SUMMARY

of the doctoral thesis entitled:

RESEARCH ON THE IMPROVING OF SOME TECHNOLOGICAL PHASES IN THE PRODUCTION OF WHITE-HEADED CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA* F. *ALBA*) SEEDS

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Since prehistoric times, people have begun cultivating vegetables to ensure a diversified and nutrient-rich food source. Over time, knowledge and methods of vegetable cultivation have consistently evolved in tandem with society development.

White-headed cabbage (*Brassica oleracea* var. *capitata* f. *alba*) is a cruciferous plant with high nutritional value, rich in fibers, vitamins, polyphenols and flavonoids. This vegetable is recognized as an essential source of minerals and vitamins, contributing to a healthy and balanced diet (Xie et al., 2018). Additionally, cabbage stands out for its high content of glucosinolates, compounds with antioxidant and anti-inflammatory properties associated with numerous health benefits (Nawaz et al., 2018; Novotny et al., 2018).

As seed quality plays an important role in modern agriculture, it is essential to deepen our understanding of the relationships between seed quality, as a synthetic property, and the key factors influencing it. In this context, the implementation and optimization of seed production technologies, as a major stage bridging plant breeding and cultivation under production conditions, becomes a priority.

The evolution of the issue regarding vernalization induction and the management of mother plants throughout the winter in the cabbage seed production chain has necessitated detailed investigations into potential risks associated with the final product, the seed. Significant qualitative and quantitative characteristics, as well as economic implications such as germination rate, hectare yield, and extensive labor utilization, have been identified as key factors for optimizing current cabbage seed production technologies.

In order to assess the factors influencing the yields of seed crops and comprehend the mechanisms facilitating the vernalization process in the case of white-headed cabbage, the research has been directed toward specific objectives manifested through the analysis of seedling production, obtaining and characterizing mother plants capable of generating vigorous seed plants, detailed evaluation of obtained seeds, and the development of effective strategies to reduce the risk of loss of mother plants, during the winter period and increase seed production yields.

The ***goal*** set forth by this doctoral thesis ***aims to obtain mother plants of cabbage capable of supporting the establishment of seed culture on their own roots***. Considering the elimination of the need for transplanting mother plants, an operation deemed difficult, costly, and labor-intensive. In this context, the thesis seeks to conduct experiments and scientific research designed to significantly contribute to the

optimization and improvement of white-headed cabbage seed production technology by establishing seed culture using mother plants on their own roots.

The research goal will be achieved through a succession of stages, each with a specific objective to be attained through scientific investigations. These objectives will converge towards the development of a dedicated solution for optimizing the technology of white cabbage seed production. To accomplish the proposed goal within the research project, a detailed pursuit of the following objectives is envisaged:

- ***objective 1:*** study of the influence of experimental factors on mother plants;
- ***objective 2:*** study of the influence of experimental factors on the phenology of seed crop plants;
- ***objective 3:*** study of the influence of experimental factors on the seed yield;
- ***objective 4:*** study of the influence of experimental factors on the seed quality.

By achieving these objectives, the series of experiments dedicated to white-headed cabbage cultivation, focused on seed production, is concluded. Validation involves confirming the most efficient and effective technology for cabbage seed production, resulting from the combination of the studied factors.

The doctoral thesis " Research on the improving of some technological Phases in the production of white-headed cabbage (brassica oleracea var. Capitata f. Alba) seeds " is structured into two parts, comprising a total of nine chapters, 38 tables, 33 figures, and 170 bibliographic titles. These have been integrated into the context of the literature review, highlighting precise references to the addressed issues, the conducted research, conclusions, recommendations, as well as the thesis's originality, innovative contributions and consulted bibliographic sources.

The first part consists of 48 pages divided into three chapters, providing a detailed review of the subject matter, emphasizing the results obtained regarding the vernalization process and seed production yield through the analysis of growth and development phases. It also addresses the current technologies used in white cabbage seed production.

