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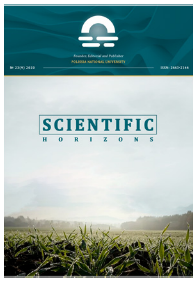

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Adaptive abilities of chard cultivars

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Abstract. The method of growing green vegetable crops in a greenhouse equipped with modern technologies allows controlling humidity, light, temperature, carbon dioxide levels, air circulation and much more. With the help of information and digital technologies, the growth rate of cultivated crops is controlled, yields are increased, and the use of water and resources is more efficient than with traditional cultivation methods. Based on the research work carried out in the period 2020-2022. according to the technology of growing chard sowing in closed greenhouses in Almaty, the Republic

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of Kazakhstan, an assessment of agrobiological properties, productivity, and adaptability was made. The purpose of the article is to study the range of chard varieties and assess the influence of soil properties, temperature, and illumination on productivity, biochemical composition, and biological activity. The following methods were used in the studies: laboratory – including monitoring and evaluation of the biochemical composition of plant material; biometrics – assessment of the parameters of a comprehensive analysis of the environment and the qualitative characteristics of the crop; phenology – observation of the phases of development; statistics – analysis of information to assess the adaptive capabilities of chard. A wide range of tolerance to growing conditions was observed in the Mercury and Buru varieties, a moderate one in the Bull's Blood and Bride varieties, and a narrower one in the Rubin variety. Under greenhouse conditions, the duration of vegetation in the spring turnover was 45-56 days: variety Mercury v 55 days, Buru – 50 days, Bull's blood – 45 days, variety Bride – 53 days and Rubin – 55 days, respectively. For three years of cultivation, the average yield of chard was Mercury – 5.27 kg/m^2, Buru – 4.51 kg/m^2, Rubin – 4.86 kg/m^2, Bride – 5.09 kg/m^2, Bull's blood – 5.54 kg/m^2. In the conditions of 2022, active accumulation of photosynthetic material took place in the leaves of most chard varieties. In particular, the practical significance of the methods of growing green vegetables in greenhouse conditions, the organizational and economic processes of greenhouse cultivation, the study of economic and biological characteristics and the yield of various chard varieties form the development strategy for the vegetable growing industry

Keywords: variety; greenhouse; biochemical composition; productivity; biological activity

INTRODUCTION

Growing environmentally friendly vegetable products in protected ground conditions is an important strategic task of the agro-industrial complex of the Republic of Kazakhstan (RK). The modern understanding of rational and proper nutrition requires the consumption of a sufficient amount and an increase in the range of green vegetable products, which allows diversifying the nutrition of the population to a certain extent. RK is one of the most developed agricultural regions with great potential, but indoor cultivation of early ripe and green vegetables remains a significant problem. According to the Greenhouse Association of Kazakhstan (2023), today there are more than 1.8 thousand hectares of land under greenhouse facilities in the country, from industrial complexes to mini-greenhouses. On the basis of the association, training courses for consultation and support are organized, as well as the management of international exhibition centres for managers and agronomists of greenhouse farms.

In their work, N. Asylkhan and N.T. Dauzhanov (2022) report that the production of green crops in the Republic of Kazakhstan is insufficient and accounts for about 2% of the total vegetable production, while in the European Union (EU) – more than 30%. According to K. Zhambakin and K. Zhapar (2020) overcoming the seasonality of greenhouse cultivation and year-round consumption of vitamin products is an important task, but to solve it, it is necessary to improve the structure of vegetable growing by introducing new valuable vegetable plants, creating varieties and hybrids for different growing regions; creation and use of preparations for the protection of plants from diseases and pests; application of new biotechnological methods for environmental protection; increase in productivity and precocity with the expansion of the zone of distribution of vegetables.

D. Wang *et al.* (2022) argue that the species diversity of plants available for cultivation in the Republic of Kazakhstan and the methods of their cultivation, collection, storage, and use depend on the following factors: the natural and climatic conditions of the region, national traditions, modern food culture and technical capabilities, as well as the availability of suitable premises for growing and storing products. In agricultural crop production, about 20 thousand plant species are grown and consumed, of which 15 thousand are vegetable-growing. In the industrial vegetable growing of the Republic of Kazakhstan, about 40-50 types of green vegetables are grown, while in personal subsidiary plots the range reaches up to 150 types of plants.

