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Role of breeding in the development of organic vegetable production in Kazakhstan

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Abstract. In the Republic of Kazakhstan, organic vegetable growing is at the initial stage of formation and requires comprehensive scientific support, including the development of specialised varieties and adapted agro-technologies. The aim of this study was to create new varieties of vegetable crops intended for organic farming, possessing a complex of economically valuable traits and adapted to different agro-ecological zones of the country. In the process of breeding research both classical and modern methods were used: obtaining inzucht lines, individual and mass selection, hybridisation, polycross, backcross, induction of polyploidy, formation of parental forms and analysis of parthenocarpy. Experimental work was carried out in a competition nursery where evaluation of 15 varietal samples was organised: 5 samples of onion, 7 of table beet and 3 of sweet pepper. As a result of multifactorial evaluation on a set of traits including yield, resistance to diseases and stresses, marketable qualities and suitability for organic production, the most promising samples were identified: 2 onion varieties, 3 beetroot varieties and 2 pepper varieties. According to the results of three-year field trials, these varieties showed stable performance and were recommended for transfer to the State Variety Trial as organic varieties. Practical significance of the study is to provide organic vegetable production of the Republic of Kazakhstan with highly productive and sustainable varieties that can be used in farming and economic structures of different regions of the country, contributing to food security and sustainable development of the industry

Keywords: organic farming; variety diversity; agroecological adaptation; stress resistance; selection of parental forms; biological features; nutritional value

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Introduction

Vegetables are an integral part of a rational human diet due to their high content of vitamins (particularly C, B, P, provitamin A), organic acids, mineral compounds and biologically active substances. According to the Ministry of Agriculture of the Republic of Kazakhstan (n.d.), in 2023 vegetable crops were cultivated on an area of more than 150 thousand hectares, and the total gross harvest amounted to more than 4.3 million tonnes. At the same time, according to the Bureau of National Statistics (n.d.), the physiological norm of vegetable consumption per person is 126 kg, which forms the domestic demand at the level of 2.52 million tonnes. The actual supply of vegetables exceeds 170 per cent. Despite the high production volumes, there is practically no certified organic vegetable production in Kazakhstan (Grigoruk & Klimov, 2016). The structure of organic agriculture in the country is dominated by grain and oilseed crops. According to estimates of international organisations, organic products in the world are produced by more than 4.3 million agricultural producers in almost 190 countries, with the most developed regions remaining the countries of the European Union and North America (FiBL & IFOAM, 2025). The organic sector is also growing in transition countries.

Organic agriculture is seen as a more sustainable alternative to conventional agricultural production (Dukhnytskyi, 2019). It involves the use of environmentally friendly cultivation methods, avoiding synthetic fertilisers, pesticides and genetically modified organisms (GMOs). According to the study by J. Trap & E. Blanchart (2023), the sustainability of agroecosystems under organic farming is ensured by restoring the natural functions of soil, agrobiocoenosis and minimising the negative impact on the environment. As shown by M. Aliyeva *et al.* (2024), state support and legislative initiatives play a key role in stimulating organic agriculture, as exemplified by the experience of Azerbaijan, where targeted policies have led to a significant increase in the area of certified organic land.

The selection of organic varieties of vegetable crops is of particular importance, as variety is a key element of agro-technology in the conditions of organic production. As shown by the work of S. Singh *et al.* (2024), the use of varieties resistant to diseases and stresses can significantly reduce or completely eliminate the use of chemical plant protection products. Thus, organic varieties should have high plasticity, adaptability to different soil and climatic conditions and increased nutritional value. As noted by O. Clausen & L. Patryeva (2021), the motivation of consumers to purchase organic products is its safety, environmental purity and high biological value. In the conditions of Kazakhstan, the development of organic vegetable production can become not only a factor of food security, but also a competitive advantage in international markets.

