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Cultivation of peas, *Pisum sativum* L. in organic farming

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ABSTRACT

Pea, *Pisum sativum* L. is a popular legume crop, the advantage of which is that nitrogen accumulates in the soil after its cultivation. It requires less nitrogen fertilizers, since nodule nitrogen-fixing bacteria are found on the roots of the crop. The study aimed to evaluate the effect of biological and chemical preparations on the yield and content of heavy metals in peas. The Aksaisky Usatyi 55 pea variety was selected, characterized by the drought and heat resistance. In total, two experiments were conducted. Experiment 1 included sowing peas with the introduction of organic manure at a calculated dose of 10 ton ha^{-1}. Biometric indicators of pea plants corresponding to the characteristics of the variety were recorded. On average the vegetation period took 94 days, and the height of the plants by the ripening phase was 50.9 cm. *Boraginaceae*, *Asteraceae*, *Convolvulaceae*, *Poaceae*, *Amaranthaceae*, *Euphorbiaceae*, and *Plantaginaceae* represented the weed families. According to the weed estimation scale, the weed infestation was slight or negligible. The yield of peas ranged from 12.5 to 17.0 c ha^{-1}, the maximum yield was obtained in the variant using the Baikal EM-1 biological preparation (17.0 c ha^{-1}), compared to the control variant (12.5 c ha^{-1}). The pea quality ranged from 16.4 to 18.5%; the carbohydrate content from 67.7 to 69.5%; fiber from 3.8 to 4.9%; fat from 0.7 to 1.6%; and ash from 1.9 to 2.8%. The heavy metal content was within the maximum permissible concentration. The heavy metal content in peas ranged from 0.79 to 46.0 mg kg^{-1}, in the control variant from 0.60 to 40.64 mg kg^{-1}, with the use of chemicals from 1.20 to 46.0 mg kg^{-1}, and with the use of biological preparations from 0.92 to 40.72 mg kg^{-1}.

Keywords: Plant, Biometric indicators, Heavy metal content, Organic farming, Pea crop, Weed infestation.
Article type: Research Article.

INTRODUCTION

Nowadays, food systems put enormous pressure on ecosystems (Willett *et al.* 2019). The complex task of protecting ecosystems while ensuring sustainable nutrition for the world's population has attracted increasing attention in recent years (Röös *et al.* 2021). Over the past decades, there has been a steady increase in the production and consumption of environmentally friendly food grown in clean areas without the use of mineral fertilizers, pesticides, and other man-made actions all over the world (Wu *et al.* 2020; Nassif *et al.* 2023). The production of high-quality agricultural products is one of the most important tasks of the crop industry (IFOAM 2008; Kantarbayeva *et al.* 2017; Kuldybayev *et al.* 2021). An equally important circumstance is the need to preserve soil fertility, maintain the ecological purity of agricultural production, and conserve resources (Bekezhanov *et al.* 2021; Al- Abbasi *et al.* 2022; Yesmagulova *et al.* 2023). To use the potential of the natural fertility of soils and plants in Kazakhstan, it is necessary to introduce adaptive forms of crop production (Aipeisova *et al.* 2023) where through the use of reproducible resources of biological communities (plant and microbial systems), plants are provided with basic nutrition elements and stress resistance (Serekpayev *et al.* 2016). One such element of organic farming is the agrocenosis of legumes with nodule bacteria, which do not enter antagonistic relations and complement each other (Willer & Lernoud 2019). In the future, the construction of

