

## ABSTRACT

Doctoral dissertation on the topic: "Development of technology for conveyor cultivation of leafy vegetable crops in open and protected ground in the Southeast of Kazakhstan." submitted for the degree of Doctor of Philosophy (PhD) in the specialty 8D08103 – "Horticulture"

**Relevance of the dissertation.** The cultivation of environmentally friendly vegetable products in protected ground conditions is an important strategic task for the agro-industrial complex of the Republic of Kazakhstan (RK). Modern understanding of rational and proper nutrition requires the consumption of sufficient quantities and an increased variety of green vegetables, which allows for a certain degree of diversification in the diet of the population. Kazakhstan is one of the most developed agricultural regions with enormous potential, but the cultivation of early-ripening and green vegetables in protected ground remains a significant problem. According to the Kazakhstan Greenhouse Association, there are currently more than 1.8 thousand hectares of greenhouse facilities in the country, ranging from industrial complexes to mini-greenhouses. Vegetable farming, as one of the leading sectors of agriculture, plays an important role in ensuring the country's food security.

The relevance of the research work is determined by the comprehensive study of hydroponics as an economical method for growing leafy green plants. Experience has shown that increasing greenhouse vegetable production, enhancing yields, improving product quality, and reducing labor costs depend on the application of new advanced energy-saving technologies and the establishment of a modern scientific and technical base. One such technology is the cultivation of vegetable crops using hydroponics. The use of hydroponics reduces financial costs associated with soil treatment, weed and pest control, and allows for the cultivation of a larger number of plants in a limited planting area. Water and mineral fertilizers are used more efficiently due to their repeated use. There is also the possibility to manage plant growth by changing the composition of the nutrient substrate and the concentration of oxygen in the solution, which increases yields. The technologies for growing chard varieties in artificial nutrient media with various substrates identification of the best technology for growing using the hydroponic method. Increasing the types and volume of leafy green production is one of the priority areas in the development of the vegetable cluster. Recently, the state has been paying more attention to the health of the nation, so the issue of environmentally friendly products remains relevant.

**Research Object:** The three studied chard varieties are registered in the Register of Breeding Achievements and approved for use in the Republic of Kazakhstan.

**The objective of the dissertation research:** To produce conveyor products of green leafy chard varieties based on modern cultivation technologies in open and protected ground.

### **Research Tasks:**

1. To study promising green leafy chard varieties for conveyor production using hydroponic systems.
2. To evaluate certain techniques of conveyor cultivation of chard varieties in protected ground.
3. To study the influence of conveyor cultivation conditions on the biochemical composition, quality, and yield of chard varieties.
4. To examine certain elements of conveyor cultivation of green leafy vegetables in protected ground in the southeast of Kazakhstan.
5. To assess the economic efficiency and profitability of conveyor cultivation of green leafy crops in open and protected ground.

**Author's personal contribution to the scientific result.** The author of the dissertation has fully contributed to defining the research objective, formulating the research tasks, conducting experiments, and summarizing and processing the obtained data.

### **Scientific novelty and significance of the dissertation work.**

Scientific novelty. For the first time in the conditions of southeastern Kazakhstan, optimal parameters of technological methods for cultivating chard varieties in protected and open ground have been studied and determined, allowing the creation of a conveyor of fresh production (selection of varieties, optimal sowing dates, cultivation methods, nutrient components). An evaluation of the economic efficiency and profitability of conveyor cultivation of green leafy vegetable crops in open and protected ground has been provided.

Practical significance of the work. As a result of the conducted research, rational cultivation methods have been developed and substantiated, allowing for the year-round conveyor production of environmentally friendly green leafy vegetables.

The studies have identified optimal parameters for the technological methods of cultivating chard varieties in the agro-climatic conditions of the southeast of Kazakhstan. This has enabled the proposal of conveyor production schemes for small-scale producers and the general population, ensuring the supply of fresh produce to the market from early June to mid-October. For modern hydroponic technologies actively implemented in protected ground, chard varieties characterized by high growth rates and productivity considering light levels are recommended. The results obtained allow for an increased assortment of cultivated leafy green vegetable crops and an extended period of fresh vegetable consumption in the southeast of Kazakhstan. The research results will be used by greenhouse complexes and farms growing leafy green crops. They will also be in demand in the future for developing educational materials for higher and secondary educational institutions in agronomy specialties.

