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ECONOMIC EFFICIENCY OF BIOSTIMULANTS IN AGRICULTURE

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ABSTRACT
Addressing issues related to the economic efficiency of biostimulants in agriculture meets the needs of farmers and consumer requirements. The urgency of this study is also determined by its compliance with the priorities of the European Union for the new CAP 2021+, in accordance with the national priorities for healthy food. Increasing plant productivity can be achieved, on the one hand, through genetics and selection, as well as through the management of physiological and biochemical processes through the use of growth regulators, on the other hand. The aim of this study is to evaluate the economic efficiency of biostimulants used in agriculture. The economic efficiency of the various biostimulants is established by solving the problem with the production structure of the agricultural holding. To establish the economic efficiency of the various biostimulants, an economic-mathematical model based on linear optimization has been developed. The results of preliminary studies show that in assessing the impact of biological substances it is necessary to take into account not only the increase in profitability and profit of a particular crop but also whether the profit of the farm as a whole has increased.

Key words: agriculture, economic effect, biostimulants, optimizing of production structure

INTRODUCTION

The goals of sustainable development, environmental protection, and healthy food require the introduction of innovations in production and research. This can be achieved with diversity in the selection of sustainable varieties of plants, animal breeds, digitalization of work processes. In the field of agricultural science, a relatively new direction is known as biological production methods - plant growth regulators (1), biologically active stimulants (BAS) (2).They regulate the natural growth of plants, maturation, increase yield, increase their biological potential (3, 4), early maturity and production quality. In their composition, they include auxins, gibberellins (5, 6), cytokinins, defoliants, feminizers, retardines (7), and others. Theoretically and practically biostimulants are natural or synthetic substances. In their creation, technologies are used to extract natural substances from plant organs (leaves, stems). Therefore, it could be assumed that when applied in a certain ratio, BAS are completely harmless to human and animal health. Growth regulators are applicable to various crops such as wheat, legumes, vegetables, orchards and more. At the present stage in Bulgaria, there is still a deficit of knowledge and research on the economic benefits of their application. Usually, when analyzing the economic effects of biostimulants, only the benefits and costs of the materials are included.

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In our opinion, in order to determine the economic efficiency of different growth regulators, all costs (not only the price of regulators) and absolutely all positive effects and a complex set of factors, interrelations, and interdependencies between all production factors must be taken into account. At this stage, this has not been done by BAS developers and distributors. In practice, the application of the biologically active substance may be economically beneficial for one farm and may be useless for another farm. The economic efficiency of the various factors must be assessed in the context of the whole set of conditions under which the agricultural enterprise operates. In other words, the economic efficiency of a factor must be assessed not only by whether the profit per unit area of the crop in question is significant but rather by whether it increases the profits of the enterprise as a whole. The aim of the study is to assess the economic effect of biostimulants in agriculture.

MATERIAL AND METHODS

Mathematical modeling will be applied to evaluate the economic efficiency of different BAS. For this purpose, a real functioning agricultural cooperative in the Veliko Tarnovo region is selected. It will be The production structure of an agricultural cooperative will be optimized by a linear function. Climatic conditions create prerequisites for growing the following crops of wheat, barley, corn, silage corn, sunflower, Burley tobacco, vineyards, fruit trees (apples, peaches, cherries), vegetables (tomatoes, peppers), alfalfa (for seeds and hay) and dairy cows. The arable land of the agricultural cooperative: 8059 decares. The necessary information was selected with the assistance of experts from the cooperative.

Economic modeling (8) is a mathematical problem that reflects with satisfactory accuracy the most important relationships and characteristics of the economic problem. These problems are built in a system of linear dependencies. They must reflect the conditions that must be taken into account when solving the task. The objective function expresses the optimality criteria (min, max):

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

$$F = C_1X_1 + C_2X_2 + \cdots + C_nX_n \rightarrow \max\ (min), \qquad (1)$$

Where:
- X_j – indicates the size (magnitude) of the activities or metrics,
- A_{ij} and Cj – indicates the activities that will be done,
- B_i – means the amount of available resources or the amount of activities (restrictions).
- The objective function F gives the optimality criteria.

