THE OPTIMIZATION OF THE FEED PRODUCTION PLAN AND ITS INFLUENCE ON THE EFFICIENCY OF ANIMAL PRODUCTION

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Abstract: *The study reflects the impact of optimizing the production plan and the use of feed on the efficiency of animal production. In this context, it was established that a significant increase in animal productivity would be possible as a result of improving the structure of the feed base, the preparation of quality fodder, as well as the use of advanced technologies and animal husbandry. The analysis is completed by illustrating the specific situation of "Vealvit - Agro" LLC from Cerniţa village, Floresti district, the Republic of Moldova in the period 2016-2018. The results show that to determine the optimal variant of the production plan and use of feed, to provide the livestock sector with quality feed, with minimal costs, along with traditional methods, it is rational to use the method of economic-mathematical modeling with solving the computer problem which is the purpose of the study.*

Key words*: feed base, optimal feed production plan, food ration structure, economic-mathematical model*

INTRODUCTION

The creation of the feed base plays an important role in the agricultural economy, ensuring the yield of animal production, increasing animal productivity, and last but not least - increasing the quality, production efficiency, and stability of the agricultural production process [5, 6].

As mentioned by various authors, including V. Kosolapov, I. Trofimov [10], and others, feed production allows the livestock sector - feed provision; plant cultivation — to capitalize efficiently on crops, to increase the harvest of crops and the agro-technical sector — to improve soil fertility.

To increase production and reduce the cost of feed, as well as the feed base as a whole, it is important that each farm, which deals with animal husbandry, determine the rational structure of the feed base, the type of feed for various categories of animals and the efficiency. Economics of feed production, adjusted to the operating conditions of the enterprise [13].

Currently, the important cause of declining indicators in the livestock sector is the lack of a strong, balanced feed base, conditioned by insufficient production and poor feed quality [7].

The highlighted problem is becoming more and more pressing for enterprises specialized in raising dairy cows, as we have mentioned in other publications because in the Republic of Moldova the coverage of milk needs is only 53% [8].

The creation of a lasting feed base is addressed in the works of several authors from abroad, such as A. Babkina and G. Svetlova [1], I. Trofimov and V. Kosolapov [10], I. Papushkina and I. Kasatkina [12] and others, as well as local scientists: S. Chilimar and T. Bajura [3], G. Stepurin [15], and so on.

However, few researchers are known about the use of the mathematical modeling method to determine the optimal plan for the production and use of feed. Thus, the authors A. Ivanov and M. Ivanova [9], in theory, propose the use of the systemic method to argue the perspective of the development of milk production. In this order of ideas, the proposed economic-mathematical model is in the form of blocks, with the objective function - maximizing milk production, taking into account the regional conditions for the development of the feed base in agricultural holdings [12].

The authors A. Babkina and G. Svetlova [1], to regulate the measures of the anti-crisis program in the cattle branch, used the linear-dynamic model for long-term planning.

MATERIALS AND METHODS

To determine the optimal plan, for production and use of feed for the existing livestock in the analyzed household, the analysis, and the mathematical modeling method were used. They provide the composition of the respective economic-mathematical model and the preparation of the initial information. Based on the methods listed below, the numerical economic-mathematics model is created, and the problem is solved on the computer. The information materials selected from:

- the financial statements of LLC "Vealvit - Agro" (years 2016-2018);
- financial reports of "Vealvit - Agro" LLC (years 2016-2018);
- guidance on animal feed standards [15];
- some materials from the primary accounting records (years 2016-2018) and norms planned for 2021;
- cost tariffs in agriculture, developed by a group of researchers from the National Institute of Economic Research of the Republic of Moldova [2].

RESEARCH RESULTS

To achieve the proposed goal, in this article, we used the database from "Vealvit - Agro" LLC from Cerniţa village, Floresti district, Republic of Moldova. This company belongs to the Association of Agricultural Producers "FLORAGROSPER", whose field of activity is cattle breeding for milk production, cereals, fruits, nuts, and berries.

The analyzed agricultural holding has a narrow specialization because, in the structure of sales revenues in 2016-2018, the share of revenues from milk sales is about 93% (Table 1) [8]. It is necessary to mention that the calves are divided into age groups, which along the way are transferred to the group of up to 3 months, then the calves from 3-6 months and older than 6 months, still filling the herd of cows.

Table 1.

