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Analysis of Efficiency of using Various Systems of Growing Flaxseed Oil Based on the Application of Siderates, Microfertilizers, Soil and Endophytic Microorganisms

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Abstract

The main purpose of our research was to study the effect of various growing systems, treatment of plant residues with nitrogen fertilizers and bacterial destructors of stubble, as well as the joint use of bacterial preparations and micro fertilizers on the parameters of plant height formation and the yield of flax oil in the Dry Steppe of Ukraine. In the process of carrying out our scientific work and writing the article, we used field, laboratory, statistical and computationally-comparative methods of research. We have established that the yield level and biometric parameters of flaxseed flax plants have high variability under the influence of the studied factors.

The combination of nitrogen fertilizers and stubble destructors, as well as tank mixtures with micro fertilizers and bacterial preparations using the canning growing system, ensured in the experiments the highest values of both plant heights and the yield of flaxseed oil.

Keywords: Flaxseed oil; Cultivation system; Plant residues; Stubble destructor; Nitrogen fertilizers; Fertilizing; Microfertilizers; Bacterial preparations; Plant height; Yield

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Introduction

The main objective of the biological product application system is to obtain high yields and quality products, which ultimately will provide a profit. Previously, the need for trace elements was satisfied by the introduction of manure and mineral micronutrients. Today, highly concentrated fertilizers that do not contain trace elements were used, and the amount of organic fertilizers has sharply decreased [1]. Often the lack of several grams of one of the necessary trace elements can limit the absorption of other nutrients and stop the further growth of productivity even on high backgrounds of mineral fertilizers [2].

The use of biological products contributes to the development of a powerful root system, which provides a more complete assimilation by plants of nutrients from the soil, and also increases the resistance of plants to drought, cold, and disease. The fertilizer application rate can be reduced by half or more due to the correct selection of the best predecessors, which are perennial leguminous herbs and leguminous crops. Alternative sources can be completely replaced by alternative sources of nutrients. The use of mineral fertilizers without organic and liming leads to significant acidification and complete degradation of soils. Reproduction of soil fertility can occur through the use of organic matter. In crop production, in the last period, there are significant changes. Various technology models have been developed: intensive, resource-saving, environmentally friendly, direct sowing (zero processing). A significant part of the sown area in the structure of crop rotation is occupied by crops. Grain production is the main agricultural sector in Ukraine. The yields of these crops fluctuate greatly in some years, and the differences are caused not so much by the difference in meteorological conditions over the years, but by imperfections of an agro technical nature, which is associated primarily with the general crisis state of the economy and the lack of funds for material support of technologies.

The absorption by plants of traditional mineral fertilizers from the soil is very low and is available only at soil temperatures of 12-25°C. The weather and climatic conditions of the Southern region (high temperatures, frequent dry winds, etc.) have become in recent years not very favorable for the absorption of mineral fertilizers from the soil. This factor has become the impetus for the search and scientific research of new technical methods to increase crop productivity. Such methods of modern technology for growing crops is the combination of the use of micronutrient fertilizers, green manure, and biological products containing soil and endophytic living microorganisms. The transformation of organic matter by microorganisms leads to an increase in the biological activity of the soil [1].

Materials and Methods

Experimental studies were carried out during the 2015-2016 agricultural year on the experimental field of the NNPTs of the Nikolaev National Agrarian University [3]. The experiments were laid in four repetitions. The soil is represented by southern chernozem, residually weakly solonetzic, hard loamy in forests. The reaction of the soil solution is neutral (pH - 6.8). The humus content in the 0-30 cm layer is 3.3%. Reserves of mobile forms of nutrients in the arable soil layer are nitrogen - 1.8, phosphorus - 7.9, potassium - 17.5 mg per 100 g of soil. The total sown area is 54 m^2, accounting - 25 m^2. Four repetitions. The predecessor is winter wheat. The background was a mineral fertilizer with a dose of N34P34K34. The experimental design included the following options:

Factor A (Growing Systems):

Mulching; Preserving; Traditional (Control).