S. Ajibade *et al.* (2022) assessed chard, chard, which widely distributed in EU countries, China, Georgia, Armenia, Turkey, USA, Japan, and India. Chard has its origins in the Mediterranean, but is most commonly grown in Switzerland, where it is known as Swiss chard. Vegetable growers need to pay more attention to the cultivation and use of this species, which can offer a wide range of vitamin products among green vegetables. Chard differs from red beets in that it has no roots, and the leaves are edible, as well as the presence of a two-year growth cycle: in the first year, green inflorescences are harvested, and in the second year, in addition to the green mass, seeds ripen.

A.B. Idrisova *et al.* (2022) described the chard depending on the shape and cut of the leaves: petiolate and leafy. Leafy chard is characterized by a lush rosette of large, fleshy leaves and narrow petioles, cultivars and hybrids called Romaine Kale or Spinach Kale can easily be used in place of leafy vegetables such as spinach, lettuce, and other leafy green vegetables. Petioled chard form bushes with numerous large stems. The leaves of these varieties are smaller, but the petioles are very tasty, juicy, replacing asparagus celery in the diet. To achieve larger stems, when growing chard, the leaves are cut off, leaving the petioles.

I. Gonzalez-Fernandez *et al.* (2016) give a detailed description of chard varieties according to varietal differences that differ in stem colour: whitish, yellowish, light green and dark green, red. Leaves can be either curly or smooth. Lyon chard is distinguished by a low but powerful rosette of delicate, salad-coloured leaves. Swiss chard is characterized by erect, yellow-green, blister-curly and relatively large leaves. Chard-Lukullus is characterized by larger and curly leaves than those of the Swiss, with a white wide petiole. Silver curly chard has heavily curly-bubbly leaves. Silver smooth chard differs from the previous variety – smooth waviness. Yellow-petiolate chard is an ornamental variety with bright yellow petioles. The red-petiolate variety of Mangold is early ripening, and forms a large, compact rosette of slightly wavy dark green leaves. The Petioles are slightly ribbed, bright red, of medium width within 3-4 cm. The Dark green chard is mid-ripening, its rosette consists of highly raised wavy-bubble green leaves, petioles are slightly ribbed, white, of average width within 4-6 cm.

The purpose of this study is to study the spectrum of varieties with low distribution and to evaluate the influence of greenhouse soil characteristics, moisture, and light conditions on the yield, biochemical composition and biological activity of chard.

THEORETICAL OVERVIEW

Chard (*Beta vulgaris L. var. cicla*) is a biennial herbaceous plant that belongs to the amaranth family (*Amarantháceae*), one of the varieties of leaf beet with a wide rosette, large leaves and short stems, besides, contrasting veins give the culture a special elegance. H. He *et al.* (2022) in their work report that based on the DNA analysis of two geographic groups of chard (African and North American), a gene pool sequence was established, including 7 sections *Lactuca and Lactuca Cyanicae, Phoenixopus, Mulgedium, Lactucopsis, Tuberosae, Micranthae and Sororiae*.

S.P.A. de Oliveira *et al.* (2021) characterize vegetable crops, including chard, which is the least demanding on growing conditions and is not afraid of diseases and pests. Having a long root, the chard easily tolerates a dry period and is resistant to low temperatures. In the period of 25-40 days after the appearance of sprouts, it produces marketable products, and the leaves are constantly renewed during the summer and autumn. As noted by A. Libutti *et al.* (2023), the yield of chard is very high. From one square meter, it is possible to get up to 30 kg of leaves and up to 10 kg of cuttings per season, while the yield of spinach is about 5-6 kg. Chard is cold-hardy and drought-tolerant. Chard is grown by sowing seeds into the soil, leafy forms are sown in mid-April with a row spacing of 25-30 cm, and petiolate Common chard 45-60 cm, it is also allowed to re-sow in July. The seeding rate is 5 g per 1 m^2. The sprouts are thinned out, leaving the plants at a distance of 8-10 cm, and then – 15-20 cm.

R. Brown and R. Gbesbm (2021) note the following types of chard: according to the shape of the leaves – narrow and long; petioles are tall and fleshy. Chard leaves are classified into horizontal, sinuous, with a smooth or blistered surface, round, oval, elongated; entire and with serrated edges. The root system of the chard is rather weak, but regenerates well and grows quickly, so the plants easily tolerate transplantation, but at the same time require constant uniform soil and moisture. Chard varies in colour from light yellow and dark green to dark red, with some varieties having distinctive anthocyanin spotting and leaf margin pigmentation. The stem of the chard is highly developed and reaches 4-5 cm or more in diameter.

