MEASURING THE EFFECT OF PRODUCTION FACTORS ON YIELD OF GREENHOUSE TOMATO PRODUCTION USING MULTIVARIATE MODEL

Mariana Nikolla, MSc

Ilir Kapaj, PhD

Ana Kapaj (Mane), Prof. As.

Jona Mulliri

Agriculture University of Tirana

Alfons Harizaj

National Agencies of Exams

Abstract:

The aim of this study is efficient use of production resources among farmers in agricultural intensive area in Lushnja region. Through application of mathematical models study aims to investigate trends of production processes and define the main paths that characterized these processes. To investigate the relation between tomato yield of production (dependent variable) and several production factors it is used the multivariate model. Collection of data is done by utilizing a face to face questionnaire and the study area involved 16 communes in Lushnja region where the target group were farmers engaged in greenhouse tomato production (data are referring to the year 2011). After the discussion with experts the most important factors affecting the yield of tomato production were identified like, organic manure, fertilizer, liquid fertilizer, pesticides and irrigation. The analysis reveals that the overall effect of these factors on yield of greenhouse tomato production was 56%, while the impact of the other production factors was minor. The correlation matrix between yield of tomato production and each independent factor revealed the following figures: fertilizer (0.369), organic manure (0.149), liquid fertilizer (0.096) and irrigation (0.189). Again, by using statistical multivariate model the maximum and potential yield was calculated considering the efficient use of production resources. The difference between theoretical maximum yield and current yield of production results in maximum potential for improvement in terms of resource use efficiency. The multivariate model was used also for other purpose, the potential for cost reduction without get rid of actual yield. Based on these results the policy makers (extension service) and farmers can develop the most appropriate model in terms of resource use efficiency.

Keywords: Tomato, Yield, Multivariate model, Lushnja region, Parameters

1. Introduction:

Sustainable agriculture requires not only increase production for each entity, but also increases their economic efficiency. One of the basic indicators for agricultural productivity growth is the recognition and effective use of internal reserves agricultural farms. Using mathematical models in financial and economic analysis of the impact of production factors on agricultural productivity growth is a priority in contemporary developments in the agricultural sector.

Recognition and the use of mathematical models is important because:

- Assist in developing economic development program and define limits for output growth given amount of production factors.
- Provide optimal levels of use of production factors, in order to get maximum value result-index (yield) or minimum value (cost).
- Determine the degree of substitution of production factors with each other.
- Provide production levels at certain moments of time.
- Provide information of a general nature, necessary to determine the degree of use of production factors.
- Serve as a basis for prognosis of development of individual branches of the economy and agricultural production.

Type of model to be used subject to the data collected, and therefore made a detailed study of the data collected to conclude on the appropriate link.

The main purpose of this paper is the use of mathematical models in order to increase the efficiency of agricultural production. As the object of study is the greenhouse tomato production in 16 communes of district Lushnja (Albania).

2. The study methodology:

In order to achieve the objectives of the study followed the following procedure:

1. Identification of key factors influencing the yield of tomato. Such factors were considered: manure, fertilizer, liquid crystalline fertilizers, pesticides (kv/dyn) and irrigation (m^3/dyn)
2. Define Treatment mathematical model that will apply. Local series techniques were used.
3. Analysis of the model parameters in order to ensure maximum effectiveness of selected production factors in the model.
4. Determination of optimal level of productivity of tomato in each municipality.
5. Calculation of unused internal resources of each municipality, obtained as a result of increasing efficiency and reducing the cost of production.
6. Calculation of factor substitution rates (in quantity and value).
7. The selection of the most rational possible variants.
8. Processing and calculations were made with the computer program Microsoft Excel.

The information gathered from the surveys was remedied and underwent regressive and correlative statistical analysis. Correlative links between the yield of crop and the factors that influence its growth, show the importance of knowledge, research and determine the most appropriate alternatives to effectively use their quantitative use in achieving the ultimate goal. Making analysis showed that the impact of these factors is about 56%.The impact of other factors of production is very small. Correlative analysis on the impact of each factor in the production of tomato, ranked in order of importance: fertilizer (0369), manure (0.149), water (0189), manure liquid crystalline (0.096). Below is the full table of this analysis.

