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Biologized Technologies for Cultivation of Field Crops in the Organic Farming System of West Kazakhstan

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ABSTRACT

In studies aimed at expanding the range of the organic farming system, the authors studied the comparative productivity of such field crops like barley and safflower cultivated with the use of traditional and biologized technologies. The use of biological preparations and organic biofertilizers of the latest generation was studied as a biologized technology on barley and safflower crops. As shown by the experimental data, with the biologized technology in the conditions of the zone in question, the yield of barley increased by 27.02% compared to traditional technologies, the harvest of protein increased by 0.02 t/ha, and the energy value by 2.25 GJ/ha. In this work, it was concluded that the use of the biologized technology of barley and safflower cultivation was important to improve the efficiency of agricultural landscape management in the system of organic farming, which constitutes the scientific novelty of the study.

Keywords: biologized technology, barley, safflower, yield, fodder, energy/protein value, oil content.

INTRODUCTION

Shortly, in Kazakhstan, to provide the livestock breeding industry with full-fledged fodder and increase export potential, ensure the country's food security, work will continue to diversify the crop production industry, replacing part of the wheat area with more popular fodder crops and oilseeds. The use of such fodder crops as barley and such oilseeds as safflower in the diversification process is associated with their potential adaptation to climate change, competitiveness, and attractiveness for the production of fodder and oilseeds. The cultivation of these crops is relevant in the conditions of West Kazakhstan characterized by high temperatures and a long season of growing [Nasiyev et al., 2018, 2021].

Diversifying crop production by replacing a wheat monoculture with agricultural landscapes of competitive and attractive crops such as chickpeas or Sudanese grass for fodder and safflower for oilseed production is considered one of the most important green agricultural policy goals in Europe [Flemmer et al., 2015; Peltonen-Sainio et al., 2016].

Over the past decade, organic farmland has more than doubled. Globally, the area of organic arable land is more than 13.3 million hectares or 19% of the world's organic agricultural land and 0.9% of the world's arable land [Willer et al., 2020].

Scientific structures of Kazakhstan, as well as globally, are constantly conducting studies to improve adaptive technologies for the cultivation of the most common fodder crops and oilseeds. An important reserve for a sustainable increase in the productivity of the aforementioned crops is the introduction of ecologically safe and cost-effective biologized technologies in the organic farming system. In Kazakhstan, barley is the most popular fodder crop used by agricultural companies for the production of grain fodder, despite its relatively average yield. With the advent of various biological preparations and biofertilizers, new reserves appeared for increasing the yield of barley in the studied area [Nasiyev et al., 2015, 2016]. Some positive experience has been reported by scientists in the study of biostimulants in barley crops [Soloviev, 2013; El-Sharkawy et al., 2017]. Barley (*Hórdeum*) is the main fodder crop in West Kazakhstan. In connection with the emergence of new preparations, the study of the effects of biostimulants on the productivity of barley becomes relevant.

In West Kazakhstan, the sowing of safflower, due to the imperfection of the traditional technology, remains insignificant, about 35 thousand hectares, and the yield is low. It is also important that the changes in the climate that have taken place over the past years, as well as the development of new safflower varieties, require the creation of technology for the use of biological preparations and biofertilizers, which, being at the optimum dosage, contribute the most to increasing the productivity and quality of products of this crop.

The ideas of the experiment are fundamentally different from existing analogs since the studies carried out in different countries are focused on other quantitative characteristics of soil, climate, levels of plant productivity, and profitability of agricultural production. In this regard, the study was aimed to increase the productivity and quality of field crops of barley and safflower for the rational management of organic agrocenoses.

MATERIALS AND METHODS

Design of the study

The field experimental part consisting of 2 field experiments was carried out in 2019–2021 at the Dəukara family-operated farm in West Kazakhstan. The soil of the experimental area is characteristic of 1 steppe zone of West Kazakhstan. The object of the study was the agricultural landscape of barley (*Hórdeum*) and safflower (*Carthamus tinctorius L.*) (Figure 1).

The field experiment design is presented in Tables 1 and 2.

Figure 1. Agricultural landscapes of barley and safflower

Table 1. Field experiment design 1 — Study of the comparative efficiency of barley cultivation technology

Variants	Traditional technology	Biologized technology*
Description of the technology	Only mineral fertilizers are used – ammonium nitrate $NH_4 NO_3$, double superphosphate $Ca(H_2 PO_4)_2$ – at a dose of $N_{20} P_{20}$ before sowing	Using the Biodux bio stimulator, Orgamica S biofungicide, Organit N, Organit P bio-organic fertilizers

* The preparations are used for the pretreatment of barley seed material and for spraying barley during the growing season in the tillering phase.