Z.T. Teshome (2022) reports that soil cultivation of chard requires loosening and weeding during the growing season. The best predecessors of chard are potatoes and nightshade vegetables. During dry periods, increased watering after cutting the leaves is recommended. If a soil crust has formed, there is not enough air in the ground, with a prolonged decrease in temperature, waterlogging of the soil, its increased acidity, diseases can develop on crops, in particular root rot and black leg.

M.K. Bozokalfa *et al.* (2011) concluded that chard leaves and stems are rich in protein, monosaccharides, and a high content of ascorbic acid was also noted – 30 mg%. The content of B vitamins indicates numerous macro- and microelements in easily digestible chelate forms in the form of sodium, iron, chlorine, calcium, phosphorus ions, etc. Leaves and petioles rich in vitamins are eaten fresh and boiled. Chard roots are not edible. The plant has a high decorative value and is good for health.

Z. Mzoughi *et al.* (2019) when creating a new variety of chard recommends using the method of individual-family selection for 7 generations from a hybrid population obtained by free cross-pollination of varieties. M. Gamba *et al.* (2021) described changes in the productive characteristics of the variety carried out according to the following indicators: high stable yield of green mass over the years; leaf blade with anthocyanin frame; rounded relatively large root crop, which is characterized by high keeping quality during storage of mother liquors, ensuring the suitability of using beam products together with the root crop; the ability of leaves to grow back after cutting; resistance to biotic and abiotic environmental factors; resistance to the formation of flowering shoots in the second year of vegetation; high seed productivity.

MATERIALS AND METHODS

The following methods were used in the study: laboratory – included monitoring and evaluation of the biochemical composition of plant material;

biometric – parameters of a comprehensive analysis of environmental conditions and qualitative characteristics of the variety and yield; phenological – observations of the stages of plant ontogenesis; statistical – analysis of information on assessing the adaptive abilities of chard.

In order to expand the range of green vegetable products in the period 2020-2022, in accordance with generally accepted methodological recommendations and taking into account the biological characteristics of species, studies of chard were carried out in innovative closed greenhouses based on Kazakh National Agrarian Research University, Almaty. Estimate morphological signs of chard sowing carried out according to Order of the Minister of Agriculture of the Republic of Kazakhstan No. 06-2/254 "Methodology of the State variety testing of agricultural crops" (2011). To study the adaptive abilities of sowing chard, the sowing of the varieties Mercury, Buru, Rubin, Bride, and Bull's blood was carried out, and the morphological-identification, biometric and biochemical characteristics of the crop were evaluated. The soils of greenhouse plots are represented by chernozem with a humus content of 3 to 6%, leached, heavy loamy typical for the southeast of the Republic of Kazakhstan for signs and properties.

The total area of the greenhouse was 500 m^2, by design it was divided into 2 sections of 250 m^2. Layered and pyramidal structures allowed more than 4 floors with shelves. The number of rows of the pyramid in which the plants were planted consisted of 8-9 tubes. A favourable microclimate was provided by automated irrigation, air conditioning, lighting, and ventilation systems at all levels. Before sowing seeds and seedlings in the greenhouse, the equipment, cassettes, and substrates used were sterilized.

Planting of seedlings in the spring turnover of closed greenhouses was carried out in the second decade of April according to the scheme 20×15 cm. The depth of planting seeds in the soil was between 2.5-3 cm. The optimal distance between rows was 25 cm. The seeds were sifted at a distance of 1 cm. The location of the plots was randomized with quadruple repetition.

During the growing season of chard sowing, phenological observations of sowing, mass shoots, technical ripeness and biometric measurements (height and diameter of the leaf rosette, number of leaves, thickness, and length of the petiole) were carried out in the research and scientific National Agrarian Research University. The chard varieties of the 2020-2022 sowing crop were analysed for the content of total sugar by the Bertrand method; dry matter by drying in a thermostat at 105°C to constant weight; ascorbic acid by titration with Tillmans stain; the content of pigments carotene, chlorophyll A and B was carried out on a gasoline extract by the spectrophotometric method at a wavelength of the spectrophotometer 450, 663 and 645 nm, respectively. In laboratory conditions, the seed suitability of chard for seed germination and germination energy was determined, which on average for all varieties was 93-97%.

Statistical processing of experimental data on yield, biometric and biochemical indicators of chard sowing was carried out by the method of analysis of variance for the reliability of the difference between the average values using the dispersion method based on the data of S.M. Lourenço (2019).