Research on the development of organic vegetable production requires scientific support, including agrochemical assessment of soils, selection of biological plant protection products, introduction of drip irrigation systems and development of adapted varieties. Special attention should be paid to breeding aimed at developing non-GMO varieties with integrated resistance and nutraceutical properties (Hamdan & Tan, 2024). In addition, there is already considerable potential in the production practices of Kazakhstan in the form of local varieties suitable for organic vegetable production. Nevertheless, expansion of breeding programmes oriented specifically towards organic farming systems is required. This is due to the need to replace imported varieties adapted to other climatic conditions with local varieties with resistance to local pathogens and climatic stresses. In this context, the study of A. Aidarova *et al.* (2024) emphasised the relevance of rational land use and introduction of organic and biological technologies in Kazakhstan, especially in the context of land degradation, which demonstrates the synergistic potential for improving the efficiency of the agricultural sector and landscape condition.

The aim of this work was to develop new organic varieties of vegetable crops, plastic to different agro-ecological conditions of the Republic of Kazakhstan, with a complex of economically valuable and nutraceutical traits.

Materials and Methods

Field breeding research was carried out on the basis of the Kazakh Research Institute of Fruit and Vegetable Growing (regional branch "Kainar") in the foothill zone of the south-east of the Republic of Kazakhstan. The trials were carried out during three growing seasons – from March to October in 2021, 2022 and 2023. Soils of the study area were represented by dark chestnut soils of medium loamy granulometric composition. Soil volume mass was 1.1-1.2 g/cm^3. The arable horizon contained 2.9-3.0% humus, 0.18-0.20% total nitrogen, 0.19-0.20% gross phosphorus, 2.2-2.4% gross potassium. The cation exchange capacity was at 20-21 mg-eq per 100 g of soil. The reaction of soil solution was slightly alkaline (pH 7.1-7.3).

The climate of the zone is characterised by sharp continentality. Mean monthly temperatures in July varied within +22 ... +24°C, and in January – from -6 to -10°C. The sum of active temperatures during the vegetation period reached 3,450-3,750°C. The duration of the frost-free period ranged from 140 to 170 days. Annual precipitation varied from 350 to 600 mm. The hydrothermal coefficient was between 0.7 and 1.0 (Kazhydromet, n.d.). Table 1 provides information on monthly climatic averages for the study period.

Table 1. Average monthly climatic indicators in the foothill zone of south-eastern Kazakhstan for 2021-2023 years

Month	Average temperature, °C	Precipitation, mm	Average humidity, %
March	5.4	45	65
April	12.3	55	60
May	18.7	62	58
June	22.5	48	52
July	24.3	38	48
August	23.9	36	50
September	18.2	40	55
October	11	32	60

Source: compiled by the authors based on the data from Kazhydromet (n.d.)

The objects of the study were 15 varieties of vegetable crops, including 5 samples of onion (*Allium cepa*), 7 samples of table beetroot (*Beta vulgaris*) and 3 samples of sweet pepper (*Capsicum annuum*). Sowing was carried out at the end of March manually in the open ground with row spacing of 45 cm, repeated three times. The area of one plot was 5 m^2. Organic cultivation system was used: mineral fertilisers and chemical plant protection products were not used, the soil was enriched with biohumus and siderates. Breeding work included individual and mass selection methods, hybridisation, polycross, backcross, inzucht lines, and induction of polyploidy. Parthenocarpy was studied using Accelerated Plant Breeding techniques (Gosal & Wani, 2020). The trials were conducted according to the recommendations of UPOV (1961). All procedures were documented in accordance with the recommendations for the breeding process (Law of the Republic of Kazakhstan No. 422-I, 1999).

For sweet pepper, 3 promising varieties were studied in the nursery of competitive trial on the complex of economically valuable traits. The seedlings of pepper varieties were grown in the selection greenhouse of the Russian Federation "Kainar", by the time of planting pepper plants had 7-8 leaves, well-developed root system, seedling height – 25-30 cm. The evaluation of sweet pepper varieties was carried out according to the parameters of plasticity and stability of the variety. As source material for research were taken 2 varieties of sweet pepper and 3 promising varieties of domestic selection – Bayan Sulu and Safiya-1818, No. 2806 (promising), No. 1105 (promising), No. 2212 (promising), the standard was approved for use variety Safiya-1818. During the vegetation of sweet pepper, biometric measurements were carried out to observe the growth and development of plants in dynamics.

