

ABSTRACT

of the dissertation by Aigerim Jantassova entitled “Introduction and research of leafy cabbage *Kale (Brassica oleracea var. Sabellica)* in the South-East of Kazakhstan” submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (PhD) in the educational program 8D08103 – “Horticulture.”

Relevance of the research topic. Plant introduction is one of the most important areas in the development of modern crop production, aimed at expanding the range of cultivated crops and enabling more efficient use of plant resources. The introduction of new plant species into different natural and climatic conditions makes it possible to identify their adaptive potential and to develop promising varieties for agriculture.

In the conditions of the Republic of Kazakhstan, a relevant direction is the diversification of vegetable production and the expansion of the range of leafy vegetable crops with high nutritional and biological value. Leafy vegetables are an important source of vitamins, minerals, antioxidants, and other biologically active compounds necessary for a balanced human diet.

In recent years, particular interest among representatives of the *Brassicaceae* family has been attracted by kale (*Brassica oleracea var. sabellica*), which is distinguished by a high content of vitamins, minerals, and phytochemical compounds. Despite the wide distribution of this crop in a number of countries, in Kazakhstan it remains insufficiently studied and is practically not used in commercial vegetable production.

In this regard, the introduction, study of biological characteristics, and evaluation of the productivity of kale under the conditions of south-eastern Kazakhstan are relevant tasks aimed at expanding the range of vegetable crops, improving the nutritional value of agricultural products, and promoting the sustainable development of vegetable production.

Purpose of the dissertation research. The purpose of this study is the introduction, establishment, and comprehensive investigation of a collection of kale (*Brassica oleracea var. sabellica*), followed by the identification of promising accessions based on a combination of economically valuable, morphological, and biochemical traits for the conditions of south-eastern Kazakhstan, as well as the assessment of the influence of different cultivation technologies (open field, hydroponics, and aquaponics) on the productivity and quality of leaf products.

Research objectives:

1. To introduce and establish a collection of kale of different ecological and geographical origins;
2. To study the morphological and economically valuable traits of kale accessions (productivity, biometric parameters) when grown under open-field conditions in south-eastern Kazakhstan;
3. To evaluate the productivity and quality indicators of kale when grown under protected cultivation using hydroponic (NFT) and aquaponic technologies;

4. To determine the content of the flavonoid quercetin and vitamin A in kale leaves grown under different conditions using chromatographic analysis;
5. To develop recommendations for the year-round cultivation of kale in open field and by the nutrient flow hydroponic method in order to create a “green conveyor” and obtain fresh, highly vitamin-rich leafy produce.

Research methods. The studies were conducted in 2021–2022 under both open-field and protected cultivation conditions, including hydroponic and aquaponic systems. Six foreign hybrids of curly kale were selected as the objects of study: Dwarf Green Curled F1, Nero di Toscana F1, Scarlet F1, Red Russian F1, Kapitan F1, and Kapral F1. Field experiments in open ground were carried out at the stationary experimental field of the “Kainar” Regional Branch of the Kazakh Research Institute of Fruit and Vegetable Growing, while studies under protected cultivation were conducted at the innovative greenhouse of the Kazakh National Agrarian Research University and at the EXEO KZ greenhouse complex in the Ili District of the Almaty Region.

A set of methods commonly used in vegetable crop research was applied to conduct the experiments. Phenological observations included recording key stages of plant development, such as sowing date, first emergence, mass emergence, and harvest dates. Biometric assessment was carried out according to standard indicators, including measurement of the height of the central stem, counting the number of leaves, and determining the leaf surface area. For the analysis of biochemical composition, leaf samples collected at different stages of development were used to determine the content of total nitrogen, potassium, calcium, phosphorus, vitamin C, and dry matter. All analyses were performed in the agrochemical laboratory of fruit and vegetable products using standard methods that ensure the reliability and reproducibility of the obtained data.

Key findings presented for defense:

1. Patterns of manifestation of economically valuable traits of *Brassica oleracea* var. *sabellica* under open-field and protected cultivation conditions.
2. The influence of agro-climatic conditions of south-eastern Kazakhstan on growth, development, and yield.
3. Assessment of the adaptability and productivity of the collection of different ecological and geographical origins. Highly adaptive and yield-stable accessions were identified.
4. Features of leaf biochemical composition. Inter-varietal differences in flavonoid, vitamin, and dry matter content.
5. The effect of cultivation technologies (open field, NFT hydroponics, aquaponics) on the accumulation of quercetin, vitamins A and C, and mineral elements.
6. Justification for the selection of promising varieties and hybrids for breeding and their introduction into production as a functional vegetable crop.