RESULTS

To expand the range of vegetable products, varieties of chard were studied in a greenhouse; they differed in the colour of the stems and the roughness of the leaves. In some varieties, the stems are better tasting than the leaves, like rhubarb and celery. The most promising are:

1. The chard variety Mercury – from early ripening, growing season – 55 days, before harvesting 95 days, the average yield is 4.4-4.9 kg/m^2. The variety is marked by a semi-vertical arrangement of large leaves. The leaves are intensely coloured red with an anthocyanin tinge. In terms of taste, it has a delicate, crisp texture of leaves with a folded surface. The rosette is 27 cm high, and the diameter of the rosette is 27-31 cm. The approximate weight of one plant is 450 g. The seeds are sown in April-May. When grown for seedlings, seeds are sown in March-April, and planted in May. To form a powerful rosette, regular and moderate watering is required to prevent stagnation of water and drying of the soil substrate.

2. The chard variety Buru is mid-season, the growing season is 48 days, before harvesting 85 days, the yield is 4.2-4.8 kg/m^2. Representatives of Buru chard have an upright rosette of leaves, slightly spreading in the upper part, 54-61 cm high. The leaf is large, elongated-oval, purple-green. The edge is slightly wavy. The surface is slightly bubbly. The length of the leaf blade is 23-25 cm, the width is 16-17 cm. The length of the petiole is 27 cm, the colour is raspberry-red, with the presence of anthocyanin.

3. The chard variety Bride is a mid-season variety that takes 55 to 65 days from germination to harvest. Young leaves and stalks of chard contain many vitamins and minerals. The leaf rosette is upright, compact, up to 60 cm high. The leaves are medium, dark green, slightly bubbly, tender and tasty. Petioles are long, wide, juicy, golden-white, 30-45 cm long. This variety is relatively drought-resistant and cold-resistant. Sow in open ground to a depth of 2.5 cm at the end of April. Multiple cleaning included. The yield of leaves and petioles is 6-7 kg/m^2.

4. The chard variety Rubin is a mid-season species, which is represented by a medium-sized rosette, consisting of green leaves with red veins and petioles. When grown directly in the ground, seeds are sown in early May; seedlings are planted in mid-May. The leaves begin to bear fruit 35-40 days after germination. The greens are harvested several times during the summer.

The plant is cold-resistant, prefers humidity, with purple-green leaves and dark red petioles 20-30 cm long.

5. The chard variety Bull's blood is a mid-season species, the growing season from germination to mass harvesting is observed within 100-110 days. The variety can be grown for microgreens. The variety has a rich ruby colour, without white streaks, and with frost, the colour of the foliage intensifies. The leaves of the variety are rounded and smooth, delicate and soft in taste. The yield of leaves and petioles is 4-5 kg/m^2.

It is important to establish microclimate parameters for the formation of chard sowing due to changes in biometric indicators. Not only the quantity of the crop, but also its quality characteristics, depended on the growing conditions. The taste of the leaves and stem of chard is affected by: the composition of the soil, adherence to agricultural practices, optimal temperature, lighting and other factors.

Common chard was sown in fertile, loose, well-watered soil, as on poor, heavy clay soils with an acidity below pH 6, the leaves will be rougher and the taste will be worse. Chard does not tolerate waterlogging, so planting in stagnant soils is not allowed. Crop rotation was also taken into account, since in one place chard and beets are grown at intervals of 3-4 years. When choosing a site, crop rotation rules are observed, recommended predecessors: carrots, radishes, legumes, tomatoes, cucumbers, radishes, do not grow well after spinach and fodder root crops. In autumn, nutrient components were introduced into the soil to a depth of 30 cm: compost, peat, humus, or other organic fertilizers – 4-5 kg per 1 m^2; superphosphate – 20-25 g; potassium chloride – 15-20 g. Also, often, in heavy soils, dense and clayey, sand is added to loosen the structure. The optimal temperature for growing chard is 16-25°C, the flowering period is 20-25°C, with good watering, growth is possible at 35°C. Seeds germinate at a temperature of 6-7°C. Young plants with 3-4 true leaves can tolerate low temperatures down to -3°C.

When planting in partial shade, it should be borne in mind that due to lack of sunlight, nitrates, and nitrites can accumulate in the leaves, and prolonged shading can slow down growth and cause the leaves to become small. Chard grows well in both full sun and partial shade and requires a lot of light, but keep in mind that the less light, the more delicate the taste of the leaves and the lower the yield. Conducted phenological observations on average for 2020-2022 assumed to take into account the beginning and main phases of the development of chard varieties. It is noted that the bequeathing stage of growth occurred with the appearance of 8-10 leaves, data on all studied varieties are noted in Table 1.