Onions for the creation of organic varieties, plastic to different agro-ecological conditions of Kazakhstan, with a complex of economically valuable traits, including nutraceutical, was laid nursery competitive trial. Biometric surveys on onion varieties in the nursery of competitive trial were conducted in the phase of mass growth of leaves in the 2nd decade of July. Morphological traits such as number of leaves, leaf length, leaf width and leaf surface area were studied. The yield of onion varieties was measured at the stage of technical ripeness. The yield from each plot was weighed in the field and the following parameters were calculated from this data:

- total yield (t/ha) – calculated as the ratio of the total weight of harvested crop to the whole plot area, converted per hectare;
- marketable yield (t/ha) – determined by weighing the marketable produce (without small, damaged and deformed bulbs), also converted per hectare;
- marketable yield (%) – calculated as the ratio of marketable yield to total yield and then multiplied by 100;
- weight of marketable bulb (g) – determined by the average weight of 30 typical bulbs from the sample;
- disease damage (%) – recorded visually by the presence of disease symptoms (rot, mould, bacteriosis) on 100 randomly selected bulbs. Results were presented as the proportion of affected specimens in the sample;
- pest damage (%) – determined similarly by visual indication of the presence of damage from soil and ground pests. Frequency and severity of damage were also recorded.

The assessment was carried out in threefold repetition, on the basis of which the mean values of indicators were calculated. Reliability of differences was assessed by analysis of variance (ANOVA), critical level of significance was $p < 0.05$.

Five new onion cultivars of different genetic nature were evaluated in a competitive variety trial nursery. All evaluated onion samples were compared with the standard variety Mereke. Phenological observations, biometric measurements and yield records were carried out. Morphological, phenological and productive parameters: fruit/root weight, disease resistance, yield, levelling and storage were used to evaluate the results. Statistical processing of data was carried out using standard methods of analysis of variance (ANOVA) with 95% confidence interval and significance criterion $p < 0.05$. Calculations were performed in Statistica 10.0 software.

For selective evaluation of economically valuable traits of 7 varieties of table beet (*Beta vulgaris* L.) under organic farming conditions, a competitive nursery was established on the basis of the Kazakh Research Institute of Fruit and Vegetable Growing (KazRIPO) (regional branch "Kainar"). The seed material consisted of collection and breeding samples that had previously passed inventory and laboratory tests for sowing qualities, including determination of germination energy, germination and weight of 1,000 seeds. All 7 table beet varieties studied were compared with the standard variety Kyzylkönkyr. Based on the obtained data, the seeding rate for field trials was calculated. Sowing was carried out in the first decade of May. Ridge wide-band planting scheme with row spacing of 70 cm was used. Repetition of the experiment was three times, the area of one plot was 5 m². All agrotechnical measures were carried out in accordance with the principles of organic farming: mineral fertilisers and chemical means of plant protection were not used. The soil was pre-fertilised with biohumus, and mechanical methods of cultivation were used to control weeds.

Phenological observations, morphological evaluation and yield records were carried out in accordance with the state variety evaluation methodology and FAO & ISTA (2023) recommendations. Morphological traits to be studied included: shape and colour of rootlets, ring expression, presence of head corking, colour and consistency of flesh. Yield was evaluated by gross weight, weight of marketable root crops, degree of marketability (%), weight of one marketable root crop (g), as well as by yield structure (proportion of underharvested, cracked, ugly, pest-damaged and disease-affected root crops). All measurements were carried out on a sample of at least 30 plants of each cultivar, followed by statistical processing of the data (mean, HCP05, precision, coefficient of variation).

Results and Discussion

Mass sprouting of onion was obtained on day 17-19 after sowing. The number of days from mass sprouting to leaf lodging was 81-85 days. In samples 02-12(2) and 05-24, the vegetation period from mass sprouting to harvesting was 134 days, i.e. they belonged to the medium maturity group. Samples 959-9, 1440 and 1588 belong to the medium-late ripeness group by the number of days from mass sprouting to harvesting – 136, 137 and 138 days. The study of interphase periods of growth and development of varietal samples of competitive nursery are given in Table 2, and the dynamics of leaf surface development – in Table 3.