The second part, consisting of six chapters, outlines the purpose and objectives of the research, detailing the methods and materials involved. It presents the results and corresponding interpretations, formulates conclusions, and provides specific recommendations. These aspects are focused on obtaining seedlings, analyzing the morphological characteristics of mother plants, examining the phenological aspects of seed plants, evaluating the quantities and yields obtained and analyzing seed quality.

Within the ***Chapter 1*** of the thesis – ***The importance of white-headed cabbage cultivation***, the global significance of this agricultural crop is explored, providing a comprehensive perspective. Details include aspects such as nutritional relevance and pharmacological properties, the economic influence of cabbage cultivation, yields and productions valorized in various forms, and the importance of seed cultivation in the technological chain. Additionally, key risk factors are analyzed, with an emphasis on the influence of climatic factors, biotic factors, and the process of regressive degradation in cabbage crops.

The ***Chapter 2*** – ***Biological and ecological features of white-headed cabbage***, highlights the essential characteristics of white cabbage, both in the vegetative and generative periods. This chapter provides a detailed analysis of the morphological features of cabbage, including aspects related to roots, stems, leaves, heads, flowers, fruits, and seeds. Additionally, the ecological characteristics and their interactions with the cabbage crop are presented, including temperature, with particular emphasis on the vernalization process.

Vernalization is the process through which positive low temperatures become the predominant factor in transitioning plants from the vegetative to the generative state, bringing them close to the flowering phase. Floral induction is largely determined by low temperatures. Vernalization, or cold exposure, is the phenomenon in which plants undergo floral induction under the influence of low temperatures, and this

process is specific to each species. In practice, without the complete fulfillment of the vernalization process, cabbage plants will not produce flowering shoots.

Furthermore, the interactions of water, light, soil, and nutrients are highlighted in the context of the developmental stages of cabbage plants. These stages encompass growth and development phases, including the juvenile phase, floral induction phase, head formation phase, with special attention given to the flowering stages, fruiting and seed formation stages.

This chapter is substantiated through the physiological foundation of growth and development processes, utilizing a literature review on inductive factors and phenomena occurring in various vegetation stages of the crop. A detailed explanation of these phenomena is provided, emphasizing their importance in the technologies for the production of white cabbage seeds.

Within the context of the ***Chapter 3*** – ***The management of the white-headed cabbage seed production system*** the importance of white cabbage seed production and its contribution to food security and agricultural sustainability are investigated. Additionally, the general outline of the seed production process is presented, with special attention given to conservative selection and methods for obtaining the base seeds.

Furthermore, within this chapter, technologies for the production of commercial white cabbage seeds are presented, with a focus on the differences between the plant-to-seed and seed-to-seed systems.

In the context of the second part of the doctoral thesis, ***Chapter 4 articulates the goal, objectives, motivation and applicability of the research***. It provides a concise presentation of the conduct and organization of the research, with special attention to the chosen organizational framework, the study material and the working techniques that underpinned the data collection within the experimental field.

The research was conducted within the experimental field of the Vegetable Research and Development Station in Bacău. The experimental design is polyfactorial, involving three main factors: planting date, density and planting technique, carried out in subdivided plots, adapted to the specific experimental conditions.

The selection of these experimental factors was based on the issues addressed in the doctoral thesis, which aims at optimizing the technology for cabbage seed production. These factors were also determined in accordance with the five proposed objectives.

- Factor A – Planting date, with three levels:

E_1 – 10.07.
E_2 – 10.08.
E_3 – 10.09.

- Factor B – Planting distances, with three levels:

D_1 – 25 × 140 cm: 28.500 plants ha^{-1}
D_2 – 40 × 140 cm: 17.850 plants ha^{-1}
D_3 – 55 × 140 cm: 12.900 plants ha^{-1}

- Factor C – Planting technique, with two levels:

T_1 – without transplantation
T_2 – with transplantation

Within the experiment, the arrangement and scheduling of experimental factors were conducted following experimental technique standards and the specific conditions of the cultivation field. To achieve a uniform experimental field, a distance of 140 centimeters was established between rows, and the distance between plants within a row was set at 25, 40, and 55 centimeters. To ensure increased data accuracy, each repetition plot from variants E, D, T was cultivated on two separate rows positioned at a distance of 140

centimeters from each other, with a row length of 10 meters. This arrangement resulted in obtaining 37, 50, and 80 plants per repetition.