Table 1. *Duration of phenological phases of leafy chard varieties*

Varieties	The period from sowing to the growth of shoots, days	Period from sowing to, days			
		Real 1 sheet	Real 3-4 sheets	Real 8-10 sheets	End of the growing season
Mercury	4	18	31	55	94
Buru	4	16	30	48	84
Ruby	5	17	32	55	96
Bride	6	16	31	53	95
Bull's blood	4	15	31	45	85

Source: *compiled by the authors*

Under the conditions of hydroponic cultivation, the first shoots were observed on the 5-6th day after sowing the seeds. Varieties of the studied chard with the appearance of 10 leaves or vegetative ripeness, were established during the period from sowing: 55 days – the Mercury variety, 50 days – the Buru variety, 45 days – the Ox's blood variety, 53 days – the Bride variety, 55 days – the Rubin variety. The studied samples differed not only in the rate of development, but also in biometric parameters according to the averaged data for 2020-2022, Table 2 shows the data of chard varieties during harvesting in the spring turnover when grown in a closed greenhouse.

Table 2. *Biometric indicators of chard varieties*

Varieties	Rosette height, cm	Outlet diameter, cm	Number of leaves, pcs
Mercury	22.4±0.15	33.5±0.07	23.2±0.12
Buru	22.3±0.51	33.5±0.13	24.5±0.45
Ruby	21.3±2.05	33.0±2.44	24.3±2.67
Bride	26.9±1.05	33.6±1.18	24.4±0.85
Bull's blood	30.7±1.83	34.5±1.40	29.4±1.95

Source: *compiled by the authors*

The reactions of varieties to greenhouse growing conditions are manifested by the degree of variability of biometric parameters, which are divided into three groups:

1. Wide range of tolerance to the conditions of the variability of all biometric parameters less than 10% (Mercury and Buru);

2. The average range of tolerance to the conditions of the variability of at least one biometric indicator by 10-20% (Bull's blood and Bride);

3. A narrow range of tolerance to the conditions of the variability of at least one biometric indicator is more than 20% (Rubin).

Chard cultivars Mercury, Buru, Rubin, Bride, and Bull's blood formed medium-sized rosettes with a leaf height of 21.3-30.7 cm, and a rosette diameter of 32.3-34.5 cm. 29 pcs. Accounting for the yield of the leaf mass of chard sowing was carried out separately according to variants and repetitions. Changes in greenhouse conditions for the current 2020-2022 research, identified varietal differences in the formation of the crop, which are detailed in Table 3.

Table 3. *Productivity and marketability of chard varieties*

Varieties	Productivity kg/m ^{2}			Average plant weight, g	Marketability, %
	2020	2021	2022		
Mercury	4.90	5.56	5.34	204	92
Buru	4.77	4.23	4.53	197	86
Ruby	4.94	4.75	4.89	198	87
Bride	5.12	4.99	5.15	198	88
Bull's blood	5.16	5.45	6.02	222	95

Source: *compiled by the authors*

When evaluating the yield, it was found that in the varieties of chard Bride, Rubin, Mercury, Buru – 4.8-5.6 kg/m^2, these indicators were inferior to the variety Bull's blood – 5.5 kg/m^2. Similarly, there was a trend in terms of average weight and marketability. Given the difference in growing conditions over the years, the yield of chard varieties changed. In 2020, moderate direct illumination of plants was used, with an average daily temperature in May of 13-18°C. In 2021, a high level of direct illumination was noted with an average daily temperature in May of 16-20°C. In 2022, moderate conditions of a high level of illumination were established with an average daily temperature in May of 14-19°C. Biochemical analysis of leaves for the content and ratio of energy pigments – chlorophyll (A, B) and carotenoids for the period 2020-2022 is noted in Table 4.

