

Modelling of state support for biodiesel production

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Abstract. Government support for the development of biofuel production is a relevant part of the system of budget regulation of agricultural production in the Russian Federation. Currently, there is no sound financing method for mechanisms of state regulation of biofuel production which impedes impartial allocation of funds and makes this procedure non-transparent and not motivated enough. In view of this situation, a mathematical economic model was developed that allows one to calculate the optimum level of government support for every type of biofuel considering main areas of state support. We propose to consider three scenarios for the determination of the optimum level of public funding. The first one allows for optimization of the level of government support considering sizes of agricultural production for the i -th crop to provide farms of the region. The second scenario suggests the determination of the maximum profit from the biofuel production through increased agriculturally used areas. Finally, the third one considers calculation of the minimum expenses of achieving the volume of production that provides the farm with raw materials. According to the first scenario, the optimum level of government support for the field should be 1163.6 million rubles. In the implementation of the second scenario in the Samara region, the agriculturally used area planted with oil crops should be increased by 47.1 thousand ha.

1 Introduction

Currently, increasing attention is paid to the use of alternative fuels, due to the reduction in the worldwide supply of biogenic energy carriers, tightened exhaust emission standards, and limitation of carbon monoxide emission [1-4]. As an alternative fuel, biodiesel is one of the best options among other sources due to its environmental friendliness and functional properties similar to diesel fuel. Biodiesel is nothing more than methyl ether, which has the

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properties of a combustible material and is obtained as a result of a chemical reaction from vegetable fats [5-8].

It is obtained from vegetable oils by transesterification: methanol is added to the vegetable oil in a ratio of approximately 9:1 and a small amount of catalyst. From one ton of vegetable oil and 111 kg of alcohol (in the presence of 12 kg of catalyst), approximately 970 kg (1100:1) of biodiesel and 153 kg of primary glycerol are obtained. It is recommended to use potassium or sodium methoxides (methyllates) as catalysts, after which the mixture is processed in a cavitation reactor [9-14].

Its chemical composition allows it to be used in diesel engines without other substances that stimulate ignition. The following useful properties of biodiesel should also be noted:

biodiesel undergoes almost complete biological decay: in the soil or in water, microorganisms recycle 99% of biodiesel in 28 days;

less CO₂ emissions;

low a number of components content in exhaust gases, such as carbon monoxide CO, unburned hydrocarbons, nitrogen oxides NOX and soot;

low sulphur content;

good lubricating characteristics. An increase in the service life of the engine and fuel pump by an average of 60% is achieved [14-18].

Governments promote the development and use of biofuel. For example, in the USA, in accordance with the adopted program, the share of renewable fuels has increased by 10% over the period from 2005 to 2017. In member states of the European Union, a Directive on the Promotion of the Use of biofuels was adopted, under which it is required to achieve at least 10% of biofuel in total fuel consumption by 2020 [19]. Biofuel production is also considered an important strategy to achieve the goals of the Paris Agreement [20].

Despite Russia being one of the largest oil exporters, many Russian scientific and manufacturing institutions have taken an active interest in production and consumption of environmentally friendly bioenergy carriers produced from renewable biological feedstock [21-23]. The use of biodiesel in agricultural production is a prerequisite for reducing the cost price of manufactured goods and increasing production efficiency. Government support for the development of biofuel production is a relevant part of the system of budget regulation of agricultural production. Currently, there is no sound financing method for mechanisms of state regulation of biofuel production which impedes impartial allocation of funds and makes this procedure non-transparent and not motivated enough.

2 Materials and methods

The study suggests the development of a mathematical model for optimization of government support for biodiesel production. This economic-mathematical model is based on principles of linear programming. Linear programming is a branch of mathematics concerned with maximizing and minimizing linear functions under constraints in the form of linear inequalities.

The development of mathematical economic models for optimization includes several interrelated steps:

First, there is a need to state the mathematical economic problem of rational use of land resources. When planning the state support for biodiesel production, we need to find a balance of crops that would be profitable. Their land size and the most profitable combinations should be economically feasible and organizationally viable in the long run. In other words, there is a need to consider both climate and economic factors and to determine a production structure of crops suited for biofuel production that would ensure the application of the objective function.

Many scientific research institution and universities, including the Samara State Agrarian University and Povolzskaya machinery testing station, conducted research on the use of RME biofuel, and developed utility flow schemes, fuel supply systems for tractors, adapted for the use of biofuel [25].

Table 1. Production of oil from various crops per ha.

Crop	Oil kg/ha	Oil l/ha
Corn	145	172
Oat	183	217
Lupine	195	232
Soybean	375	446
Flax seeds	402	478
Pumpkin seeds	449	534
Mustard seeds	481	572
Milk-cap	490	583
Sunflower	800	952
Rapeseed	1000	1190

It was established that the reduction in engine power output of biofuel is insignificant, and fuel consumption increases by 5-8%. Engine life does not change. Biofuel also has promising lubricating properties. Soot emissions decrease by 50%, carbon dioxide - by 10-12%, sulfur - by 0.05% as compared with 0.2-0.5% for diesel fuel.

Technology for the conversion of vegetable oils to biofuel has developed considerably over the past years, especially in Tatarstan. The resulting products (diesel fuel, forage pulp and glycerin) are in demand, and their joint production makes the process cost-effective.

The simplicity of the technology and economic characteristics of the process make biofuel more appealing for agricultural producers, considering that diesel fuel is the main fuel in agriculture.

