Bulgarian Journal of Agricultural Science, 31 (No 1) 2025, 28–32

Correlation and regression analysis of economic indicators after application of biofertilizers in forage grass production from bird's-foot-trefoil

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Abstract

Churkova, K. & Churkova, B. (2025). Correlation and regression analysis of economic indicators after application of biofertilizers in forage grass production from bird's-foot-trefoil. *Bulg. J. Agric. Sci., 31*(1), 28–32

In a scientific research experiment conducted in the experimental field of the Research Institute of Mountain Stockbreeding and Agriculture-Troyan, the cost-effectiveness ratio was calculated using data of economic indicators, of the forage production from bird's-foot-trefoil, after fertilizing with the organic fertilizers, such as Lumbrex at doses of 150 ml/da and 200 ml/da and Lumbrical 150 ml/m^2 and 200 ml/m^2. The used methods of correlation and regression analysis made it possible to determine dependencies between economic indicators and to present regression equations. The results have proven that the fertilizing with Lumbrex at a dose of 150 ml/da as the most economically effective and profitable agro-ecological measure. The high positive correlation coefficients between dry matter yield and gross income (r = 0.9999); cost price and production costs (r = 0.9497); yield with gross profit (r = 0.7449) proves the interconnection of fertilizing with the main economic indicators that affect yield. Graphical models based on the regression between gross income and yield (y = 0.3346x + 1.6015) are presented.

Keywords: Economic efficiency; correlations; regressions; sown grassland

Introduction

Sown grasslands are the main source of high-quality forage in mountain areas. In recent years, improvement actions have been introduced in the member countries of the European Union, with the aim of increasing the economic efficiency and the ecological impact (Fanlo et al., 2000). The requirements in this direction are related to the application of appropriate agricultural techniques, leading to economic results under market conditions, consistent with preserving and increasing soil fertility and economically significant grass species (Iliev, 2018).

An essential element of the forage production technology is the introduction of fertilizers of organic origin, in order to obtain ecologically clean plant and animal production. Organic fertilizers (biofertilizers) have a natural origin, therefore they can be used for biological fertilizing (Bozhanski et al., 2023). The choice of appropriate types and rates of fertilizing, leading to a reduction in costs and an increase in the profitability of forage production is essential for agriculture. For this purpose, various agrotechnical events related to balanced fertilizing and treatment with foliar fertilizers are applied (Ventroni et al., 2010; Churkova, 2012). In recent years, agrarian science has been directed towards the application of biological preparations for agriculture (Stoynev, 2004), which are used as substitutes for synthetic fertilizers.

In the conditions of sustainable agriculture, they are an alternative to chemical fertilizers for improving soil fertility and increasing the productive efficiencies of crops (Wu et al., 2004; Alves et al., 2009). Lumbrical and Lumbrex biofertilizers contain biologically active components (growth regulators, humic acids) that stimulate the development of soil microflora, facilitate the assimilation of organic elements (Atanassova & Nencheva, 2012) and improve the qualitative parameters of plants (Vlahova, 2013).

Comprehensive development of an element of the technology for creating biological forage, related to meeting the needs of plants with nutrients of organic origin, consistent with soil protection and improving soil fertility, is a top priority in forage production and meadow farming. This is also proven by the already studied correlation and regression connections between key nutritional values and the quality of forage biomass from bird's-foot-trefoil with soil and foliar application of Lumbrex and Lumbrical biofertilizers (Bozhanska, 2021). Dependencies of quantitative and qualitative indicators of the forage obtained from mixed grass stands are presented (Bozhanska & Churkova, 2020).

Scientifically based and in-depth economic studies determining the interconnections between the yield and the obtained economic indicators in this area are missing or scarce. The data on forage grass production is reduced to presented yields for dry matter, areas of artificial grasslands, botanical composition of the grassland. This necessitates an in-depth economic analysis and the interconnections inextricably linked to it in order to give a complete look to the research experiment on artificial grassland fertilizing.

The aim is to determine correlation and regression of economic indicators after application of biofertilizers in the forage production from bird's-foot-trefoil.

Material and Methods

The economic efficiency of forage grass production from sown grasslands was determined as a result of application of biofertilizers in a scientific research experiment in the experimental filed of the Research Institute of Mountain Stockbreeding and Agriculture-Troyan. The experiment was set according to the block method in 4 replications with a harvest plot size of 5 m^2 with a total area of 100 m^2. The grassland consists of bird's-foot-trefoil sown at a seeding rate of 1.200 kg/da in the following fertilizing variants: 1. Control; 2. Lumbrex 150 ml/da; 3. Lumbrex 200 ml/da; 4. Lumbrical 150 ml/m^2; 5. Lumbrical 150 ml/m^2. The cost-effectiveness ratio (C_{ef}) for the forage grass production has been determined. The cost-effectiveness ratio was calculated with the formula:

$$C_{ef} = income/cost.$$

Two types of costs are reported – current (production and sales expenses, which occur constantly throughout the year and characterize the production cost price) and one-time (investments, innovations, etc.). Financial indicators are also essential: production costs, cost price, revenue and gross profit. Profitability, in turn, is considered as one of the main indicators of the efficiency of production activity and is defined as the ratio of the financial result (profit) and the costs or resources spent to obtain it. Total revenue (TR) is the product of the amount of output realized and the price per unit of output. The amount of revenue is determined by the product of the market price per unit of production (P) and the amount of realized production (Q) (Dimov, 2000) according to the following formula:

*Total revenue = Unit of output * Quantity of output realized, or TR = P.Q*

Costs are the investments that have been made, multiplied by their price (Tsvetkova, 2019).

Correlation analysis determines the study on the interconnections in parallel with the achieved result of external cases. In practice, correlation and regression analysis are often used together. They make it possible to determine and evaluate the tightness of the interconnections between a given variable and one or more other variables that determine it (Ivanov, 2011).

Regression analysis allows using the technique of multiple linear regression. For the purpose of dependent variable (y) yield was taken, and factor variables (x) were costs of fertilizers, seeds, wages, etc. Each regression coefficient shows by how many units the (+/−) result (impact) changes when the i^{-th} factor changes (+/−) with the same unit (Todorov, 2004). The method is applicable when the values of the correlation coefficient between the economic indicators are high.

Results and Discussion

Economic efficiency in the forage grass production from sown grassland, as a result of application of biofertilizers

The results (Table 1) show the high values of economic efficiency after application of Lumbrex (at both doses). With a pronounced high economic efficiency of costs, which approaches the control, is the variant with application of Lumbrex at a dose of 150 ml/da, which over the years and on average for the study period is respectively: 1.12; 7.80; 9.23 and 6.05.

The lowest efficiency is registered in using Lumbrical 200 ml/m^2, with average values of 4.57 or 65.64% compared to the control. As with Lumbrex and Lumbrical, the lower dose has a higher economic effect according to the values of the efficiency coefficient.

Table 1. Cost-effectiveness ratio (Cef) in treatment of an sown grassland (bird's-foot-trefoil) with Lumbrex and Lumbrical

Variants	2014		2015		2016		2014–2016	
	C_{ef}	%	C_{ef}	%	C_{ef}	%	C_{ef}	%
1. Control (C)	1.21	100	8.95	100	10.74	100	6.97	100
2. Lumbrex 150 ml/da	1.12	92.56	7.80	87.15	9.23	85.94	6.05	86.84
3. Lumbrex 200 ml/da	1.11	91.73	7.31	81.67	8.51	79.24	5.64	81.00
4. Lumbrical 150 ml/m^2	1.07	88.43	6.56	73.30	7.79	72.53	5.14	73.78
5. Lumbrical 200 ml/m^2	1.04	85.95	6.19	69.16	6.49	60.43	4.57	65.64

Source: Own calculations

In the analysis of the economic efficiency data, the lowest value was observed and found for all variants in the year of the grass stand establishment. This is explained by the significantly higher costs incurred. A trend of a significantly higher efficiency coefficient was found when applying the Lumbrex biofertilizer, both by year and on average over the study period. The lower dose of Lumbrex according to the coefficient of economic efficiency shows a higher positive effect than the higher fertilizer rate. The overall analysis of the economic efficiency, combined with the obtained fodder production, gives reason to note the significant differences in the average yields of dry matter by years and on average for the period of study and realized gross revenues by variants. There are significant differences in the level of costs by variants, especially those for fertilizers, both in terms of their type and dose.

Correlations and regression equations

The dry matter yield has the highest positive correlation with the gross revenue (r = 0.9999) and gross profit (r = 0.7449) after fertilizing with Lumbrex and Lumbrical in a pure crop with bird's-foot-trefoil (Table 2). The cost price has a very high positive correlation with the values of production costs (r = 0.9497). Their statistical correlation coefficients of these three dependencies show that the correlation between the analyzed indicators is very strong. Yield is relatively highly correlated, but lower than the above indicators with the production costs (r = 0.6913). The correlation between gross revenues and production costs is also positive (r = 0.6931). A negative correlative relation was reported between yield and profitability (r = -0.4599).

The yield is in a good regression dependence with the gross revenues $R^2 = 0.9999$ (Figure 1), which confirms the good interconnection between them. The theoretical regression line and the equation of the regression dependence between these two indicators are represented by the equation $y = 0.3346x + 1.6015$ with a very high coefficient of determination.

The presented high coefficient of determination between the cost price and production costs determined the theoretical regression line and the equation of the regression dependence between these two indicators, which are depicted in Figure 2, where $y = 1291x – 17.566$ and $R^2 = 0.9019$.

The established high correlation dependence between yield and gross profit allows the derivation of the equation $y = 0.1798x + 71.38$, with a coefficient of determination $R^2 = 0.5548$ (Figure 3).