To analyze the performance with other manufacturers take on the study, analyzed and applied mathematical model Multivariate:

$y = a_0 x_1^{a_1} x_2^{a_2} x_3^{a_3} x_4^{a_4} x_5^{a_5}$ where x_j for j = 1,2,3,4,5 are production factors.

While a_i are the parameters of the model (i = 1, 2, 3, 4, 5). These parameters reflect the effectiveness of the use of the relevant factors. Maximum values of the parameters were calculated according to the formula:

$$a_i = p_i \max_k \left\{ \frac{\log \frac{y_k}{a_0}}{\log x_{k\,i}} \right\}, \qquad p_i = \frac{r_{yx_i}}{\sum_{i=1}^{5} r_{yx_i}} \;, \qquad a_0 = \frac{\bar{y}}{\prod_{i=1}^{5} \left(\bar{x_j}\right)^{p_i}} \;, \text{j=1-5}$$

From calculations made based on the above mathematical formulas (calculations are done with the computer program Excel) as well as the actual values of the factors of production, are taking the following values:

$p_1 = 0.537$ $p_2 = 0.216$ $p_3 = 0.140$ $p_4 = -0.167$ $p_5 = 0.274$ $a_0 = 32.602$

Has built an auxiliary table to calculate the model parameters where are set rates $\frac{log\frac{y_k}{a_0}}{logx_{ki}}$. In each column are selected their maximum values and are based on mathematical formulas for calculating of parameters $\mathbf{a_i}$. From these calculations was obtained the following values:

$a_1 = 0.1224$, $a_2 = 0.5919$, $a_3 = 0.4773$, $a_4 = 0.0274$, $a_5 = 0.0722$

With these parameters Multivariate model has the following appearance:

$$\mathbf{Y} = 32.602\ \mathbf{x_1^{0.1224}\ x_2^{0.5919}\ x_3^{0.4773}\ x_4^{0.0274}\ x_5^{0.0722}}$$

Drawing on actual levels of production factors used by each municipality, it was estimated the maximum yield that can be achieved on the basis of a more rational use of factors. Differences between maximum yield and actual yield give maximum untapped reserves. On the basis of the results obtained, were calculated for each municipality in the district of Lushnja maximum untapped reserves. But, they represent level extremely and virtually full use of them cannot be achieved.

In addition to calculating the maximum reserves were estimated reserves of each municipality based on municipalities with the best results. Municipalities with better results were called municipalities with higher than average yield. Use of these resources is available to a greater extent because their calculation is based not on the highest score of a municipality, but in a few municipalities. In this case the calculation of parameters $\mathbf{a_i}$

performed with the formula: $a_i = p_i mes_p \left\{ \frac{\log \frac{y_k}{a_0}}{\log x_{ki}} \right\}$ where $mes_p \left\{ \frac{\log \frac{y_k}{a_0}}{\log x_{ki}} \right\}$ is average of rates

$\frac{\log \frac{y_k}{a_0}}{\log x_{ki}}$ larger than the overall average. These reports fulfill the condition:

$$\frac{\log \frac{y_k}{a_0}}{\log x_{ki}} \geq \frac{\log \frac{y_k}{a_0}}{\log x_{ki}}$$

The results obtained for each factor of the model are:

0.214 2.409 2.855 -0.193 0.252

$a_1 = 0.1151$ $a_2 = 0.5201$ $a_3 = 0.3983$ $a_4 = 0.0322$ $a_5 = 0.0692$

With these parameters Multivariate model has the following appearance:

$$\mathbf{Y = 32.602\ x_1^{0.1151}\ x_2^{0.5201}\ x_3^{0.3983}\ x_4^{0.0322}\ x_5^{0.0692}}$$

On the basis of this model were calculated for each municipality untapped domestic reserves. These reserves compared to the first model are smaller, but also more likely (reserves for both models are presented in Table 2). Above models can be used to calculate reserves on cost reduction, as a difference between the actual cost of production factors of each municipality, with the minimum possible cost.

Minimum cost and minimum potential was calculated with the formula $z_{\min} = \frac{\sum_{i=1}^{n} c_i x_i}{y_{\max}}$ dhe

$$z_{mund} = \frac{\sum_{i=1}^{n} c_i x_i}{y_{mund}}$$

Were $\mathbf{c_i}$ are prices of factors $\mathbf{x_i}$,(ALL/kv).

