). The operation can be performed when the periderm has fully formed, and it can be observed that the roots have reached the specific maturity of the variety or hybrid.

Cultivating carrots in protected spaces is rare because the roots can be stored over the winter season in storage facilities.

4. MATERIAL ȘI METHOD

The aim of this work was to study the influence of the period during which the seedbed is prepared, fertilization and the commercial appearance of carrot roots. To achieve this goal, the following objectives were pursued:

- Highlight the current relevance and originality of the chosen topic.
- Emphasize the importance of the seedbed preparation period for carrot cultivation.
- Establish the efficiency of new seedbed preparation techniques.
- Apply innovative seedbed preparation methods.
- Analyze the influence of organic fertilizer (manure) on root growth and production.
- Analyze how production is influenced by plant density.
- Identify the interaction between the three studied factors and their effects on production.
- Use established scientific methods for data processing.
- Identify the most effective variants.
- Present the obtained results.

- Offer recommendations regarding carrot crop productivity based on the seedbed preparation period, manure fertilization, NPK fertilization and plant density per square meter.
- Create a bridge between food production and dietary regimes recommended for treating certain diseases.

The study employed the following methods: bibliographic study, observation, evaluation, gravimetric measurements, soil texture analysis using the Kacinscki granulometric method, phosphorus supply determination using the colorimetric method, potassium supply determination using the flame photometric method, Walkley-Black method, Kjeldahl method, pH determination using the potentiometric method, carbonate determination using the Scheibler method and data processing using Microsoft Excel.

5. RESULTS AND DISCUSSIONS

This chapter presents a comparative analysis of the influence of experimental factors on production for the agricultural years 2015 - 2016, 2016 - 2017 and 2017-2018. Additionally, a comparative analysis of the average across the three years of study is provided at the end.

Results and discussions, year I

The interaction of experimental factors in the agricultural year 2015 - 2016 generated very significant positive differences in production. In the experimental variants where the interaction between preparing the seedbed in the fall on shaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm , and fertilization with NPK was studied, the yield increase was approximately 26986 kg/ha. Thus, compared to the variant where the seedbed was prepared in the spring on unshaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm, and fertilization with NPK 15:15:15, there is an upward trend in the influence of experimental factor a_2 on production.

Analyzing the average yields obtained in the 12 experimental variants using Duncan's test for comparisons, it is evident that in the experimental variant where the seedbed was prepared in the fall and the soil was shaped x seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used x fertilization was done with NPK 15:15:15 and manure, a yield increase of 28803 kg/ha was obtained. Thus, it is recommended to respect the timing of seedbed preparation and especially the seeding scheme, because in the variant where the same seedbed preparation and fertilization method was applied, but with a different seeding scheme (in strips of 150 cm and 15 cm row spacing), the yield increase was negative.

Influence of fertilizer type on chemical composition for first year of study

The study aims to highlight the effects of NPK 15:15:15 fertilization on one hand, and manure fertilization on the other, on the chemical composition of carrot roots. At the time of harvest, two global carrot samples were collected.
The analysis results showed that the total amount of carotenoids is 12,20 mg/100 g in the sample fertilized with cattle manure and 13,95 mg/100 g in the sample fertilized with NPK 15:15:15. A significant difference can be observed in the carotenoid content identified in the carrot sample fertilized with NPK 15:15:15 compared to the one fertilized with cattle manure. It can be seen that the sample from the NPK 15:15:15

fertilized variants is richer in nitrogen, potassium, calcium, and magnesium, while the sample from the manure fertilized variants is richer in phosphorus and sodium.

Results and discussions for year II

The interaction of experimental factors in the agricultural year 2016-2017 generated very significant positive differences in production.It can be observed from the comparative analysis of the three experimental factors that the highest yield was obtained in the experimental variant where the seedbed was prepared in the fall on shaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK 15:15:15. In this variant, the yield increase was approximately 15733,33 kg/ha compared to the variant where the seedbed was prepared in the spring on unshaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK. Thus, experimental factor A tends to positively influence the yield. Thus, it is recommended for large carrot productions to prepare the seed bed in the autumn, shape the soil, sow according to the 15 cm + 15 cm + 75 cm + 15 cm + 15 sowing scheme and fertilize with NPK 15:15:15.

