Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC EVALUATION OF THE EFFECT OF THE APPLICATION OF BIOSTIMULANTS ON SPRING RAPE AND OATS

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Abstract

The effect of the application of biostimulants in agricultural crops has not been fully studied and evaluated from an economic aspect. The purpose of the research is to assess the economic efficiency of the application of biostimulants in the organic production of spring rapeseed and oats. 2-year field trials were conducted using a block method with foliar treatment with Chitosan, Vermicomposting and nature-identical growth regulator in 2 phenological stages. The biological response of the crops at different doses of the biostimulants was investigated. The obtained primary results were used as input data for the construction of an economic-mathematical model for economic evaluation. In a methodological aspect, linear modeling is applied in order to optimize the production structure of a selected agricultural holding. It is concluded that biostimulants have a positive effect on yield and biometrics of treated crops, but the complex economic effect on farm profit is organic.

Key words: *biostimulants, economic evaluation, economics model, spring rape, spring oats*

INTRODUCTION

The economic evaluation of the effect of biostimulators (BS) in agriculture is still a challenge in scientific research not only in Bulgaria, but also in the world [12, 4, 14, 6, 19, 20, 21, 22]. They are particularly relevant at the moment and in practice are an alternative for farmers in accordance with the implementation of the goals set in the Green Deal of the new CAP until 2027. In search of answers from policymakers and stakeholders [5]. Many interdependent factors should be taken into account, related not only to purely technological [13], experimental and legal constraints, but also to the diversity of economic, social, environmental and behavioral aspects [2, 26, 8]. It is currently known. Scientific research on the economic efficiency of treating agricultural crops with biostimulants (BS) has been a matter of debate for some time. In Bulgaria, this topic is a relatively new field. Although growth regulators are known to provide benefits, the economic aspects have not been fully explored. Globally, a uniform methodology for evaluating the economic benefits of the application of biostimulants in agriculture has not even been adopted. Researchers are most often limited to reporting the increase in yield, as well as some indicators in the different phenophases.

Nowadays, it is even more important to analyze whether the use of biostimulants is economically effective for farmers and whether they will contribute to increasing the profit of agricultural holdings as a whole.

Some authors indicate that treatment with biostimulators favorably affects the porosity of the soil structure, bulk density and yields [9]. Other authors in their publications emphasize that biostimulators have a positive effect on the biometric indicators of plants, as follows: branching of root structure, branching of stems, increase in leaf mass, twining, number and weight of grains, fruit yield. Often, the influence of growth regulators on the preservation of flower buds and joint ripening of fruits is enhanced [24]. From a methodological point of view, the usefulness and economic efficiency of a given biostimulator should be calculated based on the business plan of the agricultural holding. This means determining the usefulness of biostimulants in building the production structure of this farm. If the treatment of different BSs is found to have a positive economic effect on that farm, then those BSs are considered economically beneficial. We hypothesize that treatment with a certain biostimulator can increase the yield and maximize the profit of the respective crop per unit area, but to accept that this biostimulator is economically effective, it must increase the profit of the agricultural holding as a whole. The purpose of this study is to make an economic evaluation of the effect of the treatment with certain biostimulants on spring rape and oats. We proceed methodically from the point of view of the business plan. Therefore, it focuses on optimization of the production structure of a selected agricultural holding. On this basis and the obtained optimization, the economic evaluation of the effect of foliar treatment with biologically active substances with different concentrations on spring rapeseed and spring oats is given. Both crops were treated with biostimulants developed at the Institute of Cryobiology and Food Technologies at the Agricultural Academy.

The working hypothesis is that BS treatment will increase yield of rape and oats and will have a positive impact on the biometric indicators of the crops, but this will not analogously increase the economic efficiency of the specifically selected agricultural holding. Spring rape is characterized by its high yield of both seeds and oil. The oil is rich in fatty acids and has a wide range of uses. Although spring oilseed rape has a lower oil content than winter types, with the help of selection of suitable varieties with a relatively high oil content, this can be compensated. Global production of rapeseed has increased sixfold since 1975. Since the beginning of the new millennium, biodiesel production has been steadily increasing, and rapeseed oil is a good alternative among the vegetable oils required for biofuel production. Globally, in 2019, Canada was the leader in canola production with 18.5 million metric tons. In Europe, the first place is occupied by France with 3.5 million metric tons, followed by Ukraine – 3.3 million meters. etc. Spring canola will be an integral part of the future of agriculture, helping to meet new environmental and rotational requirements.