Table 2. Duration of the vegetation period of onion cultivar samples

Onion variety	Number of days from sowing to sprouting	Number of days from mass sprouting to		
		bulb formation	leaf lodging	harvesting
Mereke, standard	18	81	123	130
02-12 (2)	19	81	127	134
05-24	19	84	128	134
959-9	17	82	129	136
1440	18	85	130	137
1588	17	83	132	138

Source: compiled by the authors according to the data of field variety trial of KazNIIPO (regional branch "Kainar"), 2021-2023

Table 3. Leaf surface development in onion varieties of the competitive trial

Varieties, onion varieties	Number of leaves on the plant, pcs	Average length leaf, cm	Average leaf width, cm	Leaf area, cm²
Mereke standard	10.5	43.6	1.3	868.9
02-12(2)	10.3	44.4	1.2	867.99
05-24	10.8	45.4	1.3	930.62
959-9	11.2	47.3	1.5	1,160.1
1440	11.4	45.9	1.3	993.14
1588	10.1	43.2	1.4	891.83

Source: compiled by the authors according to the data of biometric measurements in the nursery of competitive trial KazNIIPO (regional branch "Kainar"), 2021-2023

Onion varieties 959-9 and 1440 had the largest number of leaves – 11.2-11.4 pieces, the standard Mereke had 10.5 pieces of leaves. In terms of leaf length, the studied samples differed slightly from the standard. The longest leaves were in variety 959-9 (47.3 cm). In terms of leaf area, samples 05-24 (930.62 cm²), 959-9 (1,160.1 cm²) , 1440 (993.14 cm²) differed from the standard in terms of leaf area (868.9 cm²). The economic and useful properties of the evaluated onion varieties in the competitive trial nursery are given in Table 4.

Table 4. Characteristics of onion varieties in the competitive trial nursery

Varieties, varieties onion	Yield, t/ha		Increase marketable yield, %	Marketable yield yield, %	Weight of marketable bulb, g	Disease damage, %	Damage pests pests, %
	total	marketable					
Mereke standard	33.4	29.4	–	87.9	115	0.6	0.2
02-12(2)	38.1	33.1	112.6	87.0	118	–	0.1
05-24	38.4	35.0	119.2	91.0	125	0.3	0.1
959-9	38.8	36.3	123.5	93.4	130	–	–
1440	37.6	34.2	116.4	90.8	123	–	–
1588	38.5	34.4	117.1	89.3	120	0.5	0.3

Source: compiled by the authors based on the results of yield records and phytosanitary assessment in field conditions KazNIIPO (regional branch "Kainar"), 2021-2023

All evaluated onion samples had a significant increase in marketable yield (12.6-23.5%) compared to the standard variety Mereke. The highest yield increase (23.5%) was in variety 959-9. High marketability of yield (90.8-93.4%) was observed in samples 1440, 05-24, 959-9. Onion disease damage in 2 samples was insignificant – 0.3-0.5%, here samples 02-15(2), 959-9 and 1440 were resistant. As a result of evaluation in the nursery of competitive trial on economic-valuable traits, 2 varieties were identified: 05-24 and 959-9. These samples will be further studied, multiplied and according to the results of 3-year evaluation 1 best sample will be transferred as an organic onion variety to the State Variety Trial and proposed for organic vegetable production.

Morphological features of table beet varieties were investigated in the nursery of the competitive trial. Morphological features of plants determine their resistance to biotic and abiotic environmental factors, responsiveness to agro-technological methods, intensity of formation and size of future crop yield. This is especially important for vegetable crops, including table root crops, which by their biological characteristics are very sensitive to all environmental factors and agro-technological methods. Plant morphological traits are individual and reflect the adaptive potential of each variety. In the present study, morphological characteristics of vegetative biomass and product organs of the studied table beet cultivars were evaluated. The obtained data are summarised in Tables 5 and 6. According to the obtained data, all the studied table beet samples differed significantly from each other in structure, shape, colour and other indicators of their organs.