Table 2. Field experiment design 2 — Study of the comparative efficiency of safflower cultivation technology

Variants	Traditional technology	Biologized technology*
Description of the technology	Only mineral fertilizers are used – ammonium nitrate $NH_4 NO_3$, double superphosphate $Ca(H_2 PO_4)_2$ – at a dose of $N_{20} P_{20}$ before sowing	Using the Biodux bio stimulator, Orgamica S biofungicide, Organit N, Organit P bio-organic fertilizers

* The preparations are used for the pretreatment of the safflower seed material and for spraying safflower during the growing season in the 3–4 real leaves phase.

The plot area was 50 m^2, threefold repetition, the plots were located randomly. Experiment 1 on the comparative study of the technology of barley cultivation was performed on 6 plots in total, taking into account 3 repetitions. The length of each plot was 10 m, the width was 5 m. Additionally, guard-plots with a length of 2 m and a width of 5 m were organized. Experiment 2 on the comparative study of the technology of safflower cultivation was performed on 6 plots in total, taking into account 3 repetitions. The length of each plot was 10 m, the width was 5 m. Additionally, guard-plots with a length of 2 m and a width of 5 m were organized. The distance between each experimental site was 10 m. The design of the experiments met the requirements according to the accepted modern methods [Fedin, 2017; Novoselov et al., 2017]. In both experiments, we used the soil tillage system common for zone 1 of West Kazakhstan. The experiments used a Donetsk 8 zoned variety of barley and the Ahram variety of safflower. The seeding rate of barley was 2.5 million germinating seeds per 1 ha, the seeding rate of safflower was 500 thousand germinating seeds per 1 ha. The barley and safflower were harvested by a continuous method in the phase of full ripeness, bringing the crop to standard humidity at 100% purity. For harvesting, combines with a pin drum were used at a reduced number of revolutions up to 750–800 per minute. In our experiments on the cultivation of barley and safflower, studies were carried out without the use of irrigation (rain-fed lands).

Characteristics of biological preparations and bio-fertilizers

The microbiological preparation Biodux is a bio stimulator of growth.

Regulations of application − pre-sowing seed treatment. The preparation is used at a dose of 1.0 ml/t, the consumption rate of spray material is 10 l/t. Crop treatment during the growing season. The preparation is used at a dose of 3–10 ml/ha, the consumption rate of spray material is 300 l/ha.

The Orgamica S biofungicide. The composition of the preparation − *Bacillus amyloliquefaciens* spores (titer not less than 5x10 ^{9} colony-forming units (CFU)/ml). Mode of action: Being a natural inhabitant of the soil, the *Bacillus amyloliquefaciens* strain shows its useful properties near the roots and on the surface of the leaves. When they get into a favorable habitat (moistened soil, plant surface), the spores "germinate", becoming metabolically active vegetative cells that suppress growth or destroy harmful objects through the action of antibiotics and hydrolytic enzymes.

Regulations of application − pre-sowing seed treatment. The preparation is used at a dose of 0.4 l/t, the consumption rate of spray material is 10 l/t. Crop treatment during the growing season. The preparation is used at a dose of 0.4 l/ha, the consumption rate of spray material is 300 l/ha.

The Organit N biofertilizer. The composition of the preparation − cells of the *Azospirillum zeae* strain (titer of at least 1×10^9 CFU/ml). Mode of action: The main function of the preparation is to improve the nitrogen nutrition of crops, due to the ability of *Azospirillum zeae bacteria to* fix atmospheric nitrogen and convert it into forms suitable for plant consumption. The preparation also allows improving the growth characteristics of cultivated plants, due to the synthesis of several substances of phytohormonal nature.

Regulations of application − pre-sowing seed treatment. The preparation is used at a dose of 0.4 l/t, the consumption rate of spray material is 10 l/t. Crop treatment during the growing season. The preparation is used at a dose of 3–10 ml/ha, the consumption rate of spray material is 300 l/ha.

Organit N. biofertilizers. The composition of the preparation − spores of the *Bacillus megaterium* strain (titer of at least 1×10^9 CFU/ml).

Mode of action − a safe and effective microbiological fertilizer that improves the mineral nutrition of plants by increasing the bioavailability of phosphorus. *Bacillus megaterium* spores contained in the product, when they get into the soil, are activated and colonize the rhizosphere of cultivated plants, showing their useful properties near the roots. In the process of their growth, bacterial cells dissolve organic and inorganic phosphorus compounds that are difficult to reach for plants.

Regulations of application − pre-sowing seed treatment. The preparation is used at a dose of 0.4 l/t, the consumption rate of spray material is 10 l/t. Crop treatment during the growing season. The preparation is used at a dose of 3–10 ml/ha, the consumption rate of spray material is 300 l/ha.

Stages of the study

In the experiments, phenological observations, biometric measurements, and laboratory analyses to determine the quality of the crop were carried out according to accepted modern methods.