Oats are rich in fat, the amount of which can reach up to 18% [16]. In 2021, world oat production is over 22 million tons - Russia with 17% of the total and Canada with 12%. Spring oats (*Avena sativa*) are a unique species, usually ready for pasture after 50 days or for hay after 70 days. Agronomists point out that the synergistic benefit of cultivating spring oats is to control the spread of weeds and conserve soil moisture. Very often a high yield can lead to crop latency. Oats have numerous uses in food - crushed oats, a variety of baked goods, a milk substitute, several different beverages, and more.

There are numerous publications on the subject in the scientific literature. For example: Observations on the phytosanitary status of crops in organic and conventional agriculture, the degree of weeding of winter oats [1]; in organic, biodynamic and conventional oat cultivation [15]; evaluation of the yield potential of different oat cultivars [7]; the effect of growth biostimulators on oat formation grain yield and evaluation of the economic efficiency of its use [3], evaluation of four biostimulants in different concentrations on fodder oats [11], etc.

[17] studied physiological parameters and the ameliorative effect of the application of plant biostimulants on rapeseed. In natural field experiments, biostimulants have a significant effect on plant growth in autumn, acclimatization to the cold, overwintering of plants [10]. According to [23] biostimulants increase dry matter accumulation in spring rape, etc.

MATERIALS AND METHODS

For primary data, the results obtained from the Agricultural Experimental Station (AZS) are used, in an experimental field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" - Ruse at the Agricultural Academy [25]. In the two-year period 2021-2022, 19 plots of 10 square meters each were prepared, in which seeds of spring rape (*sorte Lakritz, brassica napus* L.) and oat (*sorte Alexa*) were planted. The selection of 19 plots is consistent with the condition of having 1 control plot for both crops and 18 plots on which three repetitions of three biostimulants (BS) will be made. The spring rape and spring oatwere treated with biostimulants developed at the Institute of Cryobiology and Food Technologies (ICFT) at the Agricultural Academy, Sofia at different concentrations of the active substance. Yields of spring rape and oats, 2021 and 2022 crops are presented in Tables 1 and 2 below.

Table 1. Yield of spring rape, harvest 2021 and 2022 (average)

Biostimulant	1 rep (kg)	2 reps (kg)	3 reps (kg)	Total (kg)	Average (kg)	kg/dca	Index	% humidity
Chitosan 500 ml/ dca	1.38	1.34	1.32	4.04	1.35	134.50	1.08	8.60
Chitosan-2*500 ml/ dca	1.30	1.28	1.27	3.84	1.28	127.98	1.03	8.60
Vermi compost extract 500 ml/ dca	1.21	1.26	1.30	3.77	1.26	126.25	1.02	8.40
Vermicompost + nature-identical growth regulator 2*500 ml/ dca	1.24	1.28	1.29	3.81	1.27	126.92	1.02	8.60
Vermicompost extract 2*500 ml/ dca	1.34	1.30	1.31	3.94	1.31	131.32	1.06	8.80
Vermicompost + nature-identical stretch regulator 500 ml/ dca	1.26	1.25	1.26	3.77	1.26	125.52	1.01	8.30
Control	1.20	1.24	1.29	3.73	1.24	124.17	1.00	8.60

Source: The primary data from The Agricultural Experimental Station (AES) in a test field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" – Ruse, Agricultural Academy, Bulgaria, 2021-2022 [25].