The structure of the areas sown with agricultural crops in LLC "Vealvit-Agro" compared to the optimal plan

Name of agricultural crops	Variables ha	Data for 2019		The optimal plan for 2021		Deviations (+;-)	
		ha	%	ha	%	ha	%
Autumn wheat (feed grains)	X_1	10	6.2	16.8	10.4	+6.8	+4.2
Spring barley	X_2	28	17.3	7.7	4.7	-20.3	-12.6
Fodder peas	X_3	-	-	12.2	7.5	+12.2	+7.5
Soybean feed	X_4	-	-	4.2	2.6	+4.2	+2.6
Sunflower	X_5	6	3.7	8.3	5.1	+2.3	+1.4
Corn grain feed	X_6	20	12.3	24.6	15.2	+4.6	+2.9
Maize - silo	X_7	60	37.0	24.4	15.1	-35.6	-21.9
Corn - green mass	X_8	-	-	8.0	4.9	+8.0	+4.9
Annual plants - green mass	X_9	-	-	2.6	1.6	+2.6	+1.6
Lucerne - hay	X_{10}	21	13.0	12.2	7.5	-8.8	-5.5
Alfalfa - hay	X_{11}	11	6.8	16.2	10.0	+5.2	+3.2
Lucerne - green table	X_{12}	6	3.7	24.8	15.3	+18.8	+11.6
Total		162	100	162	100		

Source: Prepared by the authors based on data from the Financial Statements and the results obtained from the optimization of the plan for the production and use of feed.

In the next step, we will analyze the structure of the sown areas with the agricultural crops that provide the animals with fodder, at the same time comparing it with the optimal data obtained as a result of solving problems at the computer [8].

Based on the data highlighted in Table 1, we notice that in the structure of sown areas a considerable share is held by silage corn (37%). On the second position is placed spring barley (17.3%), and on the third - alfalfa for hay (13%). According to scientifically argued rules, the alfalfa is insufficient for the annual insurance of animals with the assortment of feed.

According to the optimal plan, the LLC "Vealvit-Agro" is proposed to cultivate 12 agricultural crops instead of 8 ones, which were sown in 2019.

In this way, the structure of the areas that allow the production of protein-rich legume (peas and soybeans for feed grains) concentrates is considerably modified. Moreover, these crops are good precursors for winter wheat, as well as alfalfa, corn on the cob, and green mass.

As a result, even if the area occupied by alfalfa for green mass increased by 11.6 percentages, and the annual plants for green mass and maize for green mass, being cultivated on an area of 2.6 and 8 ha respectively, it does not allow to fully provide the cattle with green fodder during the grazing period according to the green conveyor.

So, the areas are sown with agricultural crops, according to the optimal plan (Table 1), with the potential of the planned harvest and the transfer coefficients in kg nutrient units and grams, the digestible protein will provide cattle, including dairy cows, with the necessary feed in total and in the respective assortment of fodder.

We present the structure of the annual feed ration of cows with an average body weight of 400 kg and the average annual milk productivity of 4,000 liters in LLC “Vealvit-Agro”, compared to the recommended norms.

Table 2.

Comparative structure of the feed ratio of dairy cows (%)

Name of the feeds	In fact in “Vealvit-Agro” LLC	According to the recommended norm *
Concentrate	45.8	29
Coarse,	20.4	17
Including: hay	18.5	13
Haying	-	2
Straw	1.9	2
Succulents (late autumn, winter, early spring)	21.3	31
Including: silo	21.3	24
Fodder beet	-	7
Green table (late spring, summer, early autumn)	9.2	23

Source: Compiled by the authors based on data from the LLC and the recommended rules
** G. Stepurin [15]*

Based on data from Table 2, we notice that in the annual feeding structure of dairy cows, concentrates occupy 45.8%, with the recommended by G. Stepurin [15]. But such a type of food-based only concentrates, as mentioned by the author M. Moroz [11], negatively influences the health of animals (related to the state of digestion of the stomach). To avoid this situation, it is necessary to include in the annual feed ration of cows several coarse quality feeds (rich in energy exchange, protein, starch, carbohydrates that are easily assimilated).