Table 4. *Composition and content of pigments*

Varieties	Years of cultivation	Chlorophyll, mg/g		Carotene, mg/g
		A	B	
Mercury	2020	0.42	0.31	0.18
	2021	0.39	0.44	0.16
	2022	0.40	0.37	0.23
Buru	2020	0.57	0.63	0.11
	2021	0.59	0.59	0.09
	2022	0.43	0.54	0.14
Ruby	2020	0.61	0.58	0.15
	2021	0.57	0.31	0.10
	2022	0.47	0.56	0.12
Bride	2020	0.48	0.74	0.15
	2021	0.46	0.24	0.07
	2022	0.65	0.72	0.18
Bull's blood	2020	0.41	0.52	0.23
	2021	0.59	0.78	0.14
	2022	0.12	0.68	0.24

Source: *compiled by the authors*

The content of chlorophylls A and B, regardless of the variety, decreased relative to the increase in temperature and the level of direct solar energy in the greenhouse during the period from 2020 to 2022. The total content of pigments in the leaves of the varieties Bull's Blood and the Bride is higher, in contrast to Mercury, Buru and Rubin. In the Bull's blood variety, a low content of chlorophyll A was noted, due to the individual composition of this variety, but it was compensated by the content of carotene. The results of biochemical research in 2020-2022 are detailed in Table 5.

Table 5. *Biochemical composition of chard varieties, %*

Varieties	Years of cultivation	Dry matter	total sugar	organic acids
Mercury	2020	94.26	0.94	0.44
	2021	94.88	0.82	0.32
	2022	94.21	0.84	0.26
Buru	2020	94.35	1.18	0.48
	2021	94.96	1.16	0.56
	2022	94.56	1.24	0.47
Ruby	2020	94.55	1.15	0.34
	2021	94,.24	1.42	0.36
	2022	95.52	1.08	0.42
Bride	2020	94.83	0.64	0.64
	2021	95.02	0.38	0.56
	2022	94.80	0.62	0.66
Bull's blood	2020	94.69	1.27	1.28
	2021	95.62	1.47	1.31
	2022	94.24	1.87	1.22

Source: *compiled by the authors*

The biochemical composition of chard leaves is diverse, but the content of individual components is low. The accumulation of dry matter, sugars and organic acids, regardless of the variety, was more active in 2022. In the Bull's Blood variety, a high content of dry matter was noted 94.2-95.6%, total sugar – 1.3-1.9%, organic acids – 1.2-1.3%.

DISCUSSION

Greenhouse farming can provide an increase in crop yields throughout the year. At the same time, agricultural producers have more and more opportunities to control and create the optimal climatic conditions necessary for plant growth. It has been established that the greenhouse cultivation of chard increases the productivity and taste of chard, as well as the yield, which averaged 4.2-6.0 kg/m^2 in comparison with the cultivation of these crops in open ground. Optimal greenhouse conditions, increased carbon dioxide concentration enhance photosynthesis, leading to highly efficient vegetable growing in a shorter time compared to open ground. In general, when analysing biometric data, greenhouse cultivation was higher in almost all indicators, but the Bull's blood variety turned out to be the leader with an average annual yield of 5.54 kg/m^2, as well as plant height, rosette diameter and a number of leaves were the largest. Staying in the enclosed space conditions of a greenhouse prevents damage to crops from climate change, rising or falling temperatures, possible drought, and keeping birds and other animals away from crops.

H. Kabir *et al.* (2018) found that yields per m^2 increase threefold or more when greenhouses are implemented in combination with digital technologies and hydroponics strategies. The light period of greenhouse conditions during the daytime lasts 16 hours, and at night – 8 hours, the optimum temperature was at the level of 23°C, relative humidity 70%, the allowable values of CO_2 in the air were 1000 ppm or in terms of a percentage of 0.1%. F.J. Rodriguez Pulido *et al.* (2022) compare greenhouse conditions for chard cultivation with alternative open-field farming, where the yield of commercial chard cultivation is in the range of 2-2.5 c/ha, although it is quite possible to increase the yield in the range of 8-10 c/ha.

Chard at different stages of development does not consume the same amount of water, it especially needs high soil moisture during seed germination and in the first weeks after germination, so it is recommended to sow in spring in moist soil. Uneven rainfall or watering carried out with long interruptions adversely affect growth, as well as the emergence of seedlings stretched over time. V. Zunic *et al.* (2022) argue that as a result of more efficient use of resources, less waste can be generated, which contributes to greener production, which in turn can lead to increased profits. Leafy vegetables such as chard, basil, microgreens, arugula, spinach are increasingly grown in hydroponic or semi-hydroponic systems. With the growing popularity of organic food production, growing vegetables in organic conditions, without the use of inorganic fertilizers or chemical plant protection products, and using a greenhouse environment for growing and cultivating chard is the basis for modern methods for the production of functional foods.