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agrobiocenoses on a biological basis will allow for moving from modern chemical agriculture to the employment of biological mechanisms for plant nutrition, where microorganisms play an important role in fixing atmospheric nitrogen, which is of particular importance due to the increased anthropogenic impact on agroecosystems (Kiselev *et al.* 2018). Organic agriculture is developing globally. Environmentally safe products are grown in North America where 3.0 million ha are occupied by organic production, followed by Latin America (6.5 million ha), African countries (1.2 million ha), Asian countries (3.4 million ha), and the USA (2.2 million ha). In terms of areas allocated for organic agriculture, Europe, Australia and Oceania take the lead with 11.5 and 17.3 million ha, respectively (Commission Regulation of EC 2020). Land and climatic resources and folk traditions of growing crops with the maximum use of natural factors predetermine huge opportunities for the development of organic farming. The production of organic products in Kazakhstan is mainly concentrated in Akmola, Aktobe, Kostanay, and North Kazakhstan regions, where more than 300 thousand ha are used for organic production. The number of producers interested in the transition to organic agriculture in Kazakhstan is constantly growing. In the Kostanay region, more than 200 thousand ha of land is used to produce organic products. The main crops grown there are cereals and oilseeds exported to other countries. Large enterprises manufacturing organic products are mainly farms from the Fedorovsky district: Zharkol 007 LLP, Galant LLP, Kvart farm, Bekseitov farm, Metelitsa farm, and Kovrizhnykh farm engaged in processing, crop production, and cultivation of cereals and oilseeds (Grigoruk & Klimov 2020). According to the statistical data, the main cultivated crops are cereals, oilseeds, and to a lesser extent legumes. In the EU, pea, *Pisum sativum* L. is grown for export everywhere. It is the second most important crop after the common bean (*Phaseolus vulgaris* L.) grown on an area of 6.18 million ha with a total grain production of 10.48 million ton (Brijbhooshan *et al.* 2017). It is cultivated in 84 countries, of those, Canada, Russia, China, India, the USA, Ukraine, and France are important. Canada is the world's largest producer and exporter of green and yellow peas. In India, pea fields occupy 0.74 million ha, which annually yields 0.62 million ton of seeds with an average productivity of 850.3 kg ha^{-1}. The Kostanay region has territories favorable to produce environmentally safe products. Pea is a popular legume crop, the advantage of which is that after its cultivation, nitrogen accumulates in the soil (Singh *et al.* 2015; Kosev, & Naydenova 2015). The pea requires less nitrogen fertilizers, since nodule nitrogen-fixing bacteria are found on the roots of the crop. The study aimed to evaluate the effect of biological and chemical preparations on the yield and heavy metal (HM) content in peas.

MATERIALS AND METHODS

Location of the study

Our experimental studies were conducted in the Zarechnoye Agricultural Experimental Station LLP, Kostanay region (53.23888211491722, 63.73831986581824) at the station of the Department of Agronomy, A. Baitursynov Kostanay Regional University, Kostanay, Kazakhstan. The biochemical composition of grain was determined in the Republican Agrochemical Service in the Laboratory for Grain Technological Features Evaluation. The area of the experimental site was 10 ha. The placement of variants in experiments was systematic with a sequential arrangement of repetitions.

Soils at the experimental site

80 soil samples taken from the experimental site corresponded to the Southern Chernozem. The nutrient contents were as follows: humus: A 0-26: 4.82%, B_1 55-87: 3.72%, B_2 55-87: 2.84%, BC 87-105: 1.17%; nitrate nitrogen ($N\text{-}NO_3$): A 0-26: 14.4 mg kg^{-1}, B_1 55-87: 5.5 mg kg^{-1}, B_2: 3.2 mg kg^{-1}, BC 87-105: 2.1 mg kg^{-1}. The soil had a pH of 7.2.

Physicochemical parameters: mobile forms of phosphorus (P_2O_5): A 0-26: 23.3 mg kg^{-1}; B_1 55-87: 23.1 mg kg^{-1}, B_2 55-87: 16.5 mg kg^{-1}, BC 87-105: 14.4 mg kg^{-1}; exchangeable potassium (K_2O) A 0-26: 604 mg kg^{-1}, B_1 55-87: 580 mg kg^{-1}, B_2 55-87: 520.2 mg kg^{-1}, BC 87-105: 480.4 mg kg^{-1}.

Absorbed bases per 100 g of soil: Ca^{2+}: A 0-26: 37.4 mg eq^{-1}, B_1 55-87: 31.2 mg eq^{-1}, B_2 55-87: 28.2 mg eq^{-1}, BC 87-105: 24.1 mg eq^{-1}; Mg^{2+}: A 0-26: 1.3 mg eq^{-1}, B1 55-87: 2.5 mg eq^{-1}, B2 55-87: 5.2 mg eq^{-1}, BC 87-105: 7.5 mg eq^{-1}; Na^{+}: A 0-26: 0.369 mg eq^{-1}, B_1 55-87: 0.27 mg eq^{-1}, B_2 55-87: 0.13 mg eq^{-1}, BC 87-105: 0.11 mg eq^{-1}.