Biometric method. In the studies, the main phases of growth and development of barley were established, namely, seedlings, tillering, stem elongation, earing, maturation; the main phases for safflower were seedlings, 3–4 leaves, shooting, anthodium formation, blooming, maturation. The safflower plants and barley height was determined in 10 sites of the plot in 2 non-adjacent repetitions of the experiment. The calculation of the density of plant population in the seedling phase and before harvesting allowed us to establish the influence of the studied factor on the state of seedlings and the loss of plants during the growing season. The structure of the safflower crop was determined by parsing a sheaf weighing 1 kg into its parts. The biological yield of barley was established by counting the number of plants survived until harvesting, productive tilling capacity, the number of grains in the ear, and the mass of 1,000 seeds. The photosynthetic activity of barley was studied according to the accepted methodology [Nichiporovich, 2019]. The definition of the main photosynthetic indicators was carried out by the development phases of barley. The leaf area was calculated by the Anikeev-Kutuzov formula: $LA = 2/3p \cdot h$, where p is the leaf width, cm; and h is the leaf length, cm. The foliage was determined by the weight method by determining the specific leaf weight in the total green mass of barley.

The chemical analysis showed, that a fodder, energy/protein assessment of barley was carried out according to the accepted methodology [Novoselov et al., 2019]. The extraction method was used to determine the oil content in safflower seeds [Gabdulov et al., 2018].

Statistical analyses. The analysis and graph plotting were performed in SAS® OnDemand for Academics, JASP®. To identify the significance of differences between the average values, we used the Independent Samples T-Test and the BoxPlot graphs.

RESULTS AND DISCUSSION

In the studies, the development and growth of barley and safflower were significantly influenced by the prevailing weather conditions of the growing season (Table 3).

In terms of weather conditions, the most favorable conditions for the growth and development of barley and safflower were formed in 2019. In June 2019, when there was intensive

Table 3. Average monthly air temperature and rainfall during the Sudan grass growing season in 2019–2021

Years	Months			
	May	June	July	August
Mean monthly temperature, °C				
2019	18.3	22.2	22.1	19.8
2020	16.4	20.7	26.2	19.9
2021	21.5	24.5	25.3	26.1
Long-time average annual data for 10 years	15.6	20.4	22.4	20.6
Total precipitation, mm				
2019	9.2	40.2	14.4	15.8
2020	7.6	56.1	5.8	17.1
2021	19.3	68.8	15.6	1.0
Long-time average annual data for 10 years	27.0	31.0	41.0	25.0

growth and the formation of the barley crop, 40.2 mm of precipitation fell, which is 9.2 mm more compared to long-term data. In July and August, the average monthly air temperature was at the level of the average long-term data. However, the level of precipitation was lower compared to long-term data. Thus, in July, precipitation fell by 26.6 mm, and in August, by 9.2 mm less compared to long-term data. Summer rains in July coincided with the period of blooming/ripening of barley and safflower, which was reflected in the yield of fodder and oilseeds of the studied crops.

Under the conditions of 2020, during the periods of germination, initial and active growth of barley and safflower in May, 7.6 mm of precipitation fell (with a long-term level of 27.0 mm), and in June, 56.1 mm of precipitation fell, which was 25.1 mm more than the long-term level. In May and June, the air temperature was approximately at the average annual level. Subsequently, prolonged dry weather in July (5.8 mm of precipitation against 41.0 mm of long-term average level) significantly reduced the productivity of the studied crops. In July, the average monthly air temperature was 26.2 °C with an average annual level of 22.4 °C. In August, with an average monthly air temperature of 19.9 °C, precipitation fell 17.1 mm or 7.9 mm less compared to the average annual level.

The year 2021 was the most favorable in the initial period of development, due to a sufficient amount of precipitation (19.3 mm) at a high air temperature (21.5 °C). However, the weather conditions in 2021 due to the heat in June (24.5 °C) and July (25.3 °C) the months were not quite favorable for the growth and development of safflower.

It should be noted that precipitation in June (68.8 mm) and July (15.6 mm) in the conditions of 2021 contributed to an increase in the formation of more productive agricultural landscapes of safflower in the conditions of the study zone compared to 2020. Safflower, as a drought-resistant crop, managed to withstand the effects of drought during the ripening period in August and retained the yield parameters predicted in earlier months (June, July).

In general, the agrometeorological conditions of the 2020 and 2021 agricultural years were not favorable for the growth, development, and formation of the yield of the studied crops, namely barley and safflower.

Field germination of seeds is one of the most important indicators on which the formation of the optimal plant population density depends. Out of the factors affecting field germination, the moisture content of the upper soil layer (6–8 cm), in which the seeds are embedded, is in the greatest deficit. If the soil is sufficiently moistened during the sowing/germination period, the limiting factor is the soil temperature.