Objective function:
F max (gross margin/profit) = $\sum_{j\in T}^{n} C_jX_j$, (2)
where:
- C_j is (gross margin/profit) from j-th unknowns;
- T is the aggregate of the indices of the unknowns from which the gross margin / profit is obtained.

The solution of the model will answer the following questions:
1. Establishing an optimal production structure in accordance with the constraints and optimality criteria;
2. Establishing the impact of BAS on efficiency and production structure depending on the selected optimal criteria;

In order to determine the production structure of the selected cooperative, it is necessary to determine the area of crops, the number of animals and other activities to achieve maximum economic impact. During the development of the model, the criterion is to achieve a maximum gross margin with the inclusion of BAS and without their application. Solving the problem will also answer the questions about the most cost-effective production processes for crop production and for animal husbandry. In addition, the decision will present the impact of BAS on the production structure and thus on the economic result. The production structure in this case depends on the specifics of natural conditions and limiting factors. For all activities with and without application of BAS, technical and economic norms of 1 decare or 1 point of production are developed - for average yield, selling price, incoming, material costs, labor costs, production costs, income, profit, working days and etc.The Solver application is used in MS Excel, in order to optimize the objective function, Solver is an application that can be used to find the optimal solution (minimum or maximum) of an equation that is subject to various constraints. The article presents a case, with certain restrictive conditions, from which no general conclusions can be drawn about the impact of biological methods in all farms.

Development of the mathematical model

1. ***Constrants on land use:***

$$\sum X_{ij} \leq B_i \quad (3)$$

$j \in M_i$

Where:
M_i – a set of indexes, denoting the area of the j-culture;
x_{ij} - the area j-th crop on the i-th rented land;
B_i – rented land from category i.

2. **Constraints on min / max size of the areas of the autumn crops:**

$$\sum X_j - k \sum X_i \geq; \leq 0 \quad (4)$$

$j \in M \quad j \in N$

where:
к – min / max relative share of areas of autumn crops;
M – a set of unknown variables x_j, describing the area of autumn crops със слята
N - a set of unknown variables x_j, expressing the area of crops in crop rotation.

3. ***Constraints on agro-technological requirements of sunflower to crop rotation (1/6 of the crop rotation area):***

$$\boldsymbol{X_j - k \sum X_j \leq 0} \quad (5)$$

$\mathbf{j \in N}$

where:
к - a coefficient representing the crop rotation area of the j-th culture;
N - a set of unknown variables x_j, expressing the area of crops in crop rotation.

4. ***Constraints on labor resources:***

$$\boldsymbol{\sum_{j=1}^{n} A_{ij} X_j \geq, \leq B_2} \quad (6)$$

where,
A_{ij} – the quantity of the i - th resource required to carry out one unit of j - activity or the quantity of the i - th product obtained by the one unit of j - activity
B_2 – labor resources.

5. ***Constraints for min / max number of dairy cows:***

$$\boldsymbol{\sum X_i \geq; \leq B_j} \quad (7)$$

$\mathbf{i \in I}$

where,
I - a set of unknown variables, indicating the number of cows of the i-th breed
B_j – min / max number of dairy cows;

6. ***Constraints on the feed balance:***

$$\sum p_{Mi} X_{Mi} - \sum d_{Mi} X_{Mi} - \sum d_{Mi} X'_{Mi} = 0 \quad (8)$$

м∈M i∈I
where:
M is the sum of the indices of the unknowns of the different feeds in NEI
I - a set of unknown variables, indicating the number of animals
p_{Mi} - the need for the fodder in NEI for one animal
d_{Mi} - NEI of a M-th fodder, produced in the farm
x'_{Mi}- the amount of M-th fodder purchased to feed the animals

7. ***Constrants on the minimum and maximum limits of the NEI of a given type of fee:***

$$\boldsymbol{X_{dit} - k \sum X_{dit} \geq; \leq 0} \quad (9)$$

$\mathbf{d \in S \quad s \in U}$

where:
S – a set of indexes of the variables Xdit, expressing the NEI of the d-th fodder required for animal feed
U - a set of indexes of the variables Xdit, expressing required NEI for one animal
к – minimum / maximum share of NEI of the s-th fodder

8. ***Linking activities (the amount of one depends on the amount of other activities):***

$$\boldsymbol{\sum_k A_{ik} X_k \leq \sum_k A_{ir} X_r} \quad (10)$$

where,
$X_к$ is the amount of activities that depend on the amount of other activities,
X_r is the amount of activities that depend on the amount of other activities,
$A_{iк}$ and A_{ir} are coeficients, which determine the proportions between group k activities and activities form group r.