In the ***Chapter 5*** – ***Study of the influence of some experimental factors on morphology of mother-plants***, the results obtained from experiments planned, according to experimental protocols for the first year of cultivation, aiming to obtain mother plants, are presented.

The study presented in this chapter focuses on seedling production and the phenology of mother plants under the influence of experimental factors. Therefore, the aim of this research is to identify the optimal combination of factors that would generate mother plants capable of subsequently producing seed plants without the need for transplantation. To achieve this goal, the following objectives have been defined:

- identification of the optimal sowing period for obtaining quality seedlings;
- evaluation of seedling quality based on the content of assimilative pigments;
- study of the main morphological characteristics of mother plants based on the influence of the three analyzed factors.

The goal and formulated objectives aim to provide relevant information and results regarding the establishment process of a white cabbage mother plant culture. Additionally, the study of the three experimental factors is intended to substantiate the development of the most efficient mother plant culture, thereby facilitating the subsequent establishment of the seed culture without the need for transplanting work.

The results obtained regarding the combined influence of all factors on the morphological characteristics of the mother plants have highlighted significant differences for all analyzed factors. Specifically, in the case of head diameter, the factors $E_1 \times D_3 \times T_1$ (10.07 × 12.900 plants ha^{-1} × without transplanting) recorded the highest values. Additionally, plants belonging to E_3 did not reach the stage of head formation by the time they were covered with soil for winter storage.

Following the conduct of the experiment and the obtaining and interpretation of statistical results, it is observed that the experimental factors can exert a significant influence on the development of plants. The optimal selection of these factors can lead to a substantial increase in the yield of white-headed cabbage and, consequently, to the development of viable mother plants for seed production.

In the context of the ***Chapter 6*** – ***Study of the influence of experimental factors on the phenology of seed plants***, the results obtained from the experiments are presented, focusing on the analysis of the generative phase of white-headed cabbage seed crop.

The aim of this research is to facilitate a comprehensive and precise assessment of the phenological evolution of seed plants derived from both transplanted mother plants and those that were not transplanted. This analysis targets an important link in the entire process of producing high-quality seeds. To achieve the stated goal, the following objectives were defined:

- study of the influence of the sowing period on the phenology of the seed crop;
- study of the influence of planting density on the phenology of the seed crop;
- study of the influence of planting technique on the phenology of the seed crop;
- study of the combined influence of all factors on the phenology of the generative phase of white cabbage.

Achieving the stated purpose and objectives provides practical and concise information regarding the phenological development of the seed crop. The presented results will serve as the foundation for developing the most efficient technology for producing white cabbage seeds in the Northeast region of Romania.

Regarding the obtained results, the study of the multiple interactions of experimental factors on the generative crop of white cabbage revealed experimental variants with increased phenological precocity. Variant $E_1 \times D_1 \times T_1$ (10.07 × 28.500 plants ha^{-1} × without transplantation) exhibited the shortest period to reach physiological seed maturity, requiring an average of 239.0 days for harvesting, proving to be the most efficient. These statistically significant findings have essential implications for optimizing white cabbage cultivation technology.

The results obtained through the statistical analysis of the phenological traits of the seed plants of cabbage are highly relevant for optimizing the management of this agricultural crop. These data provide a solid foundation for planning and implementing of activities, with the aim of maximizing production within an appropriate time frame. It is important to note that the significant variation in the study results may be influenced by specific climatic conditions and management practices adopted in the crop system.

Throughout ***Chapter 7*** – ***Study of the influence of experimental factors on the yield of seeds***, the results derived from the seed harvest are presented and analyzed for each experimental factor, either individually or under their combined influence.