Obtaining and maintaining timely, even seedlings is one of the important conditions for the formation of an optimal high productivity density. Therefore, field germination is essential for obtaining high yields of barley. Sowing should be carried out at the optimal time to a depth that provides the seeds with moisture and available nutrients [Belyakov, 2015; Prutskov and Osipov, 2020].

In our opinion, the conditions under which seed germination occurs (humidity, temperature, depth of embedding) have a great influence on the manifestation of the responsiveness of seeds to treatment with physiologically active substances. It can be assumed that the treatment of seeds with biological preparations affects many aspects of metabolism, including the physiological activity of cell organelles. Thus, conditions that promote the biosynthesis of enzyme activation with enzymes directly involved in the assimilation of biologically active substances have a deeper and longer-lasting effect on the vital activity of plants [Posypanov et al., 2020].

Field germination largely depends on the biological characteristics of seeds, their storage conditions, soil and agrometeorological conditions of the sowing/germination period, the optimal and uniform depth of seed embedding in the soil, as well as on the timely mandatory rolling after sowing and other agrotechnical measures.

Research data show that the preparations used had a certain effect on the field germination of barley. Thus, on average for 2019–2020, field germination in the control group without the use of biological preparations (the traditional technology) was 88.97%. The use of biological preparations had a positive effect on the germination rate of barley seedlings (90.63%, which exceeds the germination rate of barley in the control group by 1.66%). In our opinion, the increased germination of spring barley is associated with favorable weather conditions during the germination period in 2019 and 2021, as well as the activation of the soil microflora from the action of biological preparations, which contributed to the transfer of mineral compounds into nutrients available to plants.

Table 4. Biometric indicators of barley depending on the cultivation technology, on average for 2019–2021

Technology	Field germination, %	The plants that survived until harvest, %	Plant height in the phase of milk ripeness, sm	Leafiness plants at the beginning of the heading phase, %	Leaves area, thousand m²/ha
Traditional (control)	88.97	70.07	63.42	33.60	26.62
Biologized	90.63	73.90	69.36	42.90	32.62

The obtained regularities in the germination of spring barley were fully manifested in the general number of plants that survived until the harvest. The result of the complex action of biological preparations in the experiments 2019–2021 years on the co-treatment of seeds before sowing with such theBiodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers was reflected in the highest survivability of the spring barley plants in comparison with the control variant: 1.68 million plants from 2.27 million plants per 1 ha survived until the harvest (survivability equaling 73.90%). With the traditional technology, 70.07% or 1.56 million plants/ha of the 2.22 mln germinated barley plants/ha survived until harvesting (Table 4).

Based on the conducted studies, it can be noted that during the years of our studies, the patterns associated with the studied factors (field germination and plant survivability) for harvesting were significantly higher when using biologized technology for cultivating spring barley.

The Organit N biological preparation contributes to the improvement of nitrogen nutrition in crops due to the ability of *Azospirillum zeae bacteria to* fix atmospheric nitrogen and convert it into forms suitable for plant consumption. The preparation also allows improving the growth characteristics of cultivated plants, due to the synthesis of several substances of phytohormonal nature. Besides that, *Bacillus megaterium* spores contained in the product are activated when they get into the soil and colonize the rhizosphere of cultivated plants, showing their useful properties near the roots. During their growth, bacterial cells dissolve organic and inorganic phosphorus compounds that are difficult to reach for plants [Swami et al., 2017; Posypanov et al., 2020; Swami, 2020].

Treatment during the growing season in the end-tillering phase with biological preparations also contributed to the active growth of barley.

On average, in the years of the study (2019–2021) in the tillering phase, the difference in the growth of spring barley plants between the experimental variants was insignificant. Starting from the tillering phase, barley plants treated with the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) were higher compared to the control plants (traditional technology). By the earing phase, the difference in the height of spring barley plants between the experimental and the control variants was 4.2 cm. During the earing phase, the barley plants treated with biological preparations had a height of 59.5 cm, and the barley plants of the control variant (traditional technology) had a height of 67.15 cm.

By the earing phase, the difference in the growth of spring barley plants between the two variants was 4.2 cm. In the experiments, the height of spring barley plants from the use of biological preparations was most increased and equaled 69.36 cm.

For the formation of a sufficient amount of harvest, not only the height of plants is important, but also the area of the leaf surface. In the field studies conducted under the conditions of 2019–2021, the maximum leaf area was formed by barley grown using biologized technology (32.62 thousand m²/ha). The use of biological preparations and biofertilizers also contributed to an increase in the leafiness of barley plants to 42.99%. In the group where barley was cultivated using traditional technology, the leaf area significantly decreased (26.67 thousand m²/ha), and the barley plants also had a low percentage of foliage (33.60%) (Figure 2).