Biometric measurements of height, diameter, and number of leaves in a rosette in chard varieties depend on varietal characteristics. In general, in the analysis of biometric data, the leader in almost all indicators was the Bull's blood variety, where the height of the rosette was 30.7 cm, the diameter of the rosette was 34.5 cm, and the number of leaves was 29.4 pieces. Among the varieties of chard, the earliest was the Bull's blood variety, and the latest – Mercury and Rubin. At the same time, chard of the Bull's blood and Mercury varieties was noted for the best commercial qualities – 92% and 95%, respectively. According to a study by G.D. Martins *et al.* (2021), comparing the obtained results of biometric indicators of the early spring and summer periods of growing lettuce of various varieties, it was found that the determining factor in productivity during the summer period was the photosynthetic activity of the leaf apparatus, namely, an increase in the length and width of the leaf blade, as well as the number of leaves in the head. During the summer period of lettuce cultivation, all varieties obtained a total yield that exceeded this indicator during the spring planting period by 1.5 t/ha – the Iceberg variety; 1.9 t/ha – Romen; 3.5 t/ha – Lollo Rossa; 2.3 t/ha – Frisse. It should also be noted that all varieties of lettuce have a high marketability relative to chard during the summer planting period, although on average it was 0.6% inferior to the marketability at the spring time of 0.8%.

The biochemical composition of chard leaves is very diverse, but the content of individual components is quite low. The study of the products of primary and secondary metabolism allows determining the required components for the daily diet. In the Bull's blood variety, a high content of dry matter was noted – 94.2%, total sugar – 1.9%, organic acids – 1.2%. In a study by P. Wagacha *et al.* (2022) estimated the dry matter index in the biochemical composition of chard: 11.3-12.5% in leaves, 22-27% in stems. Given the content of essential nutrients, chard contains more than 1% of total sugar, 1.5-1.7% of crude fibre, crude protein – 1.7-1.9%, crude fat up to 0.2%. The content of macro- and microelements in the form of mineral salts of calcium 4.5-5.1 mg/kg, iron 0.2-0.3 mg/kg, potassium – 35-38 mg kg, sodium – 20-22 mg/kg, phosphorus – 4.5-4.8 mg/kg.

Chard is rich in essential amino acids methionine and aspartic acid, as well as a number of organic acids – malic, oxalic and succinic. Based on data from A. Libutti and A.R. Rivelli (2021), rated biochemical analysis of leaves for the content of ascorbic acid, which is an important quality trait for all leafy vegetable crops, in chard its content ranges from 12.0 to 16.0 mg. Chard leaves contain hydroxycortic acids – caffeic, quinic, chlorogenic, which belong to phenolic compounds and are activators of growth processes. Chard contains water-soluble vitamins, represented by thiamine (B_1), riboflavin (B_2), nicotinic acid (PP), rutin (P), folic acid, and ascorbic acid (C). Fat-soluble vitamins in chard are represented by carotene (provitamin A), tocopherol (E), and phylloquinone (K). The study of the biochemical parameters of chard is necessary for breeding work in order to separate promising varieties from those that are developing intensively.

It is necessary to take into account the main energy costs that are associated with the creation of conditions for photosynthesis, in which absorption reactions occur, the conversion of light quanta into organic substances from carbon dioxide and water with the participation of the photosynthetic pigment chlorophyll. Chard leaves are rich in chlorophylls (A and B), carotenoids, as well as various anthocyanin derivatives, tannins, and rutins. M. Iammarino *et al.* (2022) report that pigments are involved in the absorption and transmission of light to reaction centres and have a protective effect against reactive oxygen species produced during photosynthesis. With a significant content of the above pigments, a decrease in the amount of nitrate content is observed. V. Barone *et al.* (2019) argue that the protective properties of green vegetables are primarily associated with the antioxidant properties of their components: vitamins, flavonoids, anthocyanins, polyphenols, a number of trace elements with antioxidant action, such as selenium, zinc, cuprum, ferum. In vegetable growing, several directions are intensively developing, expanding the range of vegetable products, which makes it possible to form a diet with more harmonious and nutritious substances with a high content of antioxidants. According to M. D'Imperio *et al.* (2019), the use of hydroponic systems and natural biostimulants has become a very attractive option for growing green vegetable crops due to the economic value in terms of reducing fertilizer use and maximizing yields.

CONCLUSIONS

In recent years, there has been an active introduction of new and fairly popular varieties of chard in European countries, among green vegetable crops. Based on the results of three-year studies of the adaptive ability for the period 2020-2022, it can be concluded that the cultivation of chard under greenhouse conditions in the spring turnover from germination to technical ripeness is promising. A detailed study of the products of primary and secondary metabolism makes it possible to determine the compounds that are important for human health, evaluating the indispensability of culture in the daily diet.