Description of the main research results: As a result of this study, six hybrids of kale (*Brassica oleracea* var. *sabellica*) were introduced and a collection was established. A comprehensive evaluation of the kale collection was carried out based on phenological, morphological, productivity, and biochemical parameters

under the conditions of south-eastern Kazakhstan. The study examined the growth, development, and yield formation of plants under open-field cultivation as well as in NFT hydroponic and aquaponic systems. Biochemical analysis of the leaves was conducted, including determination of dry matter, sugars, vitamin C, vitamin A, flavonoids (quercetin), and nitrates, as well as the mineral composition and chemical characteristics of nutrient solutions. Correlation and regression analyses were performed to evaluate the influence of meteorological factors on hybrid yields. The effects of genotype and cultivation technology on the productivity and quality of leafy produce were established. The most promising hybrids were identified, characterized by high yield, adaptability, and elevated content of biologically active compounds. The most effective cultivation technologies for producing high-quality kale were also determined. Differences in the content of quercetin, vitamin A, and other biochemical components were identified depending on genotype and cultivation technology. Based on these results, the most promising hybrids were selected and recommendations were developed for kale cultivation to improve yield and product quality.

Justification of novelty and significance of the results. For the first time under the conditions of the Republic of Kazakhstan, kale (*Brassica oleracea* var. *sabellica*) has been introduced and comprehensively studied as a new vegetable crop, previously not studied in domestic scientific practice. For the first time for the agro-climatic conditions of the region, a comparative study was conducted on the growth, development, and yield formation of kale under different cultivation technologies, including open-field cultivation, NFT hydroponics, and aquaponics. The influence of hybrid genotypic characteristics and applied cultivation technologies on productivity, morphophysiological traits of the plants, and leaf quality was established.

New experimental data were obtained on the accumulation of biochemical components and biologically active substances in kale leaves, including dry matter, sugars, vitamins, and flavonoids, depending on genotype and cultivation conditions. Differences in the formation of the nutritional and biological value of the leafy produce under different cultivation technologies were identified.

As a result of the comprehensive evaluation, promising kale hybrids were identified, characterized by high productivity, adaptability to the soil and climatic conditions of the region, and elevated content of biologically active compounds. These findings provide a scientific basis for the further introduction of this crop into agricultural production and for the use of the material in breeding programs aimed at developing domestic varieties adapted to the conditions of the Republic of Kazakhstan.

Compliance with directions of scientific development and state programs. The results of this study fully align with the priority directions for the development of the agro-industrial complex of the Republic of Kazakhstan and the objectives of sustainable agriculture. The research is aimed at diversifying vegetable production, introducing promising vegetable crops, and improving the efficiency of green produce cultivation, including kale, taking into account its productivity, nutritional value, and functional properties. The results support the implementation of modern

cultivation technologies that contribute to the rational use of water and land resources and enhance the resilience of the agricultural sector.

The findings provide a scientific basis for further work focused on the development of resource-saving technologies, improvement of agronomic methods, and breeding of domestic kale varieties and hybrids adapted to different soil and climatic conditions in Kazakhstan. The application of these results contributes to the expansion of the range of vegetable crops, the development of functional vegetable production, and the strengthening of regional food security.

Description of the doctoral candidate's contribution to each publication.

The main results of the dissertation research on the introduction, comprehensive study of morphological and biochemical features, and evaluation of productivity of kale (*Brassica oleracea* var. *sabellica*) under the conditions of south-eastern Kazakhstan are reflected in four scientific publications. Of these, one article was published in an international peer-reviewed journal indexed in Scopus, and three articles were published in scientific journals recommended by the Committee for Quality Assurance in the Sphere of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan (CQASHE MNHE RK).

The doctoral candidate participated directly in all stages of the research, including the development of the scientific concept, planning and execution of laboratory and production experiments, collection and systematization of experimental data, statistical processing, and interpretation of results. She personally conducted field experiments, collected and analyzed experimental data, performed statistical analyses, interpreted the findings, and prepared and formatted the scientific publications.

She also actively contributed to the preparation and editing of publications, formulation of research conclusions, and development of practical recommendations for the cultivation of kale, assessment of its productivity, and biochemical characteristics under different cultivation technologies. Thus, the doctoral candidate's contribution encompasses the full cycle of scientific research — from problem formulation and experiment organization to data analysis and preparation of scientific publications.

Volume and structure of the dissertation. The dissertation consists of an introduction, three chapters, a conclusion, recommendations, a list of references containing 205 sources (154 of which are by foreign authors), and nine appendices. The text comprises 123 pages of typed material and includes 25 figures and 14 tables.