As shown by the statistical analysis of studies, the leaves area, plant leafiness, and yield of barley grain depended on the cultivation technology. The scatter plots shown in Figure 1 for blocks A and B show the values of three variables in different technologies. Analyzing the diagrams by block, we have determined the following relationships between these variables. In block A, we can conclude that technologies influenced the plant leafiness and barley grain yield. The best technology for the ratio of plant leafiness and grain yield is the biologized technology. Block B shows the same relationship between the leaves area and grain yield in barley in terms of cultivation technology as in block A.

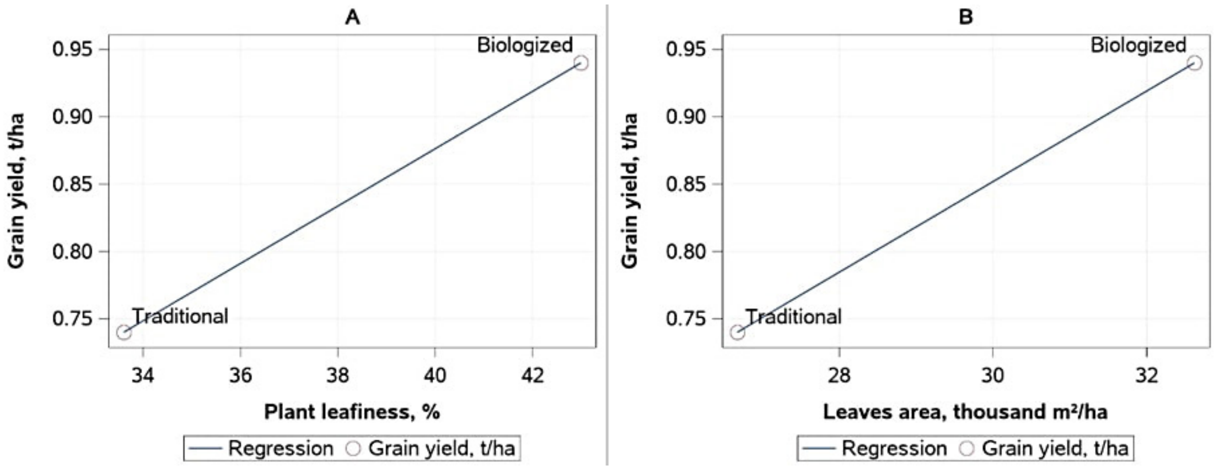

Figure 2. Influence of leafiness plants and leaves are on the yield of barley grain with different cultivation technologies, the average for 2019–2021: a) Leafiness of the plants,%; b) Leaves area, thousand m^2/ha

Barley is cultivated for the sake of grain used for food, fodder, and technical purposes. Barley should be harvested in the phase of hard ripeness. By this time, the most favorable and stable relationship between nitrogenous and carbohydrate compounds is established in the grain. Since the majority of nitrogen is accumulated in the grain of spring barley in the first period of its formation, and the accumulation of starch is the most intensive in the last phase of maturation, premature cleaning leads to increased protein content, which deteriorates the quality of brewing raw materials but improves its food and fodder properties [Belyakov, 2015; Prutskov and Osipov, 2020].

Production-important indicators of the fodder advantages of the crop are the collection of fodder units, digestible protein from the crop, and the provision of fodder with protein.

According to the research data, the treatment of seed material and spraying of plants during the tillering phase with the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) had a positive effect on the fodder and energy/protein value of spring barley. Thus, if in the conditions of 2019–2021, the average collection of fodder units at the control at the yield of digested protein was 0.08 t/ha at the level of 0.70 t/ha, then the use of biologized technology of barley cultivation increased the yield of fodder units to 0.88 t/ha or by 0.18 t/ha more compared to the control group and increased the protein value of barley to 0.10 t/ha. When using biologized technology, the protein content of fodder units increased from 110.7 g to 114.0 g.

In addition, the evaluation of the value of fodder barley was also carried out according to the output of exchange energy. According to research data, biologized technology has advantages in terms of energy indicators in comparison with traditional technology. When using the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers in experiments, the collection of exchange energy with the barley crop increased by 10.68 GJ/ha, which is more than the control group (traditional technology) by 2.25 GJ/ha or by 26.69% (Table 5).

According to the results of the analysis of the collection of fodder units of barley, it was determined that for this sample, the significance of

Table 5. The influence of cultivation technology on the fodder/protein and energy value of barley, on average for 2019–2021

Technology*	Fodder unit yield, t/ha			Digestible protein yield, t/ha			Exchange energy output, GJ/ha		
	I	II	III	I	II	III	I	II	III
1	0.67	0.70	0.73	0.07	0.08	0.09	8.10	8.66	8.52
2	0.84	0.92	0.88	0.09	0.10	0.11	10.83	10.71	10.52
t-test	*			**			**		

*1: Traditional, 2: Biologized

T-test of significance: * - p-level<0.1. **- p-level<0.05. I, II, III are the replicates of the experiment differences in the mean values was statistically significant at the p-level<0.1. With a sufficient level of reliability, we can assume the impact of the technologies used on the fodder value of barley grain. The negative sign of the t-test means that in the traditional technology group, the fodder value of barley is lower by 0.180 t/ha compared to the biologized technology.