Proceeding from the intended purpose, regarding the determination of the optimal plan for production and use of feed, as well as its impact on the efficiency of milk production in "Vealvit - Agro" LLC, based on the method of economic-mathematical

modeling and study of mathematical models of authors M.Braslaveț and R. Kravcenko [4], M.Tuneev and V. Suhorukov [14] we developed the modification of the economic-mathematical model for the specific conditions of the analyzed enterprise, which includes the following sets of restrictions:

1) rational use of arable land in the amount of 162 ha intended for the cultivation of agricultural crops;

2) use of labor resources for manual and mechanized work, limited by the number of workers (20 people);

3) compliance with the requirements of the recommended crop rotation for the conditions of the analyzed household, namely;

- regarding the rotation of agricultural crops in crop rotation;
- regarding the minimum-maximum share of some crops in the arable land (162 ha);

4) ensuring the production of the necessary feed for 106 conventional cows (with the 3-age groups), in total quintals of nutritional units and quintals of digestible protein;

5) the set of restrictions that reflect the link between the feed needs of 106 conventional cows and the production of fodder (more detailed in the fragment of the numerical economic-mathematical model), namely:

- the connection between the plant culture and the herd of animals is made through their feeding norms;
- the approximate annual structure of the ration is given;
- the restrictions regarding the insurance of the cows with each kind of feed, according to the minimum norms, taking into account their possible addition;
- according to feed consumption as a surplus at the minimum norms;
- the condition of balancing the annual feed requirement;

6) according to maintaining the positive balance of humus in the soil;

7) the use of organic fertilizers depending on the norm obtained from an animal's head and their incorporation norm at 1 ha;

8) the production of the necessary milk, meat, and sunflower seeds for their commercialization.

The modification of the mathematical model, by the specific conditions of the analyzed household, allows us to formulate the economic-mathematical problem. It consists of determining the optimal plan of production and use of feed for 2021, with the objective function - minimizing the cost of feed base, with a positive impact on the efficiency of animal production.

To describe the set of restrictions with number 5, we present in Table 3 the minimum-maximum feeding norms of cows with the types of feed.

The main variables in the problem are:

From X1 to X12 - areas are sown with agricultural crops (ha) listed in table 1;

From X13 to X21 - the addition of feed types (Table 3) for the formation of the optimal annual feeding structure of cows.

The key moment in determining the optimal structure of areas sown with agricultural crops that allows optimizing the forage base and ensuring the annual food needs of the 106 conventional cows, is the description of the restrictions of set number 5, presented below in the model fragment.

Table 3.

Annual feeding structure of cows according to the minimum-maximum norms and the optimal norm (quintals of nutritional units)

Types of feed	Variables, ha	Minimum norm	Maximum norm	Optimal norm
Total quintal nutrient units,		41.93	60.83	52.14
Including: Legume-free concentrates	X_{13}	11.78	14.96	12.96
legume concentrates	X_{14}	1.82	2.41	2.41
Silage and fodder beet	X_{15}	12.72	19.1	15.77
Haying	X_{16}	3.33	4.53	4.53
Hay	X_{17}	3.53	4.52	3.53
Straw	X_{18}	1.11	1.50	1.11
Lucerne for the green table	X_{19}	5.46	9.65	8.25
Annual plants for green mass	X_{20}	1.93	3.31	1.93
Corn for green table	X_{21}	1.65	2.26	1.65

Source: developed by the authors based on the recommended rules and the results obtained from the computer.

The fragment of the numerical economic-mathematical model of this set of restrictions consists in:

11) providing 106 cows with quintals of nutritional units in total:

55.35 X1 +…. +70 X12 > = 52.17 x106;

12) Supply with digestible protein, quintals: 0.62X1 +….. + 15.1X12> = 5.59x106

The coefficients of the variables represent the feed yield per hectare of the respective crops;

Figures 52.14 and 5.39 - correspondingly, the required in quintals of nutrient units and quintals of digestible protein in the calculation of a conventional cow;

106- the planned herd of conventional cows.

The following set of restrictions reflects the provision of the 106 cows with each type of feed according to the minimum standards (table 3), taking into account the possible addition for 106 cows, namely:

13) concentrates without legumes:

41.4X2 + 79.9X6 47.15X1 +> = 11.78x106 + X13; and so on for every kind of feed…

21) green corn mass: 37.8X8 > = 1.65x106 + X21.

The coefficients of the variables in restrictions 13-21 indicate the feed yield on 1 ha; those next to the number 106 - the minimum feeding norm for cows with the appropriate type of feed.

The restrictions from 22-30 reflect the provision of cows with each type of feed consumed more than the minimum norm, in the addition of each type of feed (from X13 to X21) does not exceed the difference between their maximum and minimum norm (Table 3), namely:

22) legume-free concentrates: X13 <= (14.96-11.78) x106 and so on for each kind of feed...

30) green mass of corn: X21 <= (2.26-1.65) x106;

31) the condition of balancing the annual feed requirement for cows in quintals of nutritional units, in other words, the sum of feed additions is equal to the difference between the average feeding norms (52.14) and the minimum (41.93): X13 +… + X21 = (52.14 to 41.93) x106.