Table. 2. Yield of spring oats, harvest 2021 and 2022 (average)

Biostimulant	1 rep (kg)	2 reps (kg)	3 reps (kg)	Total (kg)	Average (kg)	kg/dca	Index	% humidity
Chitosan 500 ml/ dca	2.62	2.21	2.32	7.15	2.38	238.47	1.14	13.35
Chitosan-2*500 ml/ dca	2.21	2.47	2.51	7.19	2.40	239.70	1.15	13.50
Vermi compost extract 500 ml/ dca	2.57	2.15	2.38	7.09	2.36	236.42	1.13	13.55
Vermicomposting + nature-identical growth regulator 2*500 ml/ dca	2.09	2.06	2.22	6.37	2.12	212.38	1.02	14.45
Vermicomposting extract 2*500 ml/ dca	2.59	2.12	2.51	7.21	2.40	217.80	1.04	14.00
Vermicomposting + nature-identical stretch regulator 500 ml/ dca	2.33	2.04	2.31	6.67	2.22	222.42	1.06	13.40
Control	1.94	2.03	2.31	6.28	2.09	209.17	1.0	13.50

Source: The primary data from The Agricultural Experimental Station (AES) in a test (experimental) field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" – Ruse, Agricultural Academy, 2021-2022 [25].

In order to make an economic evaluation of the treatment with biostimulants, an economic-mathematical model based on linear programming is applied. The solution of the mathematical problem reflects with adequate accuracy the most significant dependencies of the studied problem. Methodologically, the task is constructed in a system of linear constraints. They reflect the natural-climatic and agronomic conditions that should be taken into account when searching for the optimal solution [18].

The objective function represents the optimality requirement (min, max):

$$A_{11} X_1 + A_{12}X_2 + ... + A_{1n}X_n \leq B_1$$
$$A_{21} X_2 + A_{22}X_2 + ... + A_{2n}X_n \geq B_2$$
$$..(1)$$
$$\vdots$$
$$A_{m1} X_1 + A_{m2}X_2 + ... + A_{mn}X_n = B$$

____ ,

$F = C_1X_1 + C_2X_2 + … + C_nX_n \rightarrow max (min)$,

where:
Xj – the extent of activities or indicators
Aij and Cj - shows the coefficients before activities Xj
Bi - shows the amounts of own resources or size of activities.
F – Objective function under optimality criterion

The objective function is constructed in such a way that it is influenced by the area of cultivated land of the different crops used on the one hand, without the application of biostimulants (wheat, corn, sunflower, spring oats - control and spring rape - control), as well as with crops with included biostimulants (spring oats and spring rapeseed). Income from commodity crops (intended for sale), and subsidies (when we use subsidies in the optimization), crops treated with different biostimulants and in different concentrations (chitosan 500 ml/ha; chitosan 2*500 ml/ha; vermicompost extract 500 ml/ha; vermicompost extract 2*500 ml/ha; vermicompost + natural growth regulator 2*500 ml/ha, production costs, gross margin and profit subsidy).

The construction of the model uses two criteria - max gross margin and max profit. There were build two economic-mathematical tasks based on these criteria:

First task. A task with optimized production structure of a farm, considering the agrotechnical requirements for crop rotation. The solution gives the most optimal production structure under both criteria of *max gross margin and max profit*. It will allow obtaining a decision on how to optimally combine available resources (land, labor force, size of arable land) and farm constraints; what crops to produce; agrotechnical requirements; which biostimulants to apply; on which cultures and in what concentration to be applied BS; in which phase to treat them to achieve the highest economic effect.

Second task. There were set bounds for the minimal and maximum size of the arable land, including crops treated with biostimulants. The aim is to find an optimal solution, achieving *max gross margin* and *max profit*. The solution gives the optimal combination of the most economically effective productions. The result is the best combination of the available resources (land, labor resources, and various biostimulants), giving specific constraints. Also, what crop to produce and what agrotechnical requirements? All this achieves the highest economic effect.

Defined variables and constrains

The subjective restrictions shrink the possible solutions. This is because including more different group criteria in the model (e.g., land, crops, BS, land constraints, labor force, etc.) searches for a balance between the defined constraints and often leads to compromise solutions to the task.

The variables used to evaluate the BS effect on economic efficiency are presented in Tables 3 and 4.

Table. 3. Variables with biostimulants treatment

Crop	Biostimulants (ha)						
	Control	BS1_CH	BS2_2CH	BS3_V	BS4_2V	BS5_VR	BS6_2VR
Spring rape	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
Spring oat	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}

Source: Authors' calculations.