The statistical analysis showed a significant dependence of the average protein value of barley grain on the cultivation technology. This indicator depends on the cultivation technology used at the significance level p-level<0.05. When using biologized technology, the protein content on average increases by 0.021 t/ha compared to traditional technology.

The indicator of the energy value of barley, depending on the cultivation technology, has a significant difference in the average values. The significance index of the difference in the averages for the t-test is less than 5%. Therefore, according to the calculated data, it can be assumed with a 95% probability that the use of biologized technology on average increases the energy value of barley grain by 2.54 GJ/ha.

Thus, as a result of the conducted study, we found that pre-sowing seed treatment and the use of biological preparations and biofertilizers during the growing season (tillering phase) contributed to the activation of several growth-related, physiological and biochemical processes of plants, which led to an increase in the fodder, energy and protein value of fodder barley.

In the studies of 2019–2021, the average field germination of safflower, depending on the cultivation technology, was 92.16–93.74%. At the same time, seeds treated with biological preparations has the greatest completeness of germination.

On average for 2019–2021, in the biologized technology group, 88.00% or 41.24 thousand plants/m^2 out of 46.87 thousand germinated plants/m^2 survived until the time of harvesting, while 39.08 thousand plants/m^2 or 84.81% out of 46.08 thousand germinated safflower plants/m^2 survived in the control group. Before harvesting, 2.16 thousand more plants/m^2 survived in the sowing field with the use of biologized technology compared to the control group.

In the shooting phase, the height of the plants of the control variant was 22.73 cm, and in the group with the use of biologized technology, the plants had a height of 26.55 cm; thus, the difference between the height of the plants of the studied variants was 3.82 cm.

On average, over the years of research in the budding phase, the height of safflower plants according to the experimental variants was in the range of 50.98–54.95 cm, and by the blooming phase, safflower plants had a height of 59.88–64.37 cm. At the same time, the joint use of the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) provided the maximum growth of safflower plants compared to the control group (traditional technology). By the maturation period, the safflower plants in the biologized version of the technology had reached 67.97 cm. Before harvesting, the height of the plants of the control variant was

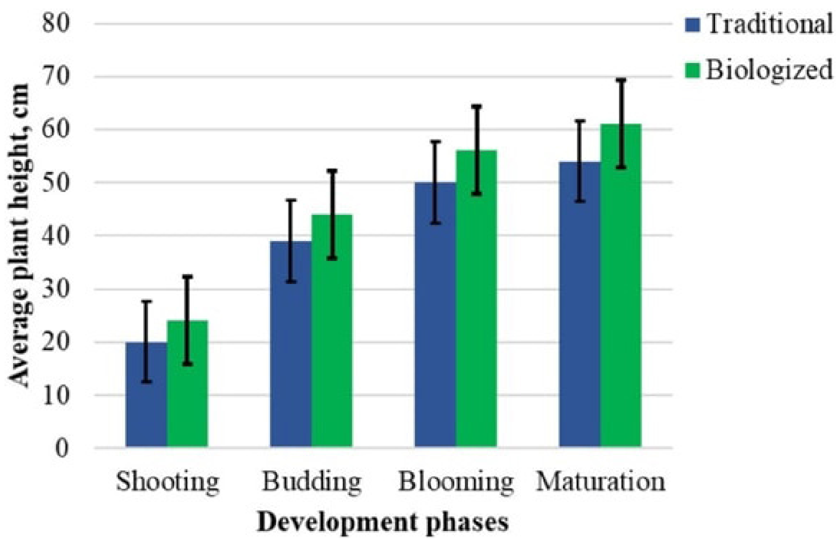

Figure 3. Dynamics of safflower growth depending on cultivation technology, cm

62.97 cm, or the plants of this variant remained 5.0 cm lower than the plants of the biologized technology variant (Figure 3).

As the accounting data showed, in the studies of 2019–2021, the greatest weed infestation of sunflower crops was observed in the control variant with the traditional technology. Thus, in the phase of 3–6 real leaves, when using the traditional (control) technology, 10 weeds with a raw mass of 30.98 g/m^2 were observed per 1 m^2. In the group with the biologized technology, the weed infestation of crops was 8 plants with a crude mass of 25.90 g/m^2, respectively. In the experimental plots, the following weeds were present: *Fallopia convolvulus*, *Capsella, Amaranthus retroflexus, Raphanus raphanistrum, Cirsium arvense, Echinochloa crus-galli, Chenopodium album*, *Convolvulus arvensis*.