The purpose of this study is to conduct a comprehensive assessment of the seed yields obtained from seed plants subjected to transplantation, as well as those that were not transplanted. This analysis focuses on an important link in the entire process of producing high-quality seeds. In order to achieve the stated purpose, the following objectives have been outlined:

- study of the influence of the planting date on the seed yield;
- study of the influence of planting density on seed yield;
- study of the influence of planting technique on seed production yield;
- analysis of the combined influence of all experimental factors on seed yield.

Achieving the stated purpose and objectives provides concise information regarding the quantitative evolution of the harvested seeds from the experimental variants. The presented results contribute to shaping and developing the most efficient technology for producing white cabbage seeds.

Regarding the obtained results of total production (kg ha^{-1}), a significant variation in averages is observed, with a minimum average of 45.02 kg ha^{-1}, recorded in the experimental variant $E_3 \times D_3 \times T_2$ (10.09 × 12.900 plants ha^{-1} × with transplanting) and a maximum average of 264.19 kg ha^{-1}, observed in the experimental variant $E_1 \times D_1 \times T_2$ (10.07 × 28.500 plants ha^{-1} × with transplanting), closely followed by the experimental variant $E_1 \times D_1 \times T_1$ (10.07 × 28.500 plants ha^{-1} × without transplanting) which recorded a value of 238.64 kg ha^{-1}.

After analyzing the results, it can be concluded that the experimental variants with the earliest planting date (10.07), a density of 28.500 plants ha^{-1}, and the use of both transplanting and non-transplanting cultivation techniques generated the most favorable production results. Although the rootstock culture variant (without transplanting) showed slightly more modest results compared to the transplanting variant, the obtained data support the hypothesis of obtaining cabbage seeds without the need for transplanting work, which is an important finding.

In the context of ***Chapter 8*** – ***Study of the influence of experimental factors on seed quality***, the research results regarding the germination of seeds from experimental variants are presented. These results are analyzed based on specific indicators such as the germination percentage, synchronization of the germination process, average germination time, germination value etc.

The purpose of this experiment is to evaluate the quality of seeds obtained from the experimental variants, with the objective of providing an overview and determining the most efficient seed production technology. To achieve the stated purpose, the following objectives were defined:

- analysis of the influence of the planting date on seed quality indicators;
- study of the influence of planting density on seed quality indicators;
- evaluation of the influence of planting technique on seed quality indicators;
- analysis of the combined influence of all experimental factors on seed quality indicators.

The stated purpose and objectives will provide specific information regarding the qualitative evolution of seeds obtained from the experimental variants. The presented results will contribute to the development and definition of the most efficient technology for producing white-headed cabbage seeds.

From the perspective of the obtained results, in the case of the germination value under the influence of all factors, statistically significant variations in the averages were observed. This indicator gathers information about the speed and degree of germination into a single score, providing a comprehensive evaluation of seed quality. High values of this parameter indicate a rapid and complete germination. The highest value was recorded for the variant $E_2 \times D_1 \times T_2$ (10.08 × 28.500 plants ha^{-1} × with transplanting), with a score of 626.38, while the lowest average was recorded for the variant $E_1 \times D_2 \times T_2$ (10.07 × 17.850 plants ha^{-1} × with transplanting), with a value of 298.89.

The results of the statistical analysis of the germination tests indicate satisfactory performance of the autumn cabbage seeds, with a high germination percentage and low variations among the different experimental variants studied. This suggests that the seeds exhibit good quality and should provide efficient germination in agricultural practice.

In the ***Chapter 9***, dedicated to ***General conclusions and recommendations***, the most successful experimental variant is presented, and new research directions are identified to clarify aspects insufficiently studied so far.

The doctoral thesis, through its results and their interpretation, constitutes a primary contribution that can be used in implementing efficient production practices and optimizing the cultivation of white-headed cabbage for seed production. It can contribute to minimizing the risks associated with the vernalization process and may open new perspectives for collaboration with institutions interested both theoretically and applied aspects of seed production.