Table 4. Other variables

Other crops (ha)		Resources		Finance (BGN)	
x_1	Wheat	x_{18}	Own arable land (ha)	x_{22}	Income
x_2	Corn	x_{19}	Rented arable land (ha)	x_{23}	Material costs
x_3	Sunflower	x_{20}	Permanently employed mechanics (number)	x_{24}	Labor costs
		x_{21}	Permanent employees (number)	x_{25}	Margin
				x_{26}	Gross margin
				x_{27}	Fixed costs
				x_{28}	Profit
				x_{29}	Profit with subsidies

Source: Authors' calculations.

In addition, it was used other factors such as other crops, resources (land, labor force), and financial indicators (gross margin, costs, profit).

Constrains

The constraints of the optimal plan are divided into three groups: land usage (Table 5); labor (Table 6); and supporting constrains (Table 7).

Table 5. First group of constrains related to the land usage (ha)

Constrains	Formula	
	Optimal production structure task (first)	Max and min area bounds task (second)
Area constrains (acres)	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} = x_{18} + x_{19}$	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17\_}17 \leq x_{18} + x_{19}$
Constrain on rented area (ha)	$x_{19} = 11{,}000$	$x_{19} \leq 11{,}000$
Constrain on owned area (ha)	$x_{18} = 1{,}000$	
Autumn cereal crops, minimum 45% of the sowing area (ha)	$x_1 \geq 5{,}400$	
Autumn cereal crops, minimum 55% of the sowing area (ha)	$x_1 \leq 6{,}600$	
Sunflower, maximum 17% (1/6) of the sowing area (ha)	$x_3 \leq 2{,}040$	
Constrains on the land, using BS, minimum (ha)		$x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} \geq 3{,}360$
Constrains on the land, using BS, maximum (ha)		$x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} \leq 4{,}560$

Source: Authors' calculations.

Table 6. Second group of constrains related to the labor (number)

Constrains	Formula
Permanently employed mechanics(number)	$x_{20} = 4$
Permanent employees (number)	$x_{21} = 2$

Source: Authors' calculations.

Table 7. Third group of constrains, supporting (BGN)

Constrains	**Formula**
Income	$116x_1 + 136x_2 + 190x_3 + 133{,}52x_4 + 135{,}48x_5 + 120{,}08x_6 + 118{,}63x_7 + 115{,}79x_8 + 127{,}12x_9 + 115{,}95x_{10} + 72{,}31x_{11} + 85{,}14x_{12} + 101{,}49x_{13} + 106{,}53x_{14} + 56{,}41x_{15} + 83{,}82x_{16} + 90{,}63x_{17} = x_{22}$
Variable material costs	$27x_1 + 27x_2 + 26x_3 + 24{,}5x_4 + 39{,}5x_5 + 39{,}5x_6 + 39{,}5x_7 + 39{,}5x_8 + 39{,}5x_9 + 39{,}5x_{10} + 31x_{11} + 46x_{12} + 46x_{13} + 46x_{14} + 46x_{15} + 46x_{16} + 46x_{17} = x_{23}$
Labor costs	$x_{24} = 18{,}000x_{20} + 18{,}000x_{21}$
Fixed costs	$x_{27} = 55x_{19}$
Margin	$x_{25} = x_{22} - x_{23}$
Gross margin	$x_{26} = x_{22} - x_{23} - x_{24}$
Profit	$x_{28} = x_{22} - x_{23} - x_{24} - x_{27}$

Source: Authors' calculations.

Objective function

The objective function and the constrained values were added in the following linear programming model, using two optimal criteria – max gross margin and max profit.

$F = 80x_1 + 102x_2 + 155x_3 + 100.02x_4 + 86.98x_5 + 71.58x_6 + 70.13x_7 + 67.29x_8 + 78.62x_9 + 71.05x_{10} + 32.31x_{11} + 30.14x_{12} + 46.49x_{13} + 51.53x_{14} + 1.41x_{15} + 28.82x_{16} + 35.63x_{17} - 18{,}000x_{20} - 18{,}000x_{21}$ →**Max gross margin, ...**(2)

$F = 80x_1 + 102x_2 + 155x_3 + 100.02x_4 + 86.98x_5 + 71.58x_6 + 70.13x_7 + 67.29x_8 + 78.62x_9 + 71.05x_{10} + 32.31x_{11} + 30.14x_{12} + 46.49x_{13} + 51.53x_{14} + 1.41x_{15} + 28.82x_{16} + 35.63x_{17} - 18{,}000x_{20} - 18{,}000x_{21} - 55x_{19} + 31x_{18} + 31x_{19}$ →**Max profit...** (3)

In the objective function, two criteria for the optimality of the solution are set: max gross margin and max profit.