Factor B (Options for the destruction of plant residues):

Without the use of nitrogen fertilizers and stubble destructor (Control); Using 100 kg / ha of ammonium nitrate; Using EcoStern (2.5 l / ha) + 100 kg / ha of ammonium nitrate.

Factor C (Micronutrient fertilizers and bacterial preparations):

Water treatment 300 l / ha (Control); Water treatment 300 l / ha + Biocomplex-BTU-r (0.7 l / ha) + urea (5 kg / ha); Water treatment 300 l / ha + Quantum microfertilizer system (Quantum complex chelate fertilizer - Technical (2.0 l / ha)) + Quantum functional microfertilizer - AquaSil (2.0 l / ha)) + urea (5 kg / ha); Water treatment 300 l / ha + Biocomplex-BTU-r (0.7 l / ha) + Quantum microfertilizer system (complex chelated fertilizer Quantum - Technical (2.0 l / ha) + functional microfertilizer Quantum - AquaSil (2.0 l / ha)) + carbamid (5 kg / ha).

The agrotechnics of the experiments was generally accepted for the Steppe zone of Ukraine, in addition to winter hardiness, they studied. The number of preparations prescribed by the experimental schemes was dissolved in water immediately before spraying the crops, the control was treated with an appropriate amount of water. Crop processing was carried out manually. Harvesting was carried out by the Sampo-130 combine in areas with grain sampling for analysis; grain weight was transferred to standard humidity and 100% purity. Crop accounting was carried out by direct weighing from the test plot, and seeds and secondary products by trial sheaf.

During the growing season, phenological observations were carried out, the reserves of productive moisture in the meter layer of soil were determined, the dynamics of mobile nutrients under crops of crops was studied. Research and analytical work was carried out by applicable regulatory documents, soil and plant sampling techniques, analyzes, and evaluation of their results. The reliability of the results of analytical and field studies is determined by the number of repetitions, mathematical analysis [4-7].

To accelerate the decomposition of crop residues of winter wheat, the EcoStern biological product was used at the rate of 2.5 l / ha + 20 kg of urea. To introduce the components, an OP-2000 sprayer was used. The rate of flow of the working fluid was 300 l / ha. At the same time, after applying EcoStern, plant residues were planted into the soil to a depth of up to 10 cm, creating the necessary amount of useful microbial grouping.

According to the experimental scheme, top dressing with biological products and micronutrient fertilizers of oil flax was carried out in the "herringbone" phase (date of application is May 20-27), depending on the year of research.

Results and Discussion

The period of seed germination, the emergence of seedlings, and the period of plant development are the most demanding on moisture in the soil? Therefore, the main task of the treatment was to create the most favorable agrophysical conditions in the sowing layer of the soil. In the first half of the growing season, with sufficient soil moisture, the development phases pass without deviations, relatively high and healthy seed yield is formed. The root system is relatively well developed and grows in land.

In the process of carrying out scientific research, phenological observations of the biometric indicators of the aerial part of the oil flax culture were carried out (Table 1). Higher indicators of the length of the aerial parts of plants (50-54 cm) were noted in the version with a preserving treatment system with the integrated use of the biological product Bio complex-BTU-r and the Quantum micronutrient system against the background of treatment of plant residues with the EcoStern stubble destructor and ammonium nitrate. When using a mulching and traditional processing system, this indicator decreased. Without the use of stubble destructors, oil flax plants had the smallest height - from 35 to 50 cm, depending on the year of research.

According to the control variant (with the traditional cultivation system without the use of nitrogen fertilizers and stubble destructor, as well as without the use of micronutrient fertilizers and bacterial preparations) and a similar variant in the mulching cultivation system, they were the lowest (35-39 cm). The preserving system for growing oil flax in the variant without the use of nitrogen fertilizers and a stubble destructor was formed by tall plants (40-46 cm). With the use of micronutrient fertilizers and bacterial preparations, with the same growing system, the height of the plants increased and the maximum (46-50 cm) was treated with the bacterial preparation Bio complex-BTU-r and the Quantum micronutrient system with the simultaneous application of 5 kg/ha of urea, while the average height of plants varied from 40 to 45 cm according to options, and from 39 to 48 cm according to growing systems.