Meteorological conditions during the study period

When conducting organic farming, climate and soil types are the most crucial natural conditions. The features of the external environment are involved in the formation of the crop as suppliers of heat and moisture used by plants and accumulated by the soil. In particular, the climate of the Kostanay region is characterized as continental with warm summers and cold winters, uniform humidification, and strong changes in weather elements in a relatively short period. A comparative analysis of bioclimatic resources was carried out according to the following parameters: annual precipitation and its distribution by months of the warm season, the sum of average daily temperatures above 0 ºC, the duration of periods and dates of temperature transition through these thresholds, as well as their average long-term characteristics.

Assessment of the thermal regime

The temperature above 0 ºC was established in the third 10-day period of March (March 30) with the transition to autumn in the third 10-day period of September (September 28). The sum of active temperatures above 0 ºC until September 30 was 2,772.6 º C or 189 days, and according to the long-term average data it equaled 2,602 ºC and fell on the period from April 10 to October 24, for a total of 196 days. The vegetation period of crops, especially peas, is limited not only by the number of active temperatures, but also by the duration of the frost-free period. It makes significant adjustments to the duration of the vegetation period and often leads to damage to crops and even their failure in the spring and late summer periods. The last frost in spring was recorded on May 10, while the first frost in autumn on September 24. Thus, the duration of the frost-free period was 138 days. The annual precipitation in this region averages 250-300 mm. Precipitation during the study period was higher than the average long-term indicators. The coefficient of water consumption using traditional pea cultivation technology was 200.7 m^3 ha^{-1}. Calculations of the hydrothermal index (HTI) carried out based on the prevailing temperature regime and the amount of precipitation during the vegetation period characterize the meteorological conditions of 2019-2022 as slightly dry (HTI = 1.2).

Object of the study

For the study, the pea variety Aksaisky Usatyi 55 was selected. The variety is recommended for cultivation in the Kostanay region. It is a drought and heat-resistant and high-yielding variety. Aksaisky Usatyi 55 has increased resistance to shedding and is technologically advanced. The beans are located in the upper part of the plant and ripen at the same time. The variety is resistant to lodging, since due to the barbate type of leaf, the plants are firmly intertwined. Laboratory germination of seeds equaled 97.6% and field germination 92.4%.

Methods of the study

In total, two experiments were conducted. The first experiment included sowing peas with the introduction of organic manure at a calculated dose of 10 ton/ha.

Experiment 1. Study of the effect of biological preparations on the yield:

1. Control (pure sowing);
2. Introduction of organic manure (estimated dose);
3. Treatment with Baikal EM-1 (during plant vegetation).

Experiment 2. Study of the influence of growth regulators on the yield:

1. Control (pure sowing);
2. Treatment with Izagri Azot;
3. Treatment with Izagri Fosfor.

The species composition and number of weeds, as well as the type of weeds, were determined visually using the quantitative method in the spring in the tillering phase. Samples were taken using 0.25 m^2 frames on an area of 100 ha. The weeds were divided into biological groups and families. The pea crop weed infestation after treatment with the Respekta biological preparation and the Pivot 10% chemical preparation was assessed.

Preparations used in the experiments

Baikal EM-1 is a biofertilizer that has a beneficial effect on the growth and thriving of plants. The preparation has a unique effect on plant surfaces, soil, and natural biological waste, thereby filtering the environment. Izagri Azot is a fertilizer with high nitrogen content in forms available to plants. It is intended for non-root feeding of agricultural plants and crops. The fertilizer is a gray-green suspension supplied in 10-L canisters and manufactured by Agrotechnik. It contains a special complex of surfactants, which guarantees excellent resistance to flushing from the surface of the leaves and the rapid flow of nutrients into the plant. It is an ideal alternative to traditional nitrogen fertilizing. The treatment of plants with mineral fertilizers Izagri Azot and Izagri Fosfor was carried out in the budding phase at a dose of 0.7 L ha^{-1} with a knapsack sprayer (twice in July). Izagri Fosfor is an agrochemical solution with the maximum phosphorus content in its composition (277 g L^{-1}) in combination with amino acids and trace elements. The balanced formula helps to accelerate metabolic processes, increases resistance to diseases, and stimulates the development of a strong root system. Treatment with the Respekta biological preparation was carried out in the budding phase with a knapsack sprayer (July) at a dose of 0.9 L ha^{-1} to protect the pea crops from diseases. Pea harvesting was carried out in the phase of full ripeness (the first 10-day period of September) by hand.

Statistical analysis

The statistical analysis of the obtained data was carried out by determining the significance of the differences between the samples according to the least significant difference (LSD).