RESULTS AND DISCUSSIONS

Analysis of the obtained results

Making a management decision is an extremely important and responsible task for agrarian entrepreneurs. The results obtained from the optimization are shown in tabular form presented below.

Table 8. Production structure and economic results of application of biostimulants

Unknown	Name	dca	Number	BGN
x_1	Wheat (dca)	5,400		
x_2	Maize, (dca)	0		
x_3	Sunflower, (dca)	3,240		
x_4	Spring rape – control (dca)	0		
x_5	Spring rape - BS 1 Chitosan 500 ml/ dca	3,360		
x_6	Spring rape – BS 2 Chitosan-2*500 ml/ dca	0		
x_7	Spring rape – BS 3 Vermi compost extract 500 ml/ dca	0		
x_8	Spring rape – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_9	Spring rape – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{10}	Spring rape BS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{11}	Spring oats – control (dca)	0		
x_{12}	Spring oats - BS 1 Chitosan 500 ml/ dca	0		
x_{13}	Spring oats– BS 2 Chitosan-2*500 ml/ dca	0		
x_{14}	Spring oats – BS 3 Vermi compost extract 500 ml/ dca	0		
x_{15}	Spring oats – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_{16}	Spring oats – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{17}	Spring oats BS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{18}	Ownarableland (dca)	1,000		
x_{19}	Leased arable land (dca)	11,000		
x_{20}	Permanently employed mechanics (no.)		4	
x_{21}	Permanently employed workers (no.)		2	
x_{22}	Income (BGN)			1,675,204.8
x_{23}	Material costs (BGN)			362,760
x_{24}	Labor costs (BGN)			108,000
x_{25}	Income (BGN)			1,312,444.8
x_{26}	Gross margin (BGN)			1,204,444.8
x_{27}	Fixed costs (BGN)			605,000
x_{28}	Profit (BGN)			599,444.8
x_{29}	Profit with subsidy (BGN)			971,444.8

Source: Authors' calculations, 2023.

Table 9. Variant when including only cultures treated in different concentrations of biostimulants. Production structure and economic results of application of biostimulants

Unknown	name	dca	Number	BGN
x_1	Wheat (dca)	0		
x_2	Maize (dca)	0		
x_3	Sunflower (dca)	0		
x_4	Spring rape – control (dca)	0		
x_5	Spring rape - BS 1 Chitosan 500 ml/ dca	12,000		
x_6	Spring rape –BS 2 Chitosan-2*500 ml/ dca	0		
x_7	Spring rape – BS 3 Vermi compost extract 500 ml/ dca	0		
x_8	Spring rape – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_9	Spring rape – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{10}	Spring rape BS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{11}	Spring oats – control (dca)	0		
x_{12}	Spring oats - BS 1 Chitosan 500 ml/ dca	0		
x_{13}	Spring oats–BS 2 Chitosan-2*500 ml/ dca	0		
x_{14}	Spring oats – BS 3 Vermi compost extract 500 ml/ dca	0		
x_{15}	Spring oats – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_{16}	Spring oats – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{17}	Spring oatsBS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{18}	Own arable land (dca)	1,000		
x_{19}	Leased arable land (dca)	11,000		
x_{20}	Permanently employed mechanics (no.)		4	
x_{21}	Permanently employed workers (no.)		2	
x_{22}	Income (BGN)			1,547,160
x_{23}	Material costs (BGN)			474,000
x_{24}	Labor costs (BGN)			108,000
x_{25}	Income (BGN)			1,073,160
x_{26}	Gross margin (BGN)			965,160
x_{27}	Fixed costs (BGN)			605,000
x_{28}	Profit (BGN)			360,160
x_{29}	Profit with subsidy (BGN)			732,160

Source: Authors' calculations, 2023.