Influence of fertilizer type on chemical composition for second year of study

In the second year of the study, the same amount of organic fertilizer, 30 t/ha of cattle manure, was applied at the time of plowing the soil. Laboratory analysis results for the two carrot root samples fertilized with NPK 15:15:15 and manure respectively showed that the total carotenoid content was 11,13 mg/100 g in the sample fertilized with cattle manure and 11,13 mg/100 g in the sample fertilized with NPK 15:15:15. We can observe a significantly positive difference in the carotenoid content identified in the carrot sample fertilized with NPK 15:15:15 compared to the one fertilized with cattle manure. The other parameters analyzed in the first year of the study remained within the value ranges of the previous year.

Results and discussions for year III

From the comparative analysis of the three experimental factors, a very significant positive difference in production is highlighted in the experimental variant where the seedbed was prepared in the fall on shaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK. In this variant, the yield increase was approximately 16640 kg/ha compared to the variant where the seedbed was prepared in the spring on unshaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK.

Influence of fertilizer type on chemical composition of carots roots

In the third year of study, the same quantity of cattle manure, 30 t/ha, was applied during plowing for the carrot crop, consistent with previous years of study.
The total amount of carotenoids was 12,12 mg/100 g in the carrot sample fertilized with cattle manure and 13,50 mg/100 g in the sample fertilized with NPK 15:15:15. A noticeable difference can be observed in the carotenoid content identified in the carrot sample fertilized with NPK 15:15:15 compared to the one fertilized with cattle manure.

It is notable that samples taken from the NPK 15:15:15-fertilized variants are richer in nitrogen, potassium, calcium, and magnesium, with the content of ammoniacal nitrogen being nearly two times higher than in the sample fertilized with cattle manure. Samples taken from the variants fertilized with cattle manure are richer in phosphorus and sodium.

Results and Discussions for years I, II and III

From the comparative analysis of the three experimental factors, a very significant positive difference in production is highlighted in the experimental variant where the seedbed was prepared in the fall on shaped terrain, seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK 15:15:15. In this variant, the yield increase was 19786 kg/ha compared to the variant where the seedbed was prepared in the spring on unshaped terrain, seeding scheme 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK 15:15:15.

Tabelul (tabel)

Sinteza comparației prin testul Duncan/The results of the comparison through the Duncan test

Nr. ctr/ No. Ctr	Variante/The variants	Producție/The production	Clasificarea/ The classification
1	$Va_1b_1c_3$	35406	A
2	$Va_1b_2c_1$	38370	AB
3	$Va_2b_1c_2$	38658	ABC
4	$Va_1b_2c_3$	40154	ABC
5	$Va_1b_1c_1$	42763	ABCD
6	$Va_1b_2c_2$	43477	ABCD
7	$Va_2b_1c_3$	44165	BCD
8	$Va_2b_2c_1$	44705	BCD
9	$Va_1b_1c_2$	45559	BCD
10	$Va_2b_2c_2$	46964	CD
11	$Va_2b_1c_3$	50205	D
12	$Va_2b_2c_1$	58157	E
$Va_1b_1C_3$,...... ,$Va_2b_2C_1$ - the meaning is presented in Annex 1.			

Influence of fertilizer type on chemical composition for years I, II, III

On the experimental plot, 30 t/ha of cattle manure was applied during plowing for the carrot crop. Laboratory analyses were conducted on two carrot root samples obtained from fertilization with NPK 15:15:15 and cattle manure.

The total amount of carotenoids was 12,20 mg/100 g in the carrot sample fertilized with cattle manure and 13,95 mg/100 g in the sample fertilized with NPK 15:15:15.

6. CONCLUSIONS AND RECOMMENDATIONS

The research results obtained under the pedoclimatic conditions of Verești commune, Suceava county, over the three experimental years (2015-2018), regarding the influence of experimental factors such as seedbed preparation, seeding scheme, and fertilization method, highlight significant increases in production. Through comparative analysis of these factors, a very significant positive difference in production is evident in the experimental variant where the seedbed was prepared in the fall, the soil was shaped, the seeding scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm was used, and fertilization was done with NPK 15:15:15.