RESULTS

Biometric indicators of pea plants during the vegetation period

The results of the sowing qualities of peas (laboratory germination, purity, germination energy) showed that the laboratory germination of peas, the germination energy and the purity were 91.0%, 96% and 96.0% respectively. Field germination of peas according to the variants of the experiment using biological preparations varied from 75.2 to 84.6%, while plant viability from 76.5 to 80.2% (Table 1).

Table 1. Field germination, plant viability, and pea height during the vegetation period.

Variants of the experiment	Phase of plant development (cm)						
	Field germination	Plant viability (%)	Shoots (01-06.06)	Branching (21-25.06)	Budding (05-08.07)	Flowering and bean formation (20.07-25.07)	Ripening 03.08-05.08
Control	75.2	76.5	5.1	10.4	19.8	28.7	42.1
Izagri Fosfor	81.7	79.6	5.9	14.8	25.2	31.8	44.4
Izagri Azot	81.4	79.9	6.4	15.2	26.0	33.1	44.9
Baikal EM-1	84.6	80.2	6.7	11.9	30.2	43.0	50.9
Manure	83.0	78.9	6.5	10.6	29.5	42.3	50.2
$LSD_{0.05}$	0.32	0.45	0.12	0.23	0.31	0.39	0.42

The period from sowing to germination lasted for 13 days. The full germination phase was recorded at the first 10-day period of June, while the branching phase at the middle of the second 10-day period. The interphase period from the full germination phase to branching was 15 days. The budding phase occurred at the second 10-day period of July, while the flowering phase started at the end of the third 10-day period of July. The interphase periods from the full germination phase to budding and flowering were 45 and 59 days respectively. The phase of bean formation began at the first 10-day period of August, at the beginning of ripening in the second 10-day period of August, and full ripening at the first 20-day period of September. The interphase period from the full germination phase to the formation of beans and at the beginning of ripening were 69 and 79 days respectively. The pea ripening phase started at the end of the first 10-day period and at the beginning of the second 10-day period in September. The interphase period of leguminous crops from the full germination to the full ripening phase was 94 days. The plant height, depending on the variants of the experiment, by the end of the vegetation of plants (the phase of bean formation) varied in pea plants from 42.1 to 50.9 cm.

Weeds during the vegetation period of plants

During the vegetation period of pea plants, some species of weed families were especially noticeable. The species composition of the following weeds belonged to the families including *Boraginaceae*, *Asteraceae*, *Convolvulaceae*, *Poaceae*, *Amaranthaceae*, *Euphorbiaceae*, and *Plantaginaceae*. The set of weeds found in pea crops included 34 species belonging to seven families. The species composition of weed vegetation changed little over the years of the study. The dominant species included couch grass, yellow thistle, corn sow thistle, barnyard grass, yellow foxtail grass, wild oats, pigweed, bee nettle, common dandelion, Tartarian buckwheat, etc. The number of weeds was particularly noticeable in the variant with the application of organic manure fertilizer. After processing pea crops, the number of weeds in the variant using Respekta varied according to the variants of the experiment: annual from 4 to 9 pcs m^{-2}, perennial up to 1 pc m^{-2}, the mass of weeds from 63.2 to 220.6 g m^{-2} (Table 2).

Table 2. Scale of pea crop weed infestation

Variants of the experiment	Number of weeds per 1 m^2	Weed infestation score	Weed infestation degree
Biological protection			
Control (without treatment)	5-15	2	slight
Respekta	< 5	1	negligible
Chemical protection			
Control (without treatment)	5-15	2	slight
Pivot 10%	< 5	1	negligible

One of the most important indicators characterizing the impact and effectiveness of the use of biological or chemical preparations is yield. It is the result of the combined influence of the elements of the crop structure. The biological yield of peas according to the experimental variants varied from 12.5 to 17.0 c/ha (Table 3).

Table 3. Elements of the pea crop structure depending on biological products, fertilizers, and cultivation technologies.