Table 5. Morphological characteristics of rootlets in different table beet varieties in the competitive trial nursery

Varieties of table beet	Shape of longitudinal section	Base shape	Head pollination characteristic	External colouring	Basic colouring of pulp	Intensity of basic colouring	Expression of rings
Kyzylkönkyr	rounded	rounded	medium	red	red	medium	medium
VR 1230	rounded	rounded	medium	red	red	dark	weak
VR 1229	rounded	rounded	medium	red	violet	medium	mild-medium
VR 1216	rounded	rounded	weak	red	red	dark	weak
VR 1209	rounded-oval	pointed	medium	red	red	dark red	medium
VR 1150	rounded	rounded	medium	red	red	dark	weak
VR 1148	rounded	rounded	weak	red	red	dark	very weak
VR 1140	rounded	rounded	weak	red	red	dark red	weak

Source: compiled by the authors according to the data of morphological evaluation of samples in field conditions KazNIIPO (regional branch "Kainar"), 2021-2023

Root crops of different varieties of table beet differed significantly from each other in morphological features (Table 6). Root skin colour of the studied samples was of different shades and differed significantly among the cultivars. In most of the samples, the intensity of the basic colour was dark and dark red, and the expression of rings was weak. The main colour of the flesh of varietal samples was mainly red, only one sample (VR 1229) had a violet tint. Root head sampling in cultivars VR 1140, VR 1148, VR 1216 was weak, while in the other four accessions it was medium. In the study of S. Rakutko *et al.* (2022) noted that for obtaining high yields of table beet under organic production, the shape and intensity of colour of root crops plays an important role, which is consistent with the identified characteristics of sample BR 1229 in the conducted experiment.

Table 6. Yield data of table beet varieties in the competition nursery

Table beet varieties	Gross yield, t/ha	Marketable yield, t/ha	Yield merchantability, %	Weight of marketable root crop, g
BR 1230	18.3	12.3	67.3	108
BR 1229	24.2	15.5	64.4	172
BR 1216	26.2	17.5	66.7	124
BR 1209	52.1	34.9	67.0	265
BR 1150	16.6	8.7	52.1	121
BR 1148	19.9	16.0	80.4	102
BR 1140	31.0	26.2	84.6	161
Kyzylkönkyr (st.)	46.3	42.4	91.6	229
$NDS05._{05}$, t/ha	2.3	1.9	6.72	–
Experimental accuracy, %	2.5	2.7	3.12	–

Note: accuracy of the experiment (%) – the indicator of repeatability of results, calculated as the ratio of standard deviation to the mean value, multiplied by 100; NSR05 (the smallest significant difference) – the minimum value of the difference between the variants, considered statistically significant at the significance level $p < 0.05$

Source: compiled by the authors on the basis of field experience KazNIIPO (regional branch "Kainar"), 2021-2023

Root yield of all studied varieties of table beet (64.4-84.6%) was lower than that of the standard variety Kyzylkönkyr (91.6%). All varieties of table beet competitive nursery after harvesting laid on storage in cold storage chambers of the Institute for further research. In table root crops, including table beetroot, the yield structure is important. Therefore, the yield structure of root crops in the studied cultivars was evaluated (Table 7). Root galls (small, underdeveloped) in the table beet competition nursery were observed in all cultivars. There were no rootstocks affected by galls in the nursery. Damage of rootlets by soil pests was found only in variety BR 1209 – 2.5%, it had a lot of cracked rootlets – 24.5%. Root crops with ugly forms were noticed only in sample BR 1229 – 10.8%. No deviation from the main variety was observed in all table beet samples.

Table 7. Root yield structure of table beet varieties evaluated in the competitive selection nursery (trials)

Table beet varieties	Root rot, %	Rots, %	Damaged by pests, %	Cracked, %	Ugly	Deviation from the main grade, %
Kyzylkönkyr	8.4	0.0	0.0	0.0	0.0	0.0
VR 1230	32.7	0.0	0.0	0.0	0.0	0.0
VR 1229	35.6	0.0	0.0	0.0	10.8	0.0
VR 1216	22.5	0.0	0.0	0.0	0.0	0.0
VR 1209	6.0	0.0	2.5	24.5	0.0	0.0
VR 1150	47.9	0.0	0.0	0.0	0.0	0.0
VR 1148	19.6	0.0	0.0	0.0	0.0	0.0
VR 1140	15.4	0.0	0.0	0.0	0.3	0.0

Source: compiled from data of yield structure evaluation in field conditions KazNIIPO (regional branch "Kainar"), 2021-2023