As follows, the sets of restrictions listed allow, together with the optimization of the structure of the areas sown with fodder crops and fodder cereals (optimal feed production plan), to form the optimal annual needs of cows with the respective feed types

in the minimum, maximum or average reflected in table 3. As we see, in the optimal norm of the annual feed ration of cows is rational to be included according to the maximum norm: legume concentrates and alfalfa hay; awarding to the minimum norm: straw, green mass of annual plants and corn, and the number of other types of feed varies between the minimum and maximum norms.

Simultaneously, we mention that the average annual feed rate for a conventional cow head is maintained at 52.14 quintals of nutrient units, and the annual structure of the ration corresponds to the recommended rules (11), namely: concentrated-29%, succulent-30%, coarse — 17% and green fodder — 23%.

The optimal plan for the production and use of feed, as well as the optimal annual feed rate for cows, will help to balance the ration granting to the nutrient units (q), the digestible protein (q), the types of feed in that assortment and finally - increasing milk productivity, reducing the cost of the feed base and increasing the efficiency of animal production (increasing profit and profitability), reflected in Table 4.

Table 4.

Economic efficiency of milk production in LLC "Vealvit-Agro"

Indicators	Average years 2016-2018	The optimal plan for the year 2021	The data of the optimal plan compared to the average of the years 2016-2018 (%)
The annual amount of milk from a cow, liters	5,914	7,025.8	118.8
Feed costs calculated at 1q of milk, lei	73.2	63.5	86.7
The cost of a q of milk, lei	424.2	381.8	90.0
The average selling price of a q of milk, lei	590.0	608.3	103.1
The value of global milk production calculated on an average annual cow, thousand lei	36.2	42.9	118.6
The profit obtained by calculating 1q of milk sold, lei	166.1	201.3	121.2
Profitability level,%	39.17	49.42	+10.25

Source: developed by the authors, based on data from the financial statements and reports of the LLC and the results obtained from the optimization of the feed production and use plan.

Analyzing the data presented in Table 4, we observe a significant increase in economic indicators, according to the optimal plan compared to the average of 2016-2018.

Thus, the average annual productivity of a cow will rise by 18.8%, the value of global milk production — by 18.6%, the cost of feed in a quintal of milk, as well as the cost of a quintal of milk will be reduced, respectively — by 13.3% and 10.0%, which will contribute to the increase of the profit in the calculation for a quintal of milk by 21.2%. As result, the level of profitability of milk production will be 49.42%, which will increase by 10.25 percentage points compared to factual data.

CONCLUSIONS

1. The research carried out allows us to deduce the important cause of the declining indicators in the livestock sector is the lack of a strong, balanced feed base, which is conditioned by insufficient production and a lower quality of feed.

2. Significant increases in animal productivity would be possible as a result of improved feed structure, quality feed preparation, balanced animal feeding, and the use of advanced technologies and animal husbandry.

3. To determine the optimal variant of the feed production and use plan, in order to provide the livestock sector with quality feed, through minimum costs, along with

traditional methods, it is rational to use the method of economic-mathematical modeling with solving the problem at the computer.

4. It is recommended for "Vialvit-Agro" LLC to carry out the production process, focusing on the optimal structure of areas sown with fodder crops and fodder cereals presented in Table 1, which will contribute not merely to the creation of a durable fodder base but also to improve soil fertility, maintain the favorable balance of humus in the soil, as well as increase the quality of production.

5. The optimal structure of the sown areas (Table 1) and the minimum-maximum norms (Table 2), will allow creating the optimal annual feeding structure of the cows (Table 3).

6. It would be beneficial for the analyzed household to manage the annual feeding structure of the cows according to the optimal norms presented in table 3; to make up the feed ration for 2 periods (winter and summer), even for 4 periods (summer, autumn, spring, and winter), taking into account the bodyweight of the cows, breed, productivity, physiological condition, and other factors.

7. As a result of optimizing the annual feed ratio of dairy cows and increasing productivity compared to the actual data, it would be rational to include in the ration, as a maximum rule, the following types of feed: legume concentrates and alfalfa hay minimum norm - straw, green mass of annual plants and corn (Table 3).

8. According to the indicators of economic efficiency of milk production, reflected in Table 4, we can conclude that the optimization of the production plan and the use of feed will exercise a beneficial influence on the significant increase of these indicators, compared to the average of 2016-2018.

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