First option. In Table 8, the parameters of the solution of the objective function with optimization and maximum gross margin and maximum profit can be traced. The decision presents an option for crop rotation of the included agricultural crops with the use of different biostimulants, and with different concentration of active substance, with/without included CAP subsidy for the farm. The optimal solution of the task also includes the set precondition for dropping the requirement for the maximum size of cultivated land.

When constructing the production structure in the farm's crop rotation, the assumption is made that the own land of 1,000 decares, and the leased land -11,000 decares, are used to their full capacity.

Solving the optimization equation is expected to give us an answer to the questions concerning the area of cultivated land to be sown with certain agricultural crops (wheat, maize and sunflower, spring oats - control and spring canola - control, spring oats and spring rape - treated with biostimulants, with admissibility for distribution of different concentration of active substance).

The main influence on the results is the type of the objective function, the constraints and the set price parameters. The type of objective function is linear. The parameters and the set price parameters have an impact on the results of the optimization. Linearity affects the results in 2 ways:

1. Maximizes cost-effective crops produced, on the one hand;
2. On the other hand, it minimizes the price disadvantages to the size of their set minimum.

Due to the listed reasons and imposed restrictive conditions in the optimization, wheat is planned to cover a minimum of 5,400 decares. This is the minimum restrictive condition for autumn cereal crops for crop rotation according to agronomic requirements (min. 45% of the area of cultivated land). In the sowing rotation area, wheat occupies the minimum limits set for autumn cereal crops. The intended maximum of 55% of the area of the crop rotation, or up to 6600 decares, is not included in the solution of the task, because the mandatory inclusion of sunflower in the crop rotation is taken into account in the restrictive condition for the minimum size of the areas. In the optimal solution, he enters with 3,240 decares. In the remaining area of 3,360 decares, spring rape is included - treated with chitosan - 500 ml/decare. A leading role in the distribution of these crops is played by those with a higher economic benefit for the farm. The optimization matrix does not include the distribution of the other spring rape and spring oats - treated with the other biostimulants.

It is noteworthy that the optimization does not include spring rapeseed and spring oats - treated with the other biostimulants within the maximum set limits of 4,560 decares. The optimization has taken into account all the limiting conditions and has included in the solution other crops that are more economically profitable. In the same way, the result should be interpreted for the inclusion of the maximum amount of land under sunflower, and corn is dropped from the crop rotation. This is because no precondition has been set for its mandatory inclusion in the solution of the task. That is, the optimization model selects the most optimal solution according to the set parameters in the objective function and offers such a distribution of the production structure, consistent with the restrictive conditions of the crop rotation, presence of biostimulants, different yield, market price, and the different economic efficiency, consequence of these conditions. Naturally, it would be interesting if other restrictive and/or mandatory conditions were set in the condition of the task. It is precisely in this that the wide possibility of this type of optimization model is cut. It is also useful in that the managers of an agricultural enterprise, applying it successfully, allows offering countless possible solutions. On this basis, in accordance with the specific subjective wishes of the producers, it allows the relevant management decisions to be made.

During the development of the technical and economic regulations (TIR), the yield of agricultural crops was determined in accordance with biological production, depending on the region, the type of soil, with/without the presence of biostimulators and different market prices of the product. This accumulates on production and labor costs, income, revenue, gross profit of the farm. According to the solution of the task, the following agricultural crops with biological production - wheat and sunflower - are included in the farm's production structure. From the point of view of crops treated with biostimulants, only spring rape, treated with chitosan 500 ml/ha, is included in the crop rotation.

According to the proposed optimization model, three agricultural crops are included in the production structure of the farm - wheat and sunflower (biological production), as well as spring rape, foliarly treated with chitosan 500 ml/ha. Corn and the other crops - spring rapeseed and oats - controls and those treated with the other biostimulants in different concentrations, which fall out of the crop rotation, are of low economic efficiency.

In the solution of the task, it is possible to trace how the minimum and maximum limits are distributed, such as the restrictive condition for the area on which the use of biostimulants is allowed - min 3,360 decares and maximum 4,560 decares. The solution to the task only includes the spring rapeseed treated with chitosan 500 ml/ha in the minimum size of 3,360 ha of land, as economically the most profitable for the farm.