In Table 2, are presented (Annex) are throwing all the results calculated according to the two models mentioned above. The data in the table we find that productivity growth stocks tomatoes are significant in municipalities: Divjake, Tërbuf, Golem, Hyzgjokaj. Reserves for reducing the cost of tomato production are significant in municipalities: Divjake, Kolonje, Tërbuf Golem, Hyzgjokaj.

An important aspect in the calculation of internal resources is to establish the correct ratios quantitative factors that affect the growth yield of crop. The same yield, but with lower costs can be achieved by relying on the ability to have different factors to replace to some extent, each other. So fertilizer can be replaced with organic fertilizer or vice versa, but since their prices are different between them can be placed such reports without reducing productivity, reduced production costs, i.e. the lower the cost per unit. For this it is necessary to calculate replacement rates mutual production factors. If x_i factor reduced or increased on average with a unit, then it can be replaced with an increase or decrease of Dx_{ji} unit of x_j factor. This amount is called the rate replacement of x_i factor t with x_j factor.

$$D_{xji} = \overline{x_j}\left[\left(\frac{\overline{x_i}}{\overline{x_i} \pm a}\right)^{\frac{a_i}{a_j}} - 1\right] \qquad D_{xji} = \overline{x_j}\left[\left(\frac{\overline{x_i}}{\overline{x_i} - 1}\right)^{\frac{a_i}{a_j}} - 1\right]$$

$\overline{x_i} \rightarrow$ average level of the i-factor,

$\overline{x_j} \rightarrow$ average level of the j-factor,

ai, aj - the coefficients of the relevant factors

So, if you reduce the amount of manure (x_1) with a unit, this reduction can be compensated by the addition of chemical fertilizer (x_2) $D_{x_{21}}$ unit to obtain the same yield

$$D_{x21} = 1.59\left[\left(\frac{90.3}{90.3-1}\right)^{\frac{0.1224}{0.5919}} - 1\right] = 0.0037 \text{ kv/dyn}$$

But, 1 kv manure costs 1700 ALL, and 0.0037kv/dyn fertilizer cost 37 lek, so this replacement is of interest from the economic point of view. Maximum rates of substitution of factors discussed above, expressed in natural measurement unit and value, are given in Table 1 (see Annex).

3. Conclusion:

The above analysis showed that the reserves to increase tomato yields were considerable. Average yield can grow with 17 kv/dyn or 30%, while in the individual municipalities, as the Golem about 38%, Tërbuf about 33% and in Divjakë about 32%.

Even in terms of the cost of tomato production, to reduce its reserves were substantial, about 21%, while in separate municipality reserves for reducing the cost of tomatoes have been even greater as: Divjakë 31%, 24% Kolonje, Tërbuf 33%.

- Replacement rates help in the design of rational alternatives to the use of production factors. Based criteria derived from these rates and that serves to develop these variants is: first used wholly beneficial factors, and other factors to be used as a complement, but with the requirement to maintain the minimum ratios between factors.
- Based on the data in table 2 and 3 can be constructed variants appropriate, economically viable, the use of production factors in order to achieve the maximum possible performance.
- Knowledge of domestic reserves helps agricultural farms in crop yield scientific planning and cost per unit.
- The same model can be used efficiently to make such analysis for other crops in the agricultural sector but also in farming. Through Multivariate mathematical model built above, recognizing that agricultural economy quantities for each factor in the planning period, can be calculated maximum yield, and he most likely.
- Obtained results are a good basis for the final design performance plan and tomato crop cost for each municipality in the district of Lushnja.

References:

Ragsdale, C. T. Spreadsheet Modeling and Decision Analysis, 5th Edition Revised South-Western, Thomson, (2008)

Spreadsheet Modeling and Decision Analysis, 5th Edition. AGEC5403 syllabus (1993)

Ragsdale, C. T. 2008. Spreadsheet Modeling and Decision Analysis. Anderson, J. R, J. L. Dillion and B. Hardaker. Agricultural Decision Analysis. Iowa State Press, (1977)