Fertilizing had the highest degree of impact on the change in yield values, and thence on the economic indica-

Table 2. Correlation coefficients (r) between yield and main economic indicators of forage production from sown grassland of bird's-foot-trefoil in applying organic fertilizers Lumbrex and Lumbrical by years and on average for the period 2014–2016

	Yield	Production costs	Cost price	Gross revenues	Gross profit	Profitability
Yield	1					
Production costs	0.6913	1				
Cost price	0.4323	0.9497	1			
Gross revenues	0.9999	0.6931	0.4344	1		
Gross profit	0.7449	0.0330	-0.2790	0.7433	1	
Profitability	-0.4599	-0.9585	-0.9992	-0.4618	0.2492	1

Source: Own calculations

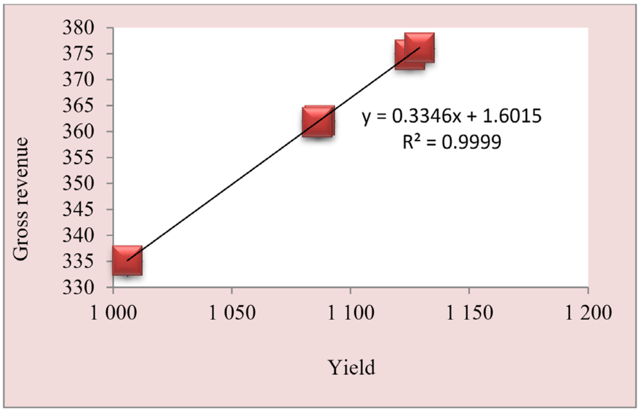

Fig. 1. Regression between gross revenue and yield after treatment the bird's-foot-trefoil grass stand with Lumbrex and Lumbrical
Source: Own calculations

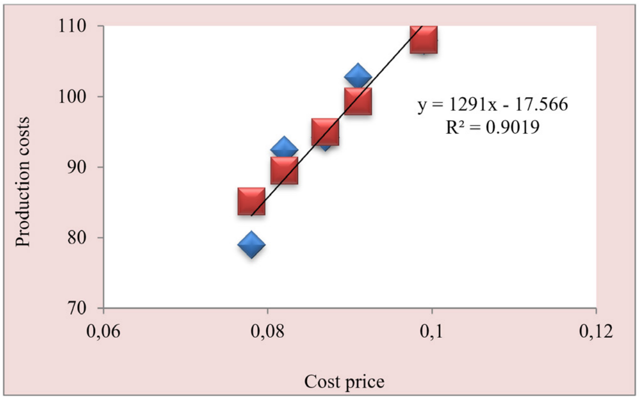

Fig. 2. Regression between cost price and production costs after fertilizing the bird's-foot-trefoil grass stand with Lumbrex and Lumbrical
Source: Own calculations

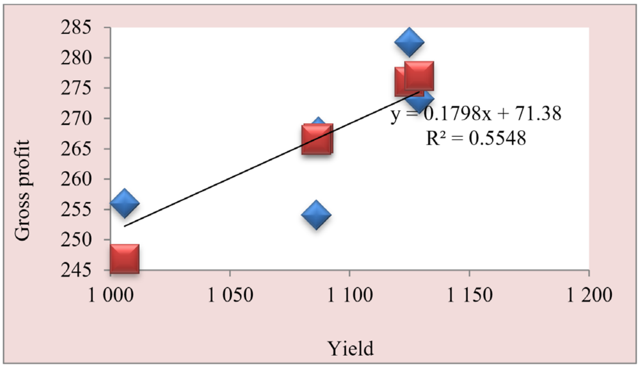

Fig. 3. Regression between gross profit and yield after treatment the bird's-foot-trefoil grass stand with Lumbrex and Lumbrical
Source: Own calculations

tors and the interconnection between them. The established correlation dependences reveal a good opportunity for tentative determination of the yield depending on the production costs, and the graphic models in Figure 2 through the specified equation determine the opportunity of forecasting the cost price of the obtained forage depending on the amount of production costs.

Conclusions

The fodder obtained from a pure crop with bird's-foot-trefoil, fertilized with the Lumbrex biofertilizer at a dose of 150 ml/da is the most cost-effective and economically efficient agro-ecological measure, according to the economic efficiency of costs.

Fertilizing with Lumbrex and Lumbrical biofertilizers determines the high positive correlation dependence between dry matter yield and gross revenue (r = 0.9999); cost price and production costs (r = 0.9497); yield with gross profit (r = 0.7449).

Gross revenue can be predicted and determined through the developed graphical models based on yield for practical purposes.

The regression dependence between gross revenue and yield determines the opportunity to present the equation (y = 0.3346x + 1.6015) between these two indicators.

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Received: **November, 22, 2023**; *Approved*: **January, 05, 2024;** *Published:* **February, 2025**