As a result, in the optimization model, all set restrictive conditions for achieving maximum economic effect - maximum gross margin and maximum profit - are fulfilled.

In the solution of the problem, the optimal economic efficiency is achieved with a Gross margin of BGN 1,204,444.8 or BGN 100.37/decare, the realized profit without subsidy of BGN 599,444.8 (BGN 49.95/decare) and with subsidy BGN 971,444.8, which is BGN 80.95/ decare.

Table 1 shows the results when profit is included as the objective function. The results of the optimization confirm the conclusions made so far. Adding fixed costs to the model does not change the final result for the optimal ratio of planted areas.

Of interest is whether the presence of subsidies will change the optimization results. The influence of the subsidies in the model is reflected by the subsidies per unit of sown area in the amount of BGN 31/ decare. The increase in profit from BGN 599,444.8 to BGN 971,444.8 is the result of the absorption of subsidies for direct payments under the first pillar of the EU's common agricultural policy.

Regarding the structure of the areas under cultivation of the various crops and the labor costs remain unchanged regardless of whether subsidies are involved or not.

Second option. Table 9 presents the results of the optimization, according to which a limit is set for minimum limits in which the cultivated land varies, but with maximum inclusion of the permissible area with the presence of crops treated with biostimulants.

Based on the set limiting conditions in the optimization, it is planned that the entire distribution of the sowing turnover area of 12,000 decares will be occupied by spring rape treated with chitosan 500 ml/decare. It is this solution that shows the variety of possible solutions of the proposed economic-mathematical model. The optimization model selects the most optimal solution according to the set parameters in the objective function and offers such a distribution of the production structure, consistent with the restrictive conditions, different yield, market price, and the different economic efficiency of it.

In the optimization model, all set restrictive conditions are met to achieve maximum economic effect - maximum gross margin and maximum profit.

In the solution of the task, the optimal economic efficiency is achieved with a Gross margin of BGN 965,160, realized profit without subsidy of BGN 360,160 and with subsidy - in the amount of BGN 732,160.

In this option, the material costs increase from BGN 362,760 to BGN 474,000, due to the need to spray the rapeseed on the entire 12,000 decares area. Betting on this production in the agricultural economy, a decrease in income by BGN 128,044.80 is reported, or from BGN 1,675,204.8 it shrinks to BGN 1,547,160. This is a clear sign that treating crops with biostimulants in order to a good economic result is obtained, an increase in yield should be achieved in larger quantities. Apparently, the positive effect on yield, which is in the range (1-5% for 2021) for spring rape and (1-30% for 2021) for spring oats, is not enough to cover the increase in labor and material (production) costs, as a result of the application of biostimulants. In practice, this 1-30% increase in spring oats did not result in the inclusion of this crop in the problem solution. Here, in all probability, the key influence was not only the price purchase levels, but also the yield of the crop during the reporting economic year, which is in the range of about 35% of the average yield for the region, which is extremely insufficient. Theoretically, if their values are changed in the condition of the task, and this is completely possible and feasible, then the model after several iterations will give another optimization. The choice of spring oats as a crop to be treated with biostimulants in comparison with other agricultural crops is not relevant in this case (due to the unsatisfactory yield achieved). It would be more correct in this case to look for other competitive advantages to argue for the inclusion of spring oats in competition with rapeseed, wheat, sunflower and corn. For example, the added benefit of growing spring oats is weed suppression and soil moisture conservation. The advantage that oats are a dietary food should also be taken into account, as they have numerous uses in food – rolled oats, various baked goods, a substitute for milk, etc.

The constructed optimization model is a good opportunity to evaluate the economic efficiency of biostimulants in the optimization of the production structure of a specific agricultural holding. This means that with other parameters of another farm, the model will give different results. All this proves the flexibility and applicability of the model when making a management decision. The optimization model included in combination the complex of internal factors in the agricultural holding. Naturally, when applying the economics model, it should be clarified that the model works with clear and accurate input data in terms of value. In this case, some important factors of the external environment are not included, including current environmental, behavioral, social, institutional, etc. Possible future changes in the market environment, the climate, the behavior of the competition, the change in taste preferences among consumers are not foreseen in the economics task. The model does not identify the factors related to threats to the farm and potential vulnerability, which are extremely important criteria in making a management decision.