Luptacik,M (2004). Mathematical Optimizacion and Economic Analysis

Van Loon and Luptacik. M (1991) Optimization, dynamics and economic analysis

Allan, R. G. D (1968). Mathematical Analysis for Economists

Silberberg,E (1990). The Structure of Economic: A Mathematical Analysis

David L. Debertin (1986). Agricultural Production Economics

Myslym Osmani, (2005). Metodat e Ekonometrisë

Johnston, J. (1984). Econometric Method

Panzar, J. C. R. Willing (1991). Economies of Scale in Multi-Output Production

ANNEX

Table 1. Data on tomato yield and use of factors in Lushnja district

Municipalities	**Actual Yield (kv/dyn)**	**Manure (kv/dyn)**	**Fertilizer**	**liquid crystalline fertilizers**	**Pesticides (kv/dyn)**	**Irrigation**
K	**Y**	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**
Bashkia Lushnjë	91	90	1. 6	1. 5	0. 06	55
Bashkia Divjakë	86	90	1. 7	1. 6	0. 65	50
Karbunar	85	100	1. 5	1. 5	0. 07	55
Fiershegan	85	80	1. 6	1. 7	0. 07	50
Allkaj	86	90	1. 8	1. 4	0. 07	40
Krutje	85	100	1. 5	1. 5	0. 65	40
Bubullimë	80	80	1. 4	1. 4	0. 07	45
Kolonjë	80	80	1. 5	1. 7	0. 07	50
Gradisht	85	100	1. 5	1. 4	0. 06	55
Remas	83	100	1. 5	1. 4	0. 06	50
Tërbuf	80	90	1. 8	1. 3	0. 65	50
Dushk	82	90	1. 4	1. 5	0. 07	50
Golem	78	90	1. 8	1. 5	0. 65	45
Grabian	84	85	1. 7	1. 6	0. 07	50
Hyzgjokaj	82	100	1. 8	1. 5	0. 08	50
Ballagat	75	80	1. 4	1. 5	0. 07	50
Averages	82. 9	90. 3	1. 5	1. 5	0. 21	49. 1
Total	**1327**	**1445**	**25. 5**	**24**	**3. 42**	**785**

Table 2. Factors substitution rates (quantity and value)

		X_1		X_2		X_3		X_4		X_5	
		N	V	N	V	N	V	N	V	N	V
X_1	N			10596. 79		6460. 41		_		1. 1037	
	V				957028		583459		_		99. 6796
X_2	N	0. 0037				2. 27		_		0. 0040	
	V		36. 74				3. 62		_		0. 0064
X_3	N	0. 0043		3. 60				_		0. 0047	
	V		8578. 21		5. 40				_		0. 0070
X_4	N	0. 0109		390223098		43825484				0. 0119	
	V		6002. 30		83507743		9378653				0. 0026
X_5	N	0. 9349		160378		69920. 45		_			

Table 3. Data on potential yield and production costs tomatoes in greenhouses, in the District of Lushnja.

	Actual Yield	yield max possible	yield most likely	Reserves in kv / dyn		*Actual cost*	*Min cost*	*Most likely cost*
				Max	*Most likely*			
Municipalities	**kv/dyn**	**(Y_{max})**	**(Y_{mm})**	**(R_{max})**	**(R_{mm})**	**(Z)**	**(Z_{min})**	**(Z_{mm})**
M	1	2	3	4=2-1	5=3-1	6	7	8
Bashkia Lushnjë	91	112	99	21	8	35199	28583	32357
Bashkia Divjakë	86	127	112	41	26	43355	29357	33162
Karbunare	85	110	97	25	12	37936	29388	33115
Fiershegan	85	117	102	32	17	42253	30710	35045
Allkaj	86	114	101	28	15	35003	26383	29906
Krutje	85	114	102	29	17	41686	31084	34626
Bubullimë	80	98	88	18	8	37368	30582	34029
Kolonjë	80	113	99	33	19	44881	31897	36231
Gradisht	85	106	94	21	9	35519	28557	32027
Remas	83	105	94	22	11	36373	28753	32238
Terbuf	80	119	107	39	27	39119	26303	29349
Dushk	82	103	92	21	10	39104	31049	34778
Golem	78	126	112	48	34	45249	27917	31494
Grabian	84	119	104	35	20	40488	28666	32713
Hyzgjokaj	82	122	107	40	25	39400	26555	30297
Ballagat	75	102	91	27	16	42527	31333	35065
Averages	**83**	**113**	**100**	**30**	**17**	**39716**	**29195**	**32902**
	1327	**1806**	**1602**	**479**	**275**	**635459**	**467115**	**526432**