Variants of the experiment	Number of plants at harvest (pcs m^{-2})	Number of beans in 1 plant (pcs.)	grain weight per plant (g)	Weight of 1,000 seeds (g)	Biological yield, (c ha^{-1})
Control	41.3	5.0	3.03	180.2	12.5
Izagri Fosfor	45.6	5.0	3.10	191.4	14.1
Izagri Azot	46.4	5.0	3.15	192.6	14.6
Manure	48.4	5.3	3.38	210.3	16.4
Baikal EM-1	48.8	5.3	3.48	212.4	17.0
$LSD_{0.05}$					0.32

Quality and HM content in peas

The used preparations had a positive effect on the biochemical composition of peas (Table 4). The biochemical composition of peas according to the experimental variants varied in protein content from 16.4 to 18.5%, in carbohydrate content from 67.7 to 69.5%, in fiber content from 3.8 to 4.9%, in fat content from 0.7-1.6%, and in ash content from 1.9 to 2.8%. Thus, the total collection of biochemical elements of peas included protein (2.03-3.07 c ha^{-1}), carbohydrates (8.56- 11.04 c ha^{-1}), fiber (0.52-0.80 c ha^{-1}), fat (0.10-0.26 c ha^{-1}), and ash (0.26-0.46 c ha^{-1}). The total collection of biochemical elements of chickpeas included protein (1.69-2.66 c ha^{-1}), carbohydrates (7.16-10.0 c ha^{-1}), fiber (0.39-0.69 c ha^{-1}), fat (0.07-0.22 c ha^{-1}), and ash (0.20-0.40 c ha^{-1}). The largest collection of biochemical elements was obtained in variants using Baikal EM-1 and manure with protein content (2.53-3.07 kg ha^{-1}), carbohydrates (9.48-11.04 kg ha^{-1}), fiber (0.63-0.80 kg ha^{-1}), fat (0.19-0.26 kg ha^{-1}), and ash (0.35-0.46 kg ha^{-1}). Studies on HM content, accumulation, and transformation in the soil and plant system were determined at the Soil Assessment Laboratory, Republican Agrochemical Service. During the vegetation period, it was observed that the background HM content in the soil was at the maximum permissible concentration (MPC) at two sites. The function of the buffer and protective biogeocenotic screen was not affected (the distance between the sites was 50 m). Against the background of application of chemical preparations, the HM content in the soil during the vegetation period of leguminous crops varied depending on the HM type and the technology used in the 0-20 cm layer from 0.19 to 14.3 mg kg^{-1} while in the 20-40 cm layer from 0.19 to 15.1 mg kg^{-1} . According to environmental regulation (Environmental Code from 09.01.2007), the MPC is consistent, but HM can migrate to plants and persist for 1 month. Against the background of application of biological preparations, the HM content in the soil during the vegetation period (Table 5) varied depending on the HM type and the technology used, so that, in the 0-20 cm layer from 0.14 to 13.4 mg kg^{-1} and in the 20-40 cm from 0.15 to 14.5 mg kg^{-1}. According to environmental regulations, the MPC was within normal limits and HM did not migrate to the plants. At the site using chemical preparations, it was observed that the HM migrated into plants. We conducted studies on the presence of HM in plants (Tables 5-6).

Table 4. Biochemical composition of peas.

Variants of the experiment	Content in seeds (% per dry substance)					
	Water	Protein	Carbohydrates	Fiber	Fat	Ash
Control	13.9	16.5	69.6	4.2	0.8	2.1
Izagri Fosfor	14.0	17.1	68.9	4.5	1.2	2.3
Izagri Azot	14.1	17.6	68.3	4.6	1.3	2.4
Baikal EM-1	13.9	18.2	67.9	4.8	1.5	2.6
Manure	13.8	18.5	67.7	4.9	1.6	2.8

Table 5. Dynamics of the HM content in the soil during the vegetation period

Soil layer (cm)	HM type, mg kg^{-1}								MPC
	Mn	Co	Cu	Zn	Mn	Co	Cu	Zn	
By application of chemical preparations									
0-20	14.3	0.22	0.19	0.25	13.5	0.18	0.29	0.18	Within normal limits
20-40	15.1	0.23	0.24	0.26	15.0	0.19	0.37	0.19	persistence of less than 1 month in plants
BC*	14.8	0.20	0.21	0.24	13.4	0.17	0.28	0.16	
By application of biological preparations									
0-20	13.4	0.16	0.14	0.15	13.4	0.13	0.27	0.14	Within normal limits
20-40	14.5	0.19	0.15	0.21	14.5	0.15	0.35	0.15	
BC*	14.0	0.14	0.12	0.12	13.0	0.12	0.24	0.12	