### **Main provisions for defense:**

- Elements of the technology for cultivating chard varieties in hydroponic complexes.
- The influence of substrates, sowing and planting dates, and nutrient components on the development of green leafy crops in protected ground.

- Elements of the technology for cultivating chard varieties in open ground in the conditions of the southeast of Kazakhstan.

- Economic efficiency and profitability of conveyor cultivation of green leafy crops in protected ground.

- The research established the high economic efficiency of growing leafy green crops. The yield of leaf-type chard varieties increases with the average plant mass. The dependence of yield on sowing dates was analyzed, and it was found that the yield of the variety "Bych'ya Krov" was significantly higher compared to the control, reaching 153 kg/m<sup>2</sup>. The highest yield was achieved with sowing dates of May 14 and May 21. The highest profitability level for the variety "Bych'ya Krov" was reached and amounted to 96-97%.

- Economic efficiency and profitability of conveyor cultivation of green leafy crops in open ground.

#### **Theoretical and practical significance of the research:**

The methodology of the dissertation research included the search and analysis of information sources on the research object; setting goals and tasks for experimental justification; conducting phenological observations, biometric measurements, yield accounting, and studying the biochemical composition of leafy green crops; summarizing research results in the form of conclusions that determine the theoretical and practical significance of the dissertation. The scientific provisions and conclusions of the dissertation are based on a large volume of experimental material obtained using modern research methods, which is confirmed by tables, graphs, and photographs. All research results were statistically processed using Microsoft Excel. The significance of the difference between means was assessed using LSD<sub>0,5</sub>. The main results were reported and discussed at the meetings of the Department of Horticulture (2020-2023).

#### **Approbation and approval of the results.**

The results and conclusions of the research are presented in 21 works, including 4 articles in journals recommended by the Committee for Control in the Field of Education and Science of the Republic of Kazakhstan, and 17 articles in the materials of international scientific and practical conferences.

**Publication of research results.** The research results were published in journals included in the Scopus and Web of Science databases, recommended by the Committee for Control in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan (COCSNVO MES RK), and in the materials of international scientific conferences.

1. Adaptive abilities of chard cultivars (Scopus) SCIENTIFIC HORIZONS Journal homepage: <https://sciencehorizon.com.ua> Scientific Horizons, 26(7), 118-128. UDC 581.1: 633.4 DOI: 10.48077/scihor7.2023.118;

2. "Innovative cultivation methods for basil and its varieties"

// Bulletin (COCSN) of Korkyt Ata Kyzylorda University, No. 4 (59) 2021, pp. 81-87

(Article in English)

3. Innovative methods for studying the biochemical composition of chard leaves // Bulletin (COCSN) of Korkyt Ata Kyzylorda University, No. 1 (60) 2022, pp. 35-44

4. Cultivation of various high-quality chard varieties (*Beta vulgaris*) in greenhouse conditions // Bulletin (COCSN) of Korkyt Ata Kyzylorda University, No. 4 (63) 2022, Part I, pp. 100-109

### **Conclusion.**

Conveyor cultivation of leafy vegetable crops of chard varieties in the innovative greenhouse of KazNARU using hydroponic technology has shown high efficiency.

The application of LED lighting with the ability to adjust to the most suitable spectrum during specific periods of vegetative plant growth, along with assimilation lighting with microclimate control systems, proper plant nutrition, and a modern air disinfection system, allows for maximum yield during periods when such produce cannot be obtained under natural conditions.

A distinctive feature of this new innovative technology is the production of quality seedlings of leafy green plants within 25-35 days.

Research results have shown that the optimal artificial substrate for hydroponic low-volume seedling cultivation of chard varieties is mineral wool.