Thus, in 2024 in the competitive nursery of table beet 7 varieties were evaluated, of which the best economic-value indicators were noted in 3 varieties – BR 1229, BR 1209 and BR 1140. To obtain high and stable yields of vegetables, it is necessary to have information about the degree of adaptability of varieties and hybrids of vegetable crops to a particular soil and climatic zone of their cultivation. The results of the field experiment on varietal testing of sweet pepper were analysed (Tables 8, 9, 10). The studied sweet pepper varieties proved to be medium-maturing: the period from sprouting to maturity – 128-177 days. Phenological phases from sprouting to flowering were marked by 73-79 days. The earliest flowered variety Safiya-1818, 73 days from mass sprouting. Bayan Sulu variety showed flowering at 76 days, variety No. 2806 at 79 days, variety No. 1105 at 76 days, and variety No. 2212 at 78 days from seedlings. The flowering-ripening period was 60-64 days, while the sprouting-ripening period was 128-137 days (Table 8).

Table 8. Phenological parameters of sweet pepper varieties

No.	Variety, hybrid of sweet pepper	Number of days			Groups of ripeness
		sprouting – flowering	flowering – ripening	sprouting – beginning ripening	
1	No. 2806 (promising)	79	64	137	medium-maturing
2	No. 1105 (promising)	76	60	129	medium-maturing
3	No. 2212 (promising)	78	63	131	medium-maturing
4	Bayan Sulu	76	61	132	medium-maturing
5	Safiya-1818 st. (standard)	73	60	128	medium-maturing

Source: compiled by the authors according to the data of yield structure assessment in field conditions KazNIIPO (regional branch "Kainar"), 2021-2023

Table 9. Biometric parameters of sweet pepper varieties (2024)

No.	Varieties of sweet pepper	Beginning of fruiting (technical ripeness)			
		Plant height, cm	Number of leaves, pieces	Number of flowers, pieces	Number of fruits, pieces
1	No. 2806 (promising)	78-90	71	12	8
2	No. 1105 (promising)	87-98	69	14	7
3	No. 2212 (promising)	89-97	67	15	10
4	Bayan Sulu	65-68	68	10	7
5	Safiya-1818 st. (standard)	68-72	70	12	8

Source: data of field observations and measurements of KazNIIPO, Vegetable Crops Breeding Department, 2024

Plant height of variety No. 2806 was 78-90 cm, No. 1105 – 87-98 cm, No. 2212 – 89-97 cm, Bayan Sulu – 65-68 cm, Safiya-1818 – 68-72 cm. The highest foliage was observed in variety No. 2806, the number of leaves was 71 pieces, the number of flowers in this sample was also higher – 12 pieces. At the beginning of technical ripeness the number of fruits was 7-10 pieces, the largest number of fruits was observed on the sample No. 2212.

Table 10. Yield and yield structure of sweet pepper varieties and samples

No.	Variety, varietal sample of sweet pepper	Total yield, kg/m^2	Share in %		Fruit weight, g
			technical technical ripeness	biological ripeness	
1	No. 2806 (promising)	21.8	35.4	59.7	270-360
2	No. 1105 (promising)	21.7	44.0	60.0	170-250
3	No. 2212 (promising)	20.6	38.6	61.3	180-225
4	Bayan Sulu	19.0	36.3	58.6	150-210
5	Safiya-1818 st. (standard)	20.2	33.8	64.1	250-300

Source: results of field trials at the Kazakh Research Institute of Fruit and Vegetable Growing, 2024

Yield of fruits above the control was formed by varieties No. 2806 (21.8 kg/m^2), No. 1105 (21.70 kg/m^2), the yield of variety No. 2212 was at the level of the standard – 20.6 kg/m^2, slightly lower compared to the control was the yield of variety Bayan Sulu – 19.0 kg/m^2, the standard yield was 20.2 kg/m^2 (Table 10). According to the number of fruits in biological ripeness to harvesting varieties and hybrids of sweet pepper can be divided into early-ripening: the proportion of fruits in biological ripeness more than 64.1% was observed in the variety Safiya-1818. In terms of fruit weight, all the evaluated pepper varieties can be classified as large-fruited, with a weight of more than 250 g. The largest fruit was sample No. 2806, which had a weight of 1 fruit up to 360 g. Fruit weight in most varieties and hybrids of sweet pepper depends on growing conditions. Lower air temperature during the period of fruit formation favours the setting of more fruits and a decrease in fruit weight. According to the results of the 3-year evaluation, the best variety of sweet pepper selected for the complex of economically valuable traits will be transferred as a new organic variety to the State Variety Trial.