*BC is the background content in the soil

The HM content during the vegetation period varied depending on chemical preparations from 1.20 to 46.06 mg kg^{-1}, depending on biological preparations from 0.92 to 40.85 mg kg^{-1}, while in the control variant from 0.60 to 40.64 mg kg^{-1}. According to environmental regulations, the HM content was within the MPC, and they did not migrate to seeds. To comprehensively substantiate the receipt and accumulation of HM from the application of the studied preparations, we conducted additional studies to identify HM (Cu and Zn) in seeds (Table 6). The HM content in peas ranged from 0.79 to 46.0 mg kg^{-1}, in the control variant from 0.60 to 40.64 mg kg^{-1}, using chemical preparations from 1.20 to 46.0 mg kg^{-1}, and in the case of biological preparations from 0.92 to 40.72 mg kg^{-1}. According to environmental regulations, the HM concentration was within the permissible norm. Thus, the HM content in the soil and plant system was within the MPC and corresponded to the environmental regulation.

Table 6. Dynamics of HM content in pea plants depending on the used preparations.

Variant/culture	HM type (mg kg^{-1})				MPC
	Mn	Co	Cu	Zn	
Control	40.64	0.79	0.60	1.00	Within normal limits do not migrate
By application of chemical preparations					
Izagri Fosfor	46.00	1.24	1.60	1.25	Within normal limits
Izagri Azot	45.08	1.23	1.56	1.20	do not migrate
By application of biological preparations					
Baikal EM-1	40.85	1.14	0.95	1.15	Within normal limits
Manure	40.75	1.10	0.92	1.10	do not migrate

DISCUSSION

Weed infestation is a serious limitation in pea production in Canada. In addition to competing for moisture, nutrients, space, and light, which reduces the yield, weeds can pollute the pea crop, harboring insects and fungi and making it difficult to harvest (Popolzuhina *et al.* 2021). The demand for high-quality pea products has put more emphasis on weed control. Interference was more severe under the delayed sowing than under early sowing conditions, leading to a 30-35% decrease in pea yield. (Patov *et al.* 2021) observed that weed control increased pea yield by 63%, while (Ingver *et al.* 2019) reported losses in pea yield due to weeds in the range from 40 to 70%. These large crop losses indicate a higher sensitivity of peas to early weed infestation and the need for timely and effective weed control in early harvests. In our study, weeds were represented by the families including *Boraginaceae*, *Asteraceae*, *Convolvulaceae*, *Poaceae*, *Amaranthaceae*, *Euphorbiaceae*, and *Plantaginaceae*. According to the weed estimation scale, the weed infestation was slight or negligible. The pea quality largely depends on the biochemical composition. The crude protein content in plants is determined by the nitrogen supply of plants. The more mineral nitrogen is contained in the soil, the more protein accumulates in the crop (Popov *et al.* 2017). According to our results, the used preparations had a positive effect on the biochemical composition of peas. The obtained results showed that there was no significant difference in the composition of biochemical elements between the variants. However, since the contents of protein and carbohydrates positively correlate with the yield of seeds, the total collection of protein and carbohydrates, while other elements from one ha according to the experimental variants significantly increase the quality indicators of peas (Nugmanov *et al.* 2022). A significant part of HM polluting the natural environment enters the soil with pesticides and organic and mineral fertilizers. The soil, being the most important biochemical barrier, is most affected by the negative effects caused by diverse human production activities and accumulates technogenic products (Doltra *et al.* 2011). We observed that the background HM content in the soil was within the MPC in the two sites. HM are one of the most important groups of toxicants polluting the soil. These include metals with a density of more than 8 thousand kg m^{-3} (except noble metals and rare elements), such as Pb, Cu, Zn, Ni, Cd, Hg, Co, Sb, Sn, and Be. In applied works, Pt, Ag, W, Fe, and Mn are often added to the list of HM. Almost all HM are toxic (Bilsborrow *et al.* 2013; Askegaard *et al.* 2005) According to our results, the concentrations of HM in peas were within the permissible norm.