On average, during the years of our studies in the blooming phase, the greatest weed infestation of safflower crops was established in the control group with the use of traditional technology. Here, 38 weeds with a raw mass of 182.55 g/m^2 were observed per 1 m^2. In the case of the use of biological preparations, the number of weeds was 23 plants with a raw mass of 115.64 g/m^2, respectively.

During the harvesting period in the control group, compared with the blooming phase, the number of weeds had increased by 10 plants, and the infestation in this variant was at the level of 48 plants/m^2. The weight of the raw mass of weed plants was 241.58 g/m^2. When using the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers, weeds of 35.5 plants per 1 m^2 with a raw weight of 182038 g/m^2 were found during the maturation of safflower.

In the studies of 2019–2021, the best indicators of the elements of the crop structure and the yield of safflower were established with the use of biologized cultivation technology.

Thus, the joint use of the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) by seed pretreatment and spraying during the growing season provided the number of productive anthodiums in safflower plants compared to the control variant up to 18.66 pcs per 1 plant.

With the average diameter of the anthodiums (2.22–2.51 cm) with the use of biologized technology, the number of seeds per 1 anthodium was 1.83 more compared with the control group. The use of biological preparations also contributed to an increase in the weight of 1,000 seeds from 42.83 g to 43.58 g (Table 6).

The huskiness of seeds is an indicator of quality that needs to be reduced. In the studies of 2019–2021, the huskiness increased with traditional cultivation technology to 33.63%. The lowest index of seed huskiness was noted when using biologized technology and equaled 32.43%.

In studies, the fat content in seeds decreased by 29.43% when using traditional technology. On average, in 2019–2021, as a result of comparative studies of safflower oil content, an increase in oil content to 30.68% was observed when using the biologized technology. From these studies, it can be seen that in the conditions of 2019–2021, the highest oil harvest of 0.28 t/ha was obtained with the joint use of the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) by seed pretreatment and spraying during the growing season. The use of traditional technology along with biological yield reduces the oil yield by 0.08 t/ha or by 40.00% (Table 7).

According to the results of the analysis, the average yield of safflower according to the traditional technology is 0.23 t/ha less compared to the biologized technology. For this sample, the value of p = 0.001 for the T-test, therefore, the difference in the average values is statistically significant.

The fat content in safflower seeds, depending on the cultivation technology according to traditional technology, is 1.23 t/ha lower compared to the biologized technology. The conducted

Table 6. The structure of elements of safflower yield depending on cultivation technology in the conditions of zone 1 of West Kazakhstan, on average for 2019–2021

Technology	Number of plants per 1 m^2, pcs	The number of productive anthodiums per 1 plant, pcs	Diameter of anthodiums per 1 plant, cm	Number of seeds per 1 anthodium, pcs	Weight of 1,000 seeds, g	Yield, t/ha
Traditional (control)	39.65	16.00	2.22	24.83	42.83.	0.68
Biologized	41.46	18.66	2.51	26.66	43.58	0.91

Table 7. Indicators of yield and quality of safflower depending on cultivation technology, on average for 2019–2021

Technology	Yield, t/ha			Oil yield, t/ha			Fat content, %		
	I	II	III	I	II	III	I	II	III
Traditional (control)	0.67	0.68	0.68	0.20	0.20	0.20	29.22	29.55	29.53
Biologized	0.89	0.89	0.93	0.27	0.27	0.29	30.53	30.65	30.85
T-test		***			***			***	

T-test of significance: *** – p <0.01. I, II, III are the replicates of the experiment.

statistical analysis showed the significant significance of the differences in the average at the level of p for the t-criterion.

The collection of safflower oil, depending on the cultivation technology, significantly depends on the cultivation technology, the differences in the average values of oil collection are 0.079 t/ha. According to the table, the significance of the differences in the averages for all indicators for the t-criterion is significant at the p <0.01.

In the study area of the technology, the area of cultivation of an important fodder crop of barley and the most popular oilseed crop of safflower among farmers is still insignificant, and the yield is low. For this reason, we set a goal to study the biologized technologies of barley and safflower cultivation in the organic farming system of West Kazakhstan.

The results showed that the biologized technology, along with biometric and qualitative indicators, had a noticeable effect on increasing the yield of fodder barley and oilseed safflower.

According to the study data, the reaction to the treatment of barley seeds with biological preparations was more significant. Barley in the control variant formed a yield that was significantly less than in the variants with seed treatment and the use of biological preparations during the growing season. Thus, on average, over the years of the study, the yield of barley in the control was 0.74 t/ha, and from the use of biological preparations, it increased to 0.94 t/ha, which is respectively 27.02% more than in the control group.