Furthermore, considering the role of chemical compounds in carrot roots in cancer treatment, the study tracked the evolution of chemical composition after applying two types of fertilizers (NPK 15:15:15 and cattle manure). It was observed that the sample from the NPK-fertilized variants had higher levels of carotenoids and other compounds. The type of fertilizer applied can significantly influence the composition of carrots.

Based on these findings, it is recommended to optimize farming practices by implementing fall seedbed preparation, using shaping techniques and employing NPK fertilization to maximize carrot production. Moreover, farmers should consider the impact of fertilizer choice on the nutritional and health-related properties of their produce, particularly in crops like carrots rich in beneficial compounds.

7. ORIGINALITY AND INNOVATIVE CONTRIBUTIONS OF THE THESIS

In the first place, the originality and innovative aspect of this work is highlighted by the complexity of the research, which studied three experimental factors (the first two factors with two levels each and the third with three levels). The influence of three essential stages within the carrot cultivation technology was studied: seedbed preparation, planting scheme and fertilization. This approach allows for the most effective recommendations regarding carrot cultivation technology elements to be offered at the end of the research.

In the second place, a particular innovation in the study is the timing of seedbed preparation, specifically the autumn preparation with ridges, a method not previously studied in the literature. Most studies and specialised readings recommend preparing the seedbed in the spring, either on the day of sowing or the day before. Another innovative aspect is the study of the interconnection between fertilization, nutrient content and the beneficial effects on incurable diseases such as cancer. A bibliographic analysis was conducted on the benefits of incorporating carrots into the daily diet of cancer patients, alongside the study of the influence of chemical and organic fertilization on the nutrient content of carrot roots.

In the third place, this is the first study conducted on this topic under the specific pedo-climatic conditions of the Verești commune, Suceava county.

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ANNEX

ANNEX 1

The experimental variant	The description of experimental variants
V1 - a1b1c1	The preparation of the germinal bed in springtime, unshaped land; planting in rows forming strips of 150 cm and the distance between rows 15 cm; fertilization with NPK 15:15:15;
V2- a1b1c2	The preparation of the germinal bed in springtime, unshaped land; planting in rows forming strips of 150 cm and the distance between rows 15 cm; fertilization with manura;
V3 - a1b1c3	The preparation of the germinal bed in springtime, unshaped land; planting in rows forming strips of 150 cm and the distance between rows 15 cm; fertilization with NPK 15:15:15 and manura;
V4 - a2b1c1	The preparation of germinal bed autumn, sheped land; planting in rows forming strips of 150 cm and the distance between rows 15 cm; fertilization with NPK 15:15:15;
V5 - a2b1c2	The preparation of germinal bed autumn, sheped land; planting in rows forming strips of 150 cm and the distance between rows of 15 cm; fertilization with manura;
V6 - a2b1c3	The preparation of germinal bed autumn, sheped land; planting in rows forming strips of 150 cm and the distance between rows of 15 cm; fertilization with NPK 15:15:15 and manura;
V7 - a1b2c1	The preparation of germinal bed in springtime, unshaped land; planting scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm; fertilization with NPK;
V8 - a1b2c2	The preparation of germinal bed in springtime, unshaped land; planting scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm; fertilization with manura;
V9 - a1b2c3	The preparation of germinal bed in springtime, unshaped land; planting scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm; fertilization with NPK 15:15:15 and manura;
V10 - a2b2c1	The preparation of the germinal bed in autumn, modeled land; sowing scheme 15 cm +15 cm + 75 cm + 15 cm + 15 cm; fertilization with NPK 15:15:15;
V11 - a2b2c2	The preparation of the germinal bed in autumn, shaped land; planting scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm; fertilization with manura;
V12 - a2b2c3	The preparation of the germinal bed in autumn, shaped land; planting scheme 15 cm + 15 cm + 75 cm + 15 cm + 15 cm; fertilization with NPK 15:15:15 and manura;