The first organization to produce biofuel in the Samara region was "Biosam" in Krasnoyarsk Krai.

On the basis of the laboratory of the Department of Tractors and Vehicles of the Samara State Agrarian University, the Biosam company tested biofuel samples produced by MIXER. The samples have demonstrated great anti-wear and anti-cuffing properties [25].

Results of bench testing of engines running on alternative fuel conducted by Povolzskaya machinery testing station showed that:

- engine power for blends of diesel and biofuel in different proportions is close enough to engine power for diesel fuel and is within tolerance limits, and differences are insignificant. A slight increase in engine power for 50% biofuel blend is due to high kinematic viscosity of blends, that allows reduction of leakage in plunger pairs;
- fuel consumption rate for engines running on blend is higher than for diesel fuel due to the lower calorific value of biofuel.

We also calculated the comparative effectiveness of biofuel production. In accordance with this calculation, the cost price of 1 litre of own-produced biofuel is 30-50% lower than the wholesale price of diesel fuel [38].

The analysis of crop producers of the region and social survey of managers and experts reveals that their situation is compounded by price disparities, lack of technical equipment, high costs of fuel, and lack of outlets for crop products. This has identified the need for the development of economic-mathematical model that allows one to calculate the optimal level of government support for every type of biofuel considering forms of government support.

The developed methodology allows for fast calculation of the optimal level of government support for biofuel production based on three scenarios (for all forms of business organization) using the Microsoft Excel tool.

We developed a model for optimization of government support for the production of biofuel by households growing oil crops, considering the directions of financing.

1. X_{1-8} - types of oil crops;
2. X_{9-14} - main directions of government support;
3. X_{15-17} - forms of business organization.

The model uses the following notations:

1. Z - the level of state support for the cultivation of the i -th crop for biofuel production;
2. C_i - costs of the unit for the i -th production technology;
3. X_i - lookup value of the i -th variable denoting the production technology and the level of support;
4. A_i - market output per unit for the i -th production technology;
5. a_{ij} - availability of the j -th resource per i -th unit;
6. b_{ij} - the amount of cash per year;
7. N_i - minimum area under the i -th oil crop used for the production of biofuel, cultivation of which must be guaranteed;
8. K_i - limited i -th production;
9. Q - limitations of economic resources

Objective functions:

1. optimization of the level of government support considering the main types of oil crops used for biofuel production to provide the region with biofuel:

$$Z = \sum C_i * X_i \rightarrow \max \quad (4)$$

2. maximization of the area under oil crops used for the production of biofuel to increase the profit;

$$A = \sum A_i * X_i \rightarrow \max; \quad (5)$$

3. minimization of costs while achieving the production volume that provides the households with enough biofuel;

$$C = N_i \sum a_{ij} * X_i \rightarrow \min. \quad (6)$$

The model allows us to obtain an optimal structure of production volume, operating costs, gross fuel price and fuel commodity price, expected profit in the context of a form of business organization.

Note that this model considers the optimal distribution of government support for all forms of business organizations (costs).

The main objective of the developed methodology is to achieve the optimal production volume at minimal cost, which would allow for determination of the optimal level of government support for biofuel production to provide the households.

Solution of this problem would allow developing an optimal and effective system for the government regulation of biofuel production.

In accordance with the objective functions, we propose to consider three scenarios of optimal government support:

1. The first scenario allows for optimization of the level of government support considering the levels of agricultural production for the i -th crop to provide farms of the region;
2. The second scenario allows for the determination of the maximum profit from the biofuel production through increased agriculturally used areas;

3. The third scenario allows for the calculation of the minimum expenses of achieving the volume of production that provides the farm with raw materials.

According to our calculations based on the first scenario, the optimum level of government support for the field should be 1163.6 million rubles.

In this case, financial resources should be distributed to the following targets:

- preferential tax, loan and financing systems for producers accumulate funds of 465.5 million rubles;
- creation of biofuel production - 407.3 million rubles;
- crop insurance - 174.5 million rubles;
- development of information consulting service and technical re-equipment - 91.9 million rubles;
- other targets - 24.4 million rubles.

In the implementation of the second scenario in the Samara region, the agriculturally used area planted with oil crops should be increased by 47.1 thousand ha. This would solve the problem of providing farms producing biofuel with raw materials, and improve the difficult financial situation of some producers.

In accordance with the third scenario, budgetary expenditures for the achievement of planned standards of production will equal to 32567 thousand rubles. The difference between the gross cost and diesel fuel per farm is 86.1 thousand rubles.

The most beneficial for agricultural organizations would be the reduction of tax payments to the federal and regional budgets.

4 Conclusions

Practical implementation of the proposed mathematical model includes the involvement of leading experts in the field of cultivation of oil crops, who can describe these functions on a quantitative basis. There is also a need for extensive testing of the model and its identification based on insufficient and inaccurate data to estimate parameters and correct the expert functions. Since we need to develop a different system of the government regulation of the field based on modern information technologies, we used methods of mathematic modelling.

The developed methodology allows us to develop an optimal structure of biofuel production, estimate money and labour costs, gross and commodity value of biofuel, and expected margin of all organizational forms of production. Generally speaking, this will allow for optimization of used tools in terms of effective use of budget funds and provision of the Samara region with biofuel.

It is essential to point out that issues of biofuel production are not only related to government support. Measures of government support can only be effective if they are based on identification and implementation of internal growth reserves and effective production of biofuel, which will result in excellent performance of farms that cultivate oil crops and produce biofuel and the agrifood complex.

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