CONCLUSION

The results of the study show that the biometric indicators of pea plants corresponded to the characteristics of the variety. On average the vegetation period took 94 days, and the height of the plants by the ripening phase was 50.9 cm. The *Boraginaceae*, *Asteraceae*, *Convolvulaceae*, *Poaceae*, *Amaranthaceae*, *Euphorbiaceae*, and *Plantaginaceae* represented the weeds. According to the weed estimation scale, the weed infestation was slight or negligible. The pea yield ranged from 12.5 to 17.0 c ha^{-1}; the maximum yield was obtained in the variant using the biological preparation Baikal EM-1 (17.0 c ha^{-1}), while the control variant yielded 12.5 c ha^{-1}. The pea quality ranged from 16.4 to 18.5%, the carbohydrate content from 67.7 to 69.5%, fiber from 3.8 to 4.9%, fat from 0.7 to 1.6%, and ash from 1.9 to 2.8%. The HM content was within the MPC. The HM content in peas ranged from 0.79 to 46.0 mg kg^{-1} and in the control variant from 0.60 to 40.64 mg kg^{-1}, by application of chemicals from 1.20 to 46.0 mg kg^{-1}, and by biological preparations from 0.92 to 40.72 mg kg^{-1}.

REFERENCES

Aipeisova, S, Utarbayeva, N, Maui, A, Kazkeev E & Baubekova, A 2023, Fabaceae Lindl. species in the floristic composition of the aktobe floristic district. *International Journal of Environmental Studies*, 80: 1076-1087, DOI: 10.1080/00207233.2022.2136851.

Al- Abbasi, SHAH, Altaef, AQ, AL-Samarraie, M, Al-Naqib, ATH & Al-Majmaei, AAM 2022, Collection and diagnosis of some wild plants in the vicinity of Samarra University, Iraq. *Caspian Journal of Environmental Sciences*, 20: 437-440.

Askegaard, M, Olesen, JE & Kristensen, K 2005, Nitrate leaching from organic arable crop rotations: Effects of location, manure and catch crop. *Soil Use and Management*, 21: 181-188, DOI: 10.1079/SUM2005315

Bekezhanov, D, Kopbassarova, G, Rzabay, A, Nessipbayeva, I & Aktymbayev, K 2021, Environmental and legal regulation of digitalization of environmental protection. *Journal of Environmental Management and Tourism*, 12: 1941–1950

Bilsborrow, P, Cooper, J, Tétard Jones, C, Średnicka Tober, D, Barański, M, Eyre, M, Schmidt, C & Wilcockson, S 2013, The effect of organic and conventional management on the yield and quality of wheat grown in a long-term field trial. *European Journal of Agronomy*, 51: 71-80, DOI: 10.1016/j.eja. 2013.06.003

Brijbhooshan, Singh, VK & Shalini 2017, Response of fieldpea (*Pisum sativum* L. var *arvense*) to various planting methods, irrigation schedule, and weed management practices. *Legume Research*, 40: 132-137, DOI:10.18805/lr.v0iOF.7107

Commission Regulation of EC 2020, No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labeling of organic products with regard to organic production, labeling and control. Current consolidated version: 07/01/2020 ELI [Electronic resource], 2020, URL: http://www.data.europa.eu/eli/reg/2008 889/oj (date of access: 30.07.2020).

Doltra, J, Lægdsmand, M & Olesen, JE 2011, Cereal yield and quality as affected by nitrogen availability in organic and conventional arable crop rotations: A combined modeling and experimental approach. *European Journal of Agronomy*, 34: 83-95. DOI: 10.1016/j.eja.2010.11.002

Grigoruk, VV & Klimov, EV 2020, Organicheskoe selskoe khozyaistvo: kontseptualnaya pozitsiya (Organic agriculture: A conceptual position). *Problemy Agrorynka*, 3: 88-101.

IFOAM 2020, Definition of Organic agriculture. International Federation of Organic Agriculture Movements, [Electronic resource], 2008, URL: http://www.ifoam.org/en/organiclandmarks/definition-organic-agriculture (date of access: 22.07.2020).

Ingver, A, Tamm, Ü, Tamm, I, Tamm, S, Tupits, I, Bender, A & Koppel, M 2019, Leguminous pre-crops improved quality of organic winter and spring cereals. *Biological Agriculture and Horticulture*, 35: 46-60. DOI:10.1080/01448765.2018.1509728.

Kantarbayeva, EE, Shayakhmetova AS, Koshen BM & Zholamanov KK 2017, The density of planting and the productivity of corn in the context of forest-steppe zone of northern Kazakhstan. *Asian Journal of Microbiology, Biotechnology & Environmental Sciences*, 19: 116-120.