In the experiment with the use of ammonium nitrate to enhance the decomposition of plant residues, a practically similar situation was manifested, except that even in the control variant, without the use of microelements and bacterial preparations, the oil flax plants were higher (42-46 cm) in the mulching system compared with plants with the traditional technology of growing crops (40-42 cm).

The use of ammonium nitrate increased the height of plants by an average of 4 cm in factors, forming them as high as possible (from 49 to 53 cm) by the preserving system for growing and using the bacterial preparation Bio complex-BTU-r and the Quantum micro fertilizer system with the simultaneous application of 5 kg/ha of urea. Ammonium nitrate made it possible for oil flax plants to form almost the same height (from 44 to 47 cm) using traditional and mulching growing systems, slightly differing in the variants with preparative elements.

The habitus of plants in height with a preservative growing system differed by 1-5 cm for other experimental options. A further increase in the average plant height by 1 cm according to the version with the destruction of winter wheat stubble using ammonium nitrate and by 5 cm with flax patches without the use of nitrogen fertilizers and bacterial destructors was noted when EcoStern was added together with ammonium nitrate.

The maximum plant height of 52 cm in the experiment (on average over 2 years) was noted with a preservative growing system using the bacterial preparation Biocomplex-BTU-r and the Quantum micronutrient system with the simultaneous application of 5 kg/ha of urea. Over the years, it varied from 50 to 54 cm in this variant, and in general, when using EcoStern and ammonium nitrate, the difference in the height indices was 13 cm.

The use of the bacterial preparation Bio complex-BTU-r and the Quantum micro fertilizer system also affected the change in the height of oil flax plants. Thus, their average rate of 48 cm was observed in the combined use as a feed-in herringbone phase. The single-use of the preparations increased the plant height to 2 cm (for the use of the Quantum microelement system) and up to 3 cm (for the use of the bacterial preparation Bio complex-BTU-r) in comparison with the control variant. In the process of scientific research, we carried out phenological observations of the density and average height of plants in the growth phases. Higher indicators of oilseed flax were observed in an experiment using the EcoStern stubble destructor and ammonium nitrate (Table 1).

High air temperature negatively affected the crop, causing burns of plants, reduced photosynthesis, the formation of fruiting organs, and seed yield, which ultimately leads to a significant shortage of yield, but they still differed quantitatively in terms of seed yield from the plant according to the experimental options.

The biological productivity of oil flax was formed at a level of 1.12 t / ha to 1.90 t / ha, depending on the tillage systems, nitrogen fertilizers, micronutrient fertilizers, and biological products (Table 3 and Table 4). The weight of 1000 seeds ranged from 5.5 g to 6.7 g, depending on the variant of the experiment. In the area where the bacterial preparation Bio complex-BTU-r and the Quantum micro fertilizer system were introduced with the simultaneous application of 5 kg/ha of urea, a higher yield was recorded for the conservation soil cultivation system, which averaged 1.88 t / ha and compared to the control yield increase was 0.7 t / ha.

Thus, the use of complexes Bio complex-BTU-r and EcoStern, as well as the Quantum micronutrient system, leads to improved plant growth and development processes, an increase in the area of leaf assimilation surface and yield.

Based on the experimental data we obtained in (Table 2), the average yields of oil flax depending on the applied nitrogen fertilizers and stubble destructor varied from 1.44 t / ha to 1.61 t / ha, and the weight of 1000 seeds from 6.3 g to 6.7 g, depending on the application of nitrogen fertilizers and stubble destructors (Figure 1).