In the conditions of 2019–2021, the joint use of the Biodux biological preparation, the Organica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) provided an additional increase in fodder grain at the level of 0.20 t/ha, which is important for the conditions of animal husbandry in arid West Kazakhstan.

From these studies, it can be seen that in the conditions of 2019–2021, the highest oil harvest of 0.28 t/ha was obtained with the joint use of the Biodux biological preparation, the Orgamica

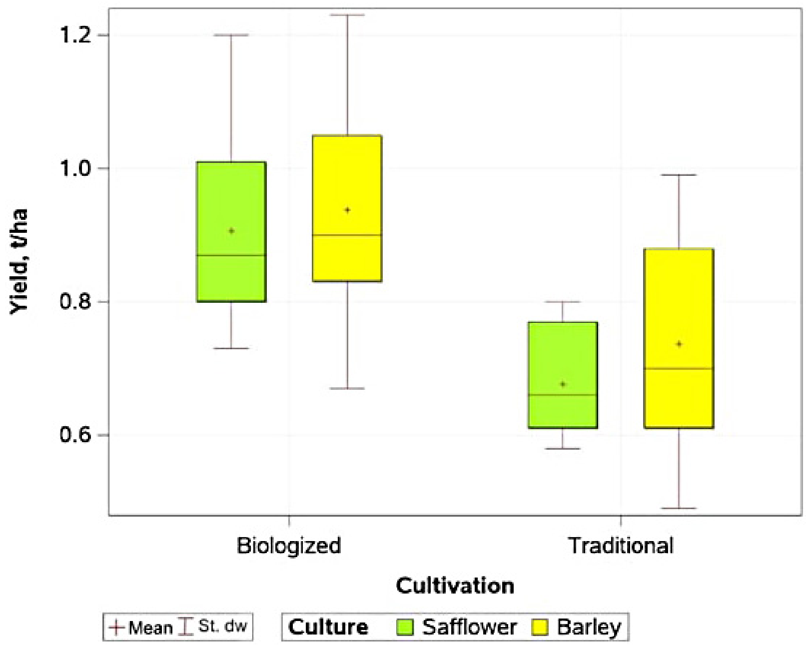

Figure 4. Barley and safflower yield depending on cultivation technology of West Kazakhstan, t/ha

S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) by seed pretreatment and spraying during the growing season. The use of traditional technology reduces the biological yield of safflower by 0.23 t/ha or by 33.82% (Figure 4).

It can be seen from the Box Plot diagram (Figure 4) that the distribution of safflower yield according to traditional and biologized technology is symmetrical, and the median is shifted closer to the center of the Box Plot. The variation in the yield of safflower by the biologized technology is higher than by the traditional one. There are significant differences in the yield levels of safflower according to traditional and biologized technologies. The yield according to the biologized technology, taking into account the variation, is significantly higher than the yield according to the traditional technology of growing safflower. The average yield of safflower according to the biologized technology differs from the traditional one by 0.230 t/ha. The analysis carried out by the T-test showed the significance of differences in the average values at the $p < 0.01$. Therefore, the choice of cultivation technology affects the yield of safflower.

It can be seen from the Box Plot diagram (Figure 4) that the distribution of barley yield according to traditional and biologized technology is symmetrical, and the median is shifted closer to the center of the Box Plot. The variation in the yield of barley according to biologized and traditional technology is equally high. The average yield of barley according to the biologized technology is higher than the traditional one by 0.201 t/ha. The analysis carried out by the T-test showed the significance of differences in the average values at the level of $p < 0.05$. Therefore, the choice of cultivation technology affects the yield of barley.

CONCLUSION

In general, to solve the problems of qualitative formation and rational use of agricultural landscapes of field crops in the system of organic farming, it is necessary to use biologized technologies with the use of organic biological preparations. The Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers were used in the studies and provided acceleration of seed germination, stimulation of shoot formation, and an increase in the yield of both barley and safflower. These preparations are widely available, inexpensive, and therefore the use of biological preparations will be increasingly used in agriculture.

Pre-sowing treatment of seeds and the use of biological preparations and biofertilizers during the growing season contribute to the activation of several growth-related, physiological and biochemical processes of plants, which leads to an increase in the yield of barley. With the combined use of the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology), the maximum yield indicators (0.94 t/ha) and the values of fodder units (0.88 t/ha), digestible protein (0.10 t/ha), as well as energy (10.68 GJ/ha) of fodder barley were obtained.

When using biologized technology, an increase in the oil content to 30.68% was noted. The highest oil yield of 0.28 t/ha was obtained with the joint use of the Biodux biological preparation, the Orgamica S biofungicide, and the Organit N and Organit P biofertilizers (biologized technology) by seed pretreatment and spraying during the growing season. The use of traditional technology along with biological yield reduces the oil yield by 0.08 t/ha or by 40.00%.

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