Planting seedlings in the spring turnover of closed greenhouses should be carried out in the second half of April according to the 20×15 scheme in closed greenhouses. A wide range of tolerance to growing conditions was noted in the Mercury and Buru varieties; the average range of tolerance is in the varieties Bull's Blood and Bride; a narrow range of tolerance – in the Rubin variety. The duration of the growing season in the spring turnover under the conditions for leaf-type chard was 45-56 days: separately for the Mercury variety – 55 days, the Buru variety – 50 days, the Bull's blood variety – 45 days, the Bride variety – 53 days, the Rubin variety – 55 days. The average yield of sowing chard varieties over a three-year growing period was: for the Mercury variety, 5.27 kg/m^2; Buru – 4.51 kg/m^2; Ruby – 4.86 kg m^2; Bride – 5.09 kg/m^2; Bull's blood – 5.54 kg/m^2. Active accumulation of photosynthesis products in the leaves of most chard varieties took place under the conditions of 2022, especially in the Bull's blood variety – 6.02 kg/m^2. Under saturated light, the content of chlorophylls A and B changed towards equal content regardless of the variety, and total carotene changed depending on the chard variety, mainly with the typical red colour of the stems and leaves of Buru and Bull's blood varieties. In the spring crop rotation, the best properties are shown in red-leaved forms. The conducted accounting of productivity in the cultivation of chard varieties showed a fairly high productivity, while no significant differences due to varietal affiliation were found.

Chard is still little grown on the territory of the Republic of Kazakhstan, but at the same time, the culture has a number of advantages: unpretentious in cultivation, decorative appearance, and most importantly, it has a rich potential for use not only in human nutrition, but also in fodder production. Given the yield data, biometric and biochemical indicators, the studied chard varieties can be recommended for development in agro-formation of all forms of ownership and management in various climatic zones of the Republic of Kazakhstan, with open and closed cultivation.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Анотація. Спосіб вирощування зелених овочевих культур у теплиці, оснащеній сучасними технологіями, дозволяє контролювати вологість, освітленість, температуру, рівень вуглекислого газу, циркуляцію повітря та багато іншого. За допомогою інформаційних та цифрових технологій контролюється швидкість зростання оброблюваних культур, підвищується врожайність, а використання води та ресурсів відбувається більш ефективно, ніж за традиційних методів обробітку. На підставі проведених науково-дослідних робіт у період 2020-2022 рр. за технологією вирощування мангольду посівного в закритих теплицях м. Алмати, Республіки Казахстан, проведено оцінку агробіологічних властивостей, врожайності та адаптивності. Мета статті – вивчення асортименту сортів мангольду посівного та оцінка впливу властивостей ґрунту, температури, освітленості на врожайність, біохімічний склад, біологічну активність. У дослідженнях використовувалися такі методи: лабораторні – які включають моніторинг та оцінку біохімічного складу рослинного матеріалу; біометрії - оцінка параметрів комплексного аналізу середовища та якісних характеристик урожаю; фенології – спостереження за фазами розвитку; статистики – аналіз інформації з оцінки адаптивних можливостей мангольда. Широкий діапазон толерантності до умов вирощування спостерігався у сортів Меркурій та Буру, помірний – у сортів Бича кров та Наречена та більш вузький – у сорту Рубін. У тепличних умовах тривалість вегетації у весняному обороті становила 45-56 днів: сорт Меркурій – 55 днів, Буру – 50 днів, Бича кров – 45 днів, сорт Наречена – 53 дні та Рубін – 55 днів, відповідно. За три роки вирощування середня врожайність мангольду склала сорти Меркурій – 5.27 кг/м^2, Буру – 4.51 кг/м^2, Рубін – 4.86 кг/м^2, Наречена – 5.09 кг/м^2 та Бича кров – 5.54 кг/м^2. У 2022 році у листі більшості сортів мангольда відбувалося активне накопичення фотосинтетичного матеріалу. Зокрема, практичне значення методів вирощування зелених овочів у тепличних умовах, організаційно-економічні процеси тепличного вирощування, вивчення господарсько-біологічних особливостей та врожайності різних сортів мангольду формують стратегію розвитку галузі овочівництва

Ключові слова: сорт; теплиця; біохімічний склад; урожайність; біологічна активність