In general, the average yield of oilseed flax seeds for all experimental variants for 2015-2016 was 1.52 t / ha, varying from 1.12 to 1.90 t / ha depending on the variant and year of research. The crop growing system proved to be the most productive, in which this indicator varied from 1.29 to 1.90 t / ha, and averaged 1.60 t / ha. Using mulching and traditional technology, oil flax yields were obtained lower 1.12 to 1.75 t / ha and from 1.13 to 1.71 t / ha, respectively. That made it possible to

Table 1: Oil flax indicators depending on the application nitrogen fertilizers and stubble destructor, (average for 2015-2016).

Phase of development	**The length of the aerial part of oil flax, cm**			**The density of oil flax plants, pcs / m²**		
Sprouting phase	I*	II**	III***	I*	II**	III***
Full shoots	2	3	2	425,0	435,0	455,0
Phase herringbone	11	13	12	418,5	427,1	451,0
Bud formation phase	31	35	35	412,2	423,3	445,4
Bloom	43	47	48	396,0	416,2	440,7
Early yellow ripeness	43	47	48	395,8	415,4	440,5
*Without the use of nitrogen fertilizers and stubble destructor; **Using ammonium nitrate; ***Using EcoStern+ammonium nitrate.						

Table 2: Oil flax seed yield depending on the applied nitrogen fertilizers and stubble destructor (average for 2015-2016 year.)

Indicator	**Experience Options**		
	I*	**II****	**III*****
Yield, t / ha	1,44	1,52	1,61
Growth before Control, t / ha	-	+0,08	+0,17
The mass of 1000 seeds, g	6,3	6,6	6,7
*Without the use of nitrogen fertilizers and stubble destructor; **Using ammonium nitrate; ***Using EcoStern+ammonium nitrate.			

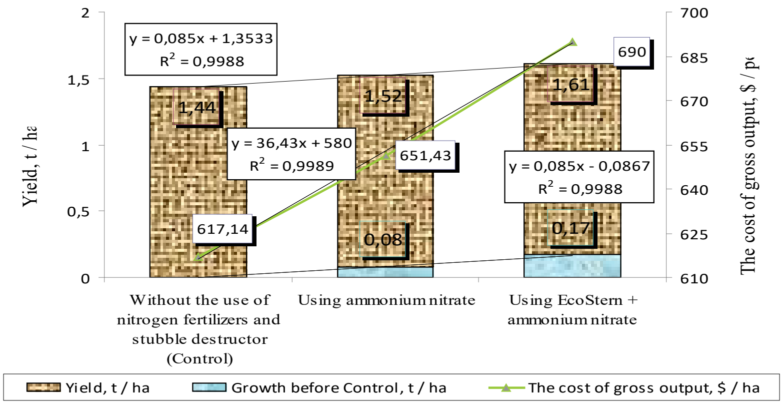

Figure 1: The straight line of the trend and the value of the approximation reliability according to the effect of nitrogen fertilizers and stubble destructor on productivity oil flax seeds (average for 2015-2016).

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obtain average indicators for them of 1.50 and 1.4 t / ha.

The use of micronutrient fertilizers and bacterial preparations also affected the yield of oil flax seeds. So, the control variant, which formed it at the level of 1.33 t / ha, turned out to be the lowest average yield indicators for this factor. With the use of bacterial preparations and micronutrient fertilizers, the yield increased and amounted to: when processing crops with the bacterial preparation Biocomplex-BTU-r with the simultaneous application of 5 kg / ha of urea - 1.56 t / ha, while treating the crops with the microfertilizer system Quantum with simultaneous application of 5 kg / hectare of urea - 1.53 t / ha; and when processing crops with a complex of the bacterial preparation Biocomplex-BTU-r and the Quantum microfertilizer system with simultaneous application of 5 kg / ha of urea - 1.66 t / ha.

In the test cases without the use of nitrogen fertilizers and a stubble destructor, the yield of oilseed flax seeds varied from 1.12 to 1.66 t / ha, depending on the growing system and the preparations used in the feed. Despite the difference in yield indices for feeding options with micronutrient fertilizers and bacterial preparations, on average for this factor, this indicator in the traditional and mulching growing systems was equal to 1.41 t / ha. A little higher (1.49 t / ha) he was behind a preservative growing system.

