Improving the methodology for predicting the yield of walnuts in farms based on econometric models

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Abstract. Agrarian reforms carried out in the agriculture of the republic, along with the development of production sectors, provide for the diversification of products, the development of new areas, as well as the expansion of previously unclaimed areas on the world market, but today the demand for which is growing. At the same time, the effective use of the opportunities of farms and family household plots is of great importance. Given the importance of the walnut, which is in high demand on the world market, one of the modern requirements is to further stimulate and increase the efficiency of the use of rain fed lands in the republic, the widespread introduction of scientifically based methods and intensive technologies for growing walnuts and the creation of modern walnut plantations with an increase in production competitive in the domestic and foreign markets for walnuts. In the course of a survey of farms and household plots of the district, it was noted that by placing new varieties of walnut, it is possible to obtain a good income, long-term return on investment, low cost. The article describes the results of research in important areas, based on the characteristics of the current stage of development of walnut cultivation in farms. Keywords: land resources, level of utility, redistribution, land market, organizational and economic mechanism, raising efficiency, economics, nut processing, walnut, specialization, risk, selection, mountainous and foothill areas, biological opportunity.

1 Introduction

In the countries of the world, the need to provide their population with food products, the issue of maintaining economic security and social stability is becoming more and more urgent [1-5]. Food security provides for the provision of the country's population with basic food products due to sufficient domestic capabilities, as well as the solution of such issues as reducing import dependence [5-9]. In particular, this causes various difficulties associated with the system of growing agricultural products and delivering them to consumers at the level of demand, that is, their transportation, storage, processing and sale [10-12]. This requires special attention to such topical issues as the efficient use of land, the increase in food production and the development of links for their delivery to consumers, the adaptation of integration and cooperation relations between the subjects of the value chain to market

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requirements and economy, especially ensuring the food security of the country [7, 10]. Due to the limited land resources in Uzbekistan, the importance of agricultural holdings in improving the provision of food to the population and achieving food security is increasing [12-15].

The President of the Republic of Uzbekistan, Shavkat Mirziyoev, in his address to the Oliy Majlis on December 29, 2020, specifically emphasized that "the factor that will give the fastest results in reducing poverty and increasing the income of rural residents is the sharp increase in productivity and efficiency in agriculture." In this process, it was made a priority to increase the income from each hectare of land from the current average of 2,000 UZS to at least 5,000 UZS, and it was determined that we should widely introduce the most advanced technologies, water-saving and biotechnologies [7].

Decree of the President of the Republic of Uzbekistan No. PQ-4575 of January 28, 2020 "On measures to implement the tasks set in the strategy for the development of agriculture of the Republic of Uzbekistan for 2020-2030", No. PQ-4424 of August 23, 2019 "To increase the efficiency of the use of forests in the Republic "On Additional Measures", dated June 1, 2017 No. PQ-3025 "On Establishing the Association of Walnut Producers and Exporters and Organization of its Activities" and the Decree of the President of the Republic of Uzbekistan on October 10, [9] 2017 No. PQ-3318 "On the measures to further develop the activities of farms and estate landowners and organize their effective use of arable land" to further increase the capabilities of farmers, farms and estate landowners in the production of agricultural products. In the conditions of Uzbekistan, researches related to finding solutions to economic problems of walnut cultivation, development of the industry were studied by a number of scientists, including Ya. Yaroslav, J. Shigaeva, B. L. Iomdin, M. Konstantinova, Yu. Grinyuk, S.G. .Biganova, Yu.I. Sukhorukikh, B. Nosirov, O. Shaymatov, H. Hamroev, D. Yoromatova, M. Abdujabborov, N. Khushmatov and others, and some positive results were achieved [5-11].

2 Materials and Methods

Nuts contain vitamins A, E, I, P, C, minerals such as potassium, sodium, phosphorus, iron, magnesium, calcium and iodine. Although the stomach is 60 % fat, it does not contain cholesterol. In addition, walnuts are extremely rich in protein. This boic can replace animal squirrels. The famous American scientist A. Chase lists the following advantages of nut protein compared to meat protein:

1. There is a lot of beef waste in meat protein, but there is no waste in nut protein.
2. Meat protein contains decomposed deadly poison and microorganisms.

Peanut proteins are microbial and aseptic.

Therefore, it is not recommended to eat more than two or three nuts in one day.

Nuts improve digestion, strengthen the stomach, and eliminate attacks of ctenosis. It nourishes brain tissues and improves brain activity. Today, there are more than 4.9 million farms and households in the republic, which produce 64% of gross agricultural output. Their weight is very large, especially in the production of meat and dairy products. It can be seen that the cultivation of walnuts is also mainly carried out by farmers (Table 1).

Table 1. Activities of farms in the republic change in general indicators.

Indicators	Unit	2020	2021 year	in 2021 compared to last year, %
Number of farms	'000	4894531	4981534	101.8
Share of agricultural holdings in the republic:				
-In gross agricultural product	%	62.9	64.0	+1.1 points
- as part of agricultural land	%	2.0	2.0	-
- includes arable land	%	11.0	11.0	-
- when growing vegetables	%	67.7	66.5	-1.2 points
- when growing potatoes	%	79.9	83.4	+3.5 points
- when growing polyester products	%	50.1	51.5	+1.4 points
-share in walnut production	%	90.1	91.5	+1.4 points
- when growing fruits	%	49.9	52.2	+2.3 points
- when growing grapes	%	45.1	46.4	+1.3 points
- when growing dairy products	%	95.8	96.7	+0.9 points
- when growing meat products	%	92.0	95.0	+3.0 points
farms compared to farms :				
- Production of products at the expense of 1 person	once	1.3	1.4	107.7
-Product cost per 1 ha	once	10.8	11.0	101.8

The low shelf life value of walnuts gives farmers additional opportunities to sell or export while waiting for market prices to change. Due to the high material interest in farms, the output per employee is 1.4 times higher than in farms, and the cost of products obtained from 1 hectare of cultivated land is 10 times higher.

The current state of the problem under consideration. The diversification of agricultural production in the republic today is aimed at providing the population of the country with food products, as well as increasing the export potential of the agricultural sector. In this regard, it is necessary to encourage and improve the efficiency of the use of rainfed lands in Uzbekistan, increase