The results obtained during the study demonstrate the significant potential of breeding organic varieties of vegetable crops for the conditions of Kazakhstan. High yields and quality of the developed varieties of onion, table beet and sweet pepper, grown without the use of synthetic fertilisers and pesticides, confirm the fundamental possibility of developing organic vegetable production in the region (Karamatov, 2021). These data are consistent with the general trends of global organic agriculture, which is actively developing as a response to the growing consumer demand for safe and environmentally friendly products, as well as in the

context of the search for sustainable agricultural practices (Zhang *et al.*, 2024). Many studies emphasise that organic farming practices improve soil health, increase biodiversity and reduce negative environmental impacts compared to conventional systems (Tuomisto *et al.*, 2012; Biswas *et al.*, 2014; Nghia *et al.*, 2025).

In particular, the successful adaptation of developed varieties to local soil and climatic conditions demonstrated in this study is a critical aspect. Resistance to abiotic and biotic stresses, achieved through targeted breeding, can minimise yield losses and reduce dependence on external influences, which is particularly relevant for organic systems, as indicated in the study by M. González Guzmán *et al.* (2022). This confirms the importance of genetic diversity and the development of local varieties that are better adapted to the specificities of the region. One of the aspects identified was the possibility of obtaining varieties with improved nutraceutical properties. The increased content of vitamins and other bioactive substances in organic produce is one of the main motivations for consumers. Research suggests that organic growing methods may favour the accumulation of certain beneficial compounds in plants, although this issue requires further study and depends on multiple factors, say researchers X. Zhao *et al.* (2006) and G. Feliziani *et al.* (2025) The development of such a direction of breeding is promising for improving the competitiveness of Kazakhstani organic products in domestic and international markets.

Despite the positive results obtained, further development of organic vegetable production in Kazakhstan requires a comprehensive approach. It is necessary to take into account economic barriers, such as high costs of certification and marketing of organic products, which may restrain the wide introduction of these methods (Khasanov & Kirchner, 2024). The development of effective agrochemical soil assessment systems and the selection of biological plant protection products also remain important challenges. Overall, this study lays the foundation for further breeding programmes aimed at developing high-yielding, resistant and nutritionally valuable organic varieties of vegetable crops that contribute to sustainable agricultural development in Kazakhstan.

Conclusions

The conducted breeding research in the conditions of Kazakhstan was aimed at the creation of new organic varieties of vegetable crops, resistant to different agro-ecological conditions and possessing a complex of economically valuable and nutraceutical traits. As part of the work in the nursery of competitive variety testing were studied 15 varieties: 5 – onions, 7 – table beetroot and 3 – sweet pepper. According to the results of research among onion varieties, the best performance showed the samples 05-24 and 959-9. Sample 959-9 was distinguished by high marketable yield (36.3 tonnes/ha), the largest leaf area (1,160.1 cm^2), as well as resistance to diseases and pests. Variety 05-24 stood out for its high bulb weight (125 g) and marketability (91.0%). These samples will be pre-tested and if the results are positive, one of them will be recommended as an organic variety for inclusion in the State Register.

Among the table beet samples, BR 1229, BR 1209 and BR 1140 were the leaders. BR 1209 was particularly notable for its highest gross yield (52.1 tonnes/ha), marketable root weight (265 g) and pest resistance. Sample BR 1140 had the highest marketability of 84.6 per cent. These varieties are characterised by pronounced adaptive traits and are suitable for organic vegetable production. For sweet pepper, the samples No. 2806 and No. 1105 were recognised as promising, showing yields above the standard, good plasticity, large fruitfulness (up to 360 g) and a high percentage of biological ripeness. Thus, the practical significance of the work lies in the selection of stable and productive genotypes suitable for organic farming. Prospects for research include in-depth biochemical and molecular evaluation of the isolated samples, as well as the development of elements of organic cultivation technology for implementation in agropractice.

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Conflict of Interest

None.