When using ammonium nitrate for the decomposition of plant residues of the precursor of oil flax (winter wheat), the situation slightly changed in the direction of increasing the yield by 0.04 t / ha according to the mulch growing system (1.50 t / ha) relative to the traditional one. The lowest indicator for this factor (1.46 t / ha) was characterized by plants using traditional growing technology. An increase in the average yield by 0.09 and 0.13 t / ha compared with the previous ones was provided by the preserving system. A similar pattern in the formation of oilseed flax seed yield was also observed in the experimental plots using the EcoStern bio destructor and ammonium nitrate, but the difference between the indices for different cultivation technologies was more significant. According to the traditional, mulching, and preserving system, these indicators were 1.52; 1.59 and 1.3 t/ha, respectively.

The difference between the indicators in the yield of oil flax seeds, depending on the use of micronutrient fertilizers and biological products for different growing systems, had a large variation (from 0.29 to 0.41 t / ha) in the experimental versions where nitrogen fertilizers and bacterial preparations were used to decompose plant residues. When using ammonium nitrate and a tank mixture with ammonium nitrate and the bacterial destructor EcoStern, variation on this factor decreased from 0.28 to 0.37 t / ha and from 0.28 to 0.35 t / ha, respectively. A comparison of economic indicators of the technology of growing oil flax was carried out according to general methods taking into account the factors studied (Figure 2).

Based on the data obtained by us, it can be stated that the growing systems affected the financial and economic indicators during the cultivation of oil flax. So, the highest indicators of the formation of gross crop production in monetary terms ($ 685.71) were obtained for growing according to the preserving system, which ensured an increase of $ 60.00 compared to the control variant (traditional technology). Using a mulching system formed the average cost of gross output growth relative to the control of $ 17.14, which is $ 42.86 less compared to the best option. Growing oilseed flax culture by mulching and preserving systems led to a decrease in gross costs compared with traditional technology by $ 4.77 and $ 2.08 / ha, with a profit of $ 330.02 and $ 370.19 / ha, profitability 105, 5 and 117.3% and the economic effect of 21.91 and 62.08 $ / ha, respectively (Figure 3).

The maximum cost of gross production of oil flax in the study of the influence of factor B ($ 690.00 / ha) was observed when using

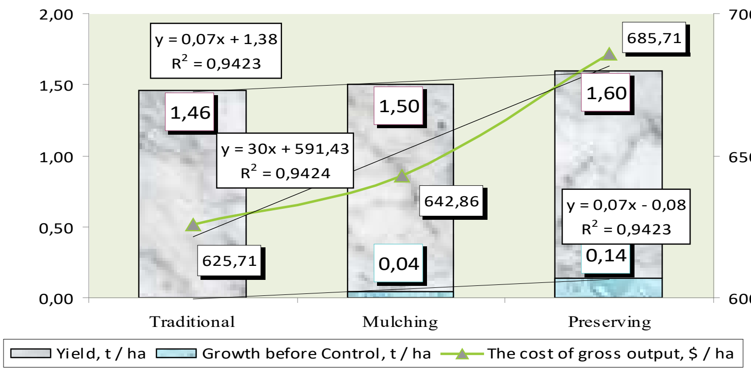

Figure 2: A straight line of the trend and the value of the approximation reliability according to the influence of growing systems on productivity indicators, its growth and the gross cost of oil flax seeds per hectare (average for 2015-2016 year).