RESULTS

Table 1 shows the economic efficiency of the farm respectively with/without the use of growth regulators (BAS) at the criteria of maximum income and maximum profit. According to the results of the optimization, the application of BAS is cost-effective for the cooperative. In the optimal criterion in the maximum income function, the optimal use of BAS gives 47% more incomings. At the same time, the use of biostimulants increased production costs by 9.9%. As a result of the application of BAS, the income in the cooperative increases by 52% and the profit by over 91% compared to optimization without the use of biostimulants. With the criterion of optimum maximum profit, the application of BAS gives - 50% higher revenues; production costs increased by 13%, income - 57%, and profit 94.4% compared to optimization without the use of biostimulants.

Table 1. *Results of economics effect, BGN*

Indicators	F max gross margin with biological activity substance	F max gross margin without biological activity substance	F max profit with biological activity substance	F max profit without biological activity substance
1. Incomings -1 da	1 863 309.6 246.6	1 211 412.8 167.6	1 862 044.8 246.4	1 123 100.8 163.2
2. Material costs -1 da	555 366 73.5	492 949.6 68.2	553 172.4 73.2	402 469.8 64.2
3. Labor costs -1 da	201 745.2 26.7	165 521.2 22.9	201 016.2 26.6	147 948.4 23.6
4.Production costs (2+3) -1 da	757 111.2 100.2	658 470.8 91.1	754 188.6 99.8	550 418.2 87.8
5. Income (1-3) -1 da	1 661 564.4 219.9	1 045 891.6 144.7	1 661 028.6 219.8	975 152.4 139.6
6. Profit (1-4) -1 da	1 106 198.4 146.4	552 942 76.5	1 107 856.2 146.6	572 682.6 75.4

Source: Authors's elaboration based on survey result

Table 1. Results of the optimization model, decares/n.

Products, decares	F max gross margin with biological activity substance	F max gross margin without biological activity substance	F max profit with biological activity substance	F max profit without biological activity substance
Wheat	991	991	991	1239
Barley	2179	2665	2116	2614
Maize	3046	1980	3047	793
Maize silage	104	125	104	125
Sunflower	97	111	97	111
Tobacco	-	-	-	-
Tomato	567	313	567	407
Pepper	-	459	-	345
Vineyards	91	91	91	91
Apples	60	60	60	60
Peaches	72	72	72	72
Cherries	16	16	16	16
Lucerne, seed	270	270	270	270
Barley feed	63	75	126	126
Dairy cows, n	20	20	20	20
Leased land	503	831	502	1790
Total decares	8059	8059	8059	8059

Source: Authors's elaboration based on survey result.

The solution of the task (table 2) gives an answer for optimizing the production structure of the agricultural cooperative. The problem is solved with different optimality criteria: maximum income and maximum profit, respectively, with/without the use of biostimulants (BAS). Optimization of the maximum income cereals (wheat and barley) using biostimulants occupies 41.9% of arable land, and corn covers 40.3%. Without BAS, wheat, and barley reach 50% of the land, and corn - 27.3%. Pepper and tobacco are inefficient productions and are not included in the optimization of the production structure when using BAS.

CONCLUSIONS

The assessments of the economic efficiency of the different bio-stimulators are made through an optimization model for the structure of agricultural production. The results showed that when assessing the impact of biostimulants, it is necessary to take into account not only the increase in profitability and profit of certain crops but also whether the profit of the farm as a whole is increasing. The production and sales of growth regulators on international markets will increase and will be included in the European Commission and CAP programs for the Green Deal. In Bulgaria, there is potential for the use of biostimulants in agriculture. Strong support in a new endeavor is the research centers and the dissemination of knowledge and information about the positive economic effect.

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