Kiselev, AS, Popolzuhina, NA, Popolzuhin, PV, Parshutkin, YY & Gaydar, AA 2018, The effect of inoculation on the formation of photosynthetic and symbiotic apparatus of sowing peas and its productivity in the conditions of the southern forest-steppe of Western Siberia. *Bulletin of the Novosibirsk State Agrarian University*, 3: 23-30

Kosev, V & Naydenova, Y 2015, Heritability of qualitative traits in forage pea (*Pisum Sativum* L.). *OnLine Journal of Biological Sciences*, 15: 274-281.

Kuldybayev, N, Dutbayev, Y, Lozowicka, B, Iwaniuk, P, Slyamova, A & Tsygankov, V 2021, Effects of root rot in soybean cultivars with diverse susceptibility to the disease on plant physiology, yield, amino acids, and mycotoxins profile in climatic conditions of kazakhstan. *OnLine Journal of Biological Sciences*, 21: 312-321.

Nassif, WG, Lagenean, FHS & Al-Taai, OT 2023, Impact of vegetation cover on climate change in different regions of Iraq. *Caspian Journal of Environmental Sciences*, 21: 333-342.

Nugmanov, AB, Tokusheva, AS, Ansabayeva, AS, Baidalin, ME, Kalyaskarova, AE & Bugubaeva, AU 2022, Assessing the influence of cereal-legume mixtures on the productivity of degraded pastures in the Kostanay region of northern Kazakhstan. *Revista Facultad Nacional De Agronomia Medellin*, 75 : 9877-9886. DOI: 10.15446/RFNAM.V75N1.95199, [In Russian].

Petrov, S, Mamaeva, N, Renev, E & Narushko, M 2021, Characteristics of the cultivated area and its structure under conditions of increasing average annual temperatures. Paper presented at the IOP Conference Series: *Earth and Environmental Science*, 699, DOI: 10.1088/1755-1315/699/1/012035

Popolzuhina, NA *et al.* 2021, 666 062022DOI 10.1088/1755-1315/666/6/062022. IOP Conference Series: Earth and Environmental Science paper, the following article is open access biological products to improve the adaptability and productivity of grain and leguminous crops.

Popov, V, Serekpaev, N, Zharlygasov, Z, Stybaev, G & Ansabaeva, A 2017, Adaptive technology of environmentally–friendly production of legumes in the dry steppe zones. *Journal of Central European Agriculture,* 18: 73-94, DOI:10.5513/JCEA01/18.1.1869.

Röös, E, Bajzelj, B, Weil, Ch, Andersson, E, Bossio, D & Line, J 2021, Gordon Global Food Security. 28: 100487

Serekpayev, N, Popov, V, Stybayev, G, Nogayev, A & Ansabayeva, A 2016, Agroecological aspects of chickpea growing in the dry steppe zone of Akmola region, northern Kazakhstan. *Biosciences Biotechnology Research Asia*, 13: 1341-1351. DOI: 10.13005/bbra/2275.

Singh, J, Dhall, RK & Aujla, IS 2015, Characterization of resistance response of garden pea (*Pisum sativum* L.) against powdery mildew (*Erysiphe pisi* DC) in sub-tropical plains of India. *Sabrao Journal of Breeding and Genetics*, 47: 384-393.

Willer, H & Lernoud J 2019, The world of organic agriculture statistics and emerging trends. *Electronic Resource.* URL: http:// www.shop.fibl.org/CHde mwdownloads/download/link/id/1093/?ref=1 [In English] (date of access: 13.03.2020).

Willett, W, Rockström, J, Loken, B, Springmann, M, Lang, T, Vermeulen, S, Garnett, T, Tilman, D, DeClerck, F, Wood, A, *et al.* 2019, Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. 393: 447-492, DOI: 10.1016/S0140-6736(18)31788-4. Epub 2019 Jan 16.

Wu, D, Wei, Z, Qu, F, Mohamed, TA, Zhu, L, Zhao, Y, Jia, L, Zhao, R, Liu, L, Li, P 2020, Effect of Fenton pretreatment combined with bacteria inoculation on humic substances formation during lignocellulosic biomass composting derived from rice straw. *Bioresource Technology*, 303: 122849, https://doi.org /10.1016/j.biortech.2020.122849.

Yesmagulova, BZ, Assetova, AY, Tassanova, ZB, Zhildikbaeva, AN & Molzhigitova, DK 2023, determination of the degradation degree of pasture lands in the west Kazakhstan region based on monitoring using geoinformation technologies. *Journal of Ecological Engineering*, 24: 179-187.

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