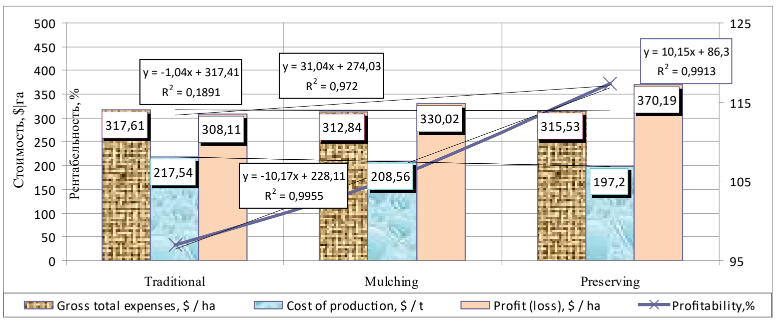

Figure 3: The straight line of the Trend and the value of the approximation reliability by the influence of the growing system on the indicators of gross expenditures, cost, profit and profitability of oilseed flax seed production (average for 2015-2016 year).

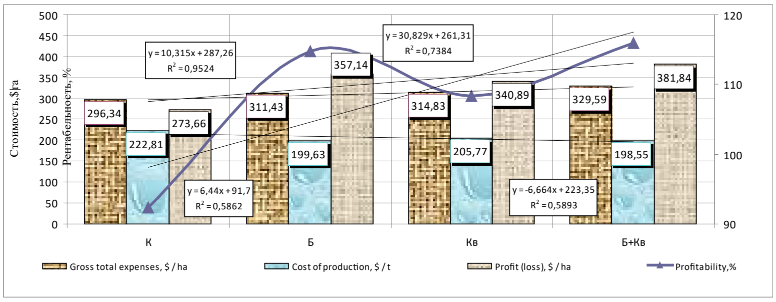

Figure 4: A direct trend line and the value of the approximation reliability according to the influence of micronutrient fertilizers and bacterial preparations on the indicators of gross expenditures, cost, profit and profitability of oilseed flax seed production (average for 2015-2016 year).

nitrogen fertilizers and stubble destructor. The use of only ammonium nitrate for the destruction of plant residues led to its reduction by $ 38.57 ($ 651.43 / ha). The lowest cost of gross output ($ 617.14 / ha) was obtained in the control variant. Fertilizing micronutrient fertilizers and bacterial preparations (Figure 4) in the experiment were the most effective, and the gross production variability for two years on average was $ 141.43 / ha, varying from $ 570.00 / ha in the control variant to $ 711.43 / hectares for using the bacterial preparation Biocomplex-BTU-r and the Quantum microfertilizer system as a top dressing with the simultaneous introduction of 5 kg / ha of urea. The gross cost of obtaining oilseed flax products as a result of the application of feed feed during the growing season, the form of the drug relative to the control variant increased by 15.09, 18.49 and 33.25 $ / ha when processing crops with the bacterial preparation Biocomplex-BTU-r with a simultaneous application of 5 kg / hectare urea, when processing crops with the Quantum microfertilizer system with simultaneous application of 5 kg / ha of carbamide and when treating crops with a complex of the bacterial preparation Biocomplex-BTU-r and the Quantum microfertilizer system with simultaneous application of 5 kg / ha mida respectively.

These options provided a profit of $ 357.14, 340.89 and $ 381.84 / ha, profitability of 114.7, 108.3 and 115.9% and an economic effect of 83.48, 67.23 and $ 108.18 / ha, while the control yield options of $ 273.66 / ha and a profitability level of 92.3%.

Conclusion

According to the results of studies conducted by us during 2015-2016, we can conclude that using a preservative treatment system, the culture of oil flax in a field crop rotation in the southern chernozem of the dry Steppe zone of Ukraine, ensured a high biological yield of seeds (1.86-1.90 t / ha) and a mass of 1000 seeds against the background of mineral nutrition N34P34K34, in an experiment with the treatment of plant residues of winter wheat as a precursor with a bacterial preparation, EcoStern destructor, at a rate of 2 l / ha and simultaneous application of ammonia total saltpeter 100 kg / ha in physical weight with a working solution of 300 l / ha and using the bacterial preparation Biocomplex-BTU-r and the Quantum micronutrient system with the addition of 5 kg / ha of urea as a top dressing of vegetating plants in the herringbone phase.

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Conflict of interest

The author declares that there is no conflict of interests regarding the publication of this manuscript.

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