The fact that a competitive economy is built on the basis of a complex of multiple factors should not be ignored. Therefore, it is necessary to consider the importance of each one of them, to pay the necessary attention and priority. It would be difficult to reduce costs at the same time; to increase yields; to increase the quality of the manufactured product; to conserve natural resources, etc.

Additionally, some specific characteristics of the agricultural holding are not included in the construction of the limiting conditions of the optimization model. For example:

- Staff experience and management skills;
- Relationships, trust and reputation among society;
- Advantages in certain competitive positions, such as: own technology, advertising campaigns, economies of scale of production; innovative products and technologies;
- Location of the business;
- Partnerships;
- Quality management systems, etc.

These are existing positive factors in the business unit that favor the company's mission (conquered market positions, high qualification of personnel, registered patents and other objects of intellectual property).

Behavioral characteristics of managers, employees and all stakeholders are not included in the task condition. This largely predetermines the possible optimal decisions, which accordingly does not provide grounds for making the best management decision. The task does not provide an opportunity to take into account important factors for the operation of the farm, if it is in a situation of an unfavorable position compared to the competition. Also, the model does not allow recognition of the signals of the external environment. These are unused, potential opportunities and challenges facing the economy:

- Entering new markets and opening market segments;
- Implementation of new technologies;
- Vertical integration and diversification;
- Ability to adapt the existing technology for the production of new products;
- Strategic alliances, entrepreneurial networks.

Of course, all the above listed weaknesses of the proposed optimization model have a theoretical possibility to be included in the condition of the task and to construct additional restrictive conditions.

However, it should be kept in mind, purely theoretically, that the model allows to formulate such a task and seek optimization. All of the factors listed above could be involved in solving the task. In this case, when constructing the task, it would be appropriate to approach it with a certain "weight", as the qualitative indicators should be transformed into quantitative dimensions. With this option, the task will be extremely "difficult" to solve in EXCEL SOLVER. The purpose of such optimizations is based on optimality criteria: max or min of a selected economic indicator. It would be difficult to seek optimization in the objective function simultaneously to achieve maximum economic effect (purely mathematical values) with a combination of ecological, behavioral, market, etc. optimization. The more restrictive conditions are set (especially those based on expert opinion or of a purely subjective nature), the more the optimization seeks a balance between all of them, which is not always the best solution for such a case. However, priority should be given to a selected criterion. Another possibility is to compose different tasks, in which as criteria for optimality different optimization goals can be set, such as: achieving maximum ecological effect, maximum positive social effect, etc.

Another possibility provided by the model is to optimize the production structure with the use of biostimulants, in several consecutive years (for example three). In this option, it will be necessary to calculate new technical and economic norms, as well as to set different yields of agricultural crops, during the three years in which the crops are treated with biostimulants in the farm, a change in market prices of input factors of production and changes in the price of output. In the model proposed above, the effect on yield is taken from one economic year. In practice, this is a "snapshot" for a certain agrotechnical year and the obtained result is based on the defined criteria and restrictive conditions and, accordingly, results in specific agroclimatic conditions.

CONCLUSIONS

Based on the research done, the following conclusions can be summarized. Chitosan, vermicompost and nature-identical growth regulator are among the preferred and often applied products with biological activity in agricultural production. Foliar treatment with biostimulants has been found to have a positive effect on yield, technological and biometric indicators in organic cultivation of spring rapeseed and spring oats. On the basis of the experimental data from the Polish trials for two consecutive years, an optimization model was developed to evaluate the economic efficiency of the application of biostimulants. A positive economic result was reported for both treated crops, but this did not give an analogous result on the simulation model of a specific agricultural holding. It has been shown that although foliar treatment with biostimulants increases the profit per unit area, it does not affect the profit for the farm as a whole. Therefore, the optimization model should be applied independently and no hasty decisions should be made.

ACKNOWLEDGEMENTS

This work was supported by Project "Use of biostimulants in organic farming - assessment of contributions to the bioeconomy", funded by Contract № KP-06-N46 / 6 of 27.11.2020 from the Research Fund of the Ministry of Education and Science.

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