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Казакстанда органикалык жашылча өстүрүүнү өнүктүрүүдөгү селекциянын ролу

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Аннотация. Казакстан Республикасында органикалык жашылча өстүрүү азырынча калыптануу стадиясында болуп, атайын сортторду чыгарууну жана адаптацияланган агротехнологияларды иштеп чыгууну камтыган комплекстүү илимий колдоону талап кылат. Бул изилдөөнүн максаты – органикалык дыйканчылык үчүн арналган, чарбачылыкка пайдалуу белгилердин комплекси бар жана өлкөнүн ар түрдүү агроэкологиялык зоналарына ылайыкташкан жаңы жашылча өсүмдүктөрүнүн сортторун жаратуу болгон. Селекциялык изилдөөлөрдүн жүрүшүндө классикалык жана заманбап ыкмалар колдонулган: инцухт-линияларды алуу, индивидуалдык жана массалык тандоо, гибриддештирүү, поликросс, беккросс, полиплоидияны индукциялоо, аталык-энелик формаларды түзүү жана партенокарпияны талдоо. Эксперименттик иштер сынак питомнигинде жүргүзүлүп, 15 торттун туруктуулугу бааланган: 5 баштык пияз, 7 баштык кызылча жана 3 баштык таттуу калемпир. Көп факторлуу баалоонун жыйынтыгында, түшүмдүүлүк, ооруларга жана стресс факторлорго туруктуулук, товардык сапаттар жана органикалык өндүрүшкө жарактуулугу сыяктуу көрсөткүчтөрдүн жыйындысы боюнча эң перспективалуу үлгүлөр бөлүнүп чыккан: 2 пияз сорту, 3 кызылча сорту жана 2 калемпир сорту. Үч жылдык талаа сыноолорунун негизинде бул сорттордун туруктуу көрсөткүчтөрдү көрсөтүп, органикалык сорт катары Мамлекеттик сорт сыноого өткөрүү үчүн сунушталган. Изилдөөнүн практикалык мааниси – Казакстан Республикасынын органикалык жашылча өстүрүү тармагын жогорку түшүмдүү жана туруктуу сорттор менен камсыз кылууда, алар өлкөнүн ар кандай аймактарындагы фермердик жана чарбалык түзүмдөрдө колдонулуп, азык – түлүк коопсуздугуна жана тармактын туруктуу өнүгүшүнө өбөлгө түзөт

Негизги сөздөр: органикалык дыйканчылык; сорттук ар түрдүүлүк; агроэкологиялык ылайыкташуу; стресске туруктуулук; аталык-энелик формаларды тандоо; биологиялык өзгөчөлүктөр; азыктуулук баалуулугу

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Аннотация. В Республике Казахстан органическое овощеводство находится на начальном этапе становления и требует комплексной научной поддержки, включая выведение специализированных сортов и разработку адаптированных агротехнологий. Целью настоящего исследования было создание новых сортов овощных культур, предназначенных для органического земледелия, обладающих комплексом хозяйственно-ценных признаков и приспособленных к различным агроэкологическим зонам страны. В процессе селекционных исследований применялись как классические, так и современные методы: получение инцухт-линий, индивидуальный и массовый отбор, гибридизация, поликросс, беккросс, индукция полиплоидии, формирование родительских форм и анализ партенокарпии. Экспериментальная работа проводилась в конкурсном питомнике, где была организована оценка 15 сортообразцов: 5 образцов лука репчатого, 7 – столовой свеклы и 3 – сладкого перца. В результате многофакторной оценки по совокупности признаков, включая урожайность, устойчивость к болезням и стрессам, товарные качества и пригодность к органическому производству, были выделены наиболее перспективные образцы: 2 сорта лука, 3 сорта свеклы и 2 сорта перца. По итогам трехлетних полевых испытаний эти сортообразцы показали стабильные показатели и рекомендованы к передаче на Государственное сортоиспытание как органические сорта. Практическая значимость исследования заключается в обеспечении органического овощеводства Республики Казахстан высокопродуктивными и устойчивыми сортами, которые могут быть использованы в фермерских и хозяйственных структурах различных регионов страны, способствуя продовольственной безопасности и устойчивому развитию отрасли

Ключевые слова: органическое земледелие; сортовое разнообразие; агроэкологическая адаптация; устойчивость к стрессам; отбор родительских форм; биологические особенности; питательная ценность