We tested mineral wool cubes measuring 10x10x6.5 with the trade names "Grodan," produced in the Netherlands, and "Aroban," produced in the Czech Republic. Mineral substrates contributed to earlier seedling emergence (by 2-4 days). The most effective options were observed with "Grodan" and "Aroban," where for the «Bych'ya Krov'» and «Nevesta» varieties, vegetation was completed in 18 and 20 days, respectively, and for the Ruby variety, it was 32 days after sowing. Seedlings of chard varieties at 18 days on "Grodan" had excellent biometric indicators: the average plant height exceeded the control by +8 cm, the number of leaves increased by +1.5, with a total leaf area of +127 cm<sup>2</sup>.

The study on sowing dates showed that with later sowing dates—May 21 and May 28—the yield of chard varieties "Rubin" and "Nevesta" was significantly lower. The yield of the variety "Bych'ya Krov'" was higher when planted in the first decade of May (May 7 and May 14). On average, over three years of research, the yield at these sowing levels was 3.15-4.4 kg/m<sup>2</sup>. The varieties "Nevesta" and "Rubin" reached maturity and marketable yield when planted in the first decade of May—May 14 and May 21 (1.63-1.53 kg/m<sup>2</sup>).

The studied methods of treatment with growth regulators—soaking seeds for 3 and 6 hours, twice watering pots and trays with nutrient solutions containing growth substances—significantly enhanced shoot growth, increased leaf area, and stimulated root system development compared to the control. The variant using the St.+Super Humisol (0.5%) preparation yielded the best seedling results across all indicators. In this variant, the development of chard varieties was 1.4-1.6 times better

compared to the control in terms of leaf apparatus. This, in turn, allowed for planting the seedlings 3-4 days earlier in the production area, which subsequently ensured the production of higher quality marketable products. The height of "Nevesta" and "Rubin" plants in the variant with Super Humisol (0.5%), the number of leaves, and leaf area per plant exceeded these biometric indicators compared to the control by an average of 1.2-1.5 times.

High content of dry matter, sugars, organic acids, ascorbic acid, and phenolic compounds has been noted in the "Bych'ya Krov" variety of chard.

As a result of biochemical studies conducted in 2021-2023, it was established that the variety "Bych'ya Krov" (leaf type) and the varieties "Nevesta" and "Rubin" accumulated more dry matter in the conditions of 2021 compared to 2022. A high content of ascorbic acid, chlorogenic acid, quinic acid, and phenolic compounds was noted in the leafy green variety "Bych'ya Krov". It was also observed that lower temperatures during late sowing of chard varieties contribute to increased sugar accumulation in the leaves.

According to the results of the correlation analysis, strong relationships were found between phenotypic and economically valuable traits. Leaves with red pigmentation tend to accumulate less sugar ( $r = -0.45$ ) and synthesize more ascorbic acid ( $r = 0.37$ ) and phenolic compounds ( $r = 0.36$ ), and also show a strong correlation with anthocyanin content ( $r = 0.71$ ). A trend towards reduced levels of phenolic compounds ( $r = -0.36$ ) and anthocyanins ( $r = -0.41$ ) is observed in varieties with oily and crispy leaf textures. Among all these indicators, the most effective chard variety recommended for cultivation in protected environments was "Bych'ya Krov".

In open ground, planting seedlings of chard varieties grown in the innovative greenhouse allowed for a high yield within optimal time frames. The yield of the chard varieties "Nevesta" and "Rubin" was harvested 60 days after planting the seedlings, while the variety "Bych'ya Krov" was harvested after 56 days.

Biometric and biochemical analysis showed that the addition of nutrients to the growth solution for seedling cultivation was also highly effective in open ground. The rosette height, rosette diameter, and number of leaves in chard varieties before harvest were significantly higher, on average 12-14% over two years of research. The content of dry matter, total sugars, organic acids, chlorophyll, and carotenoids in the plants of chard varieties was significantly higher compared to the control. Ultimately, the yield in the experiment was significantly higher than in the control, with an average increase of 12-16% over two years.

The profitability level of growing chard in the innovative greenhouse reached 290.5%, while for the "Nevesta" variety, it was 137%.

The profitability level of growing the variety "Bych'ya Krov" in open ground in southeastern Kazakhstan was 213% at 2023 prices, while for the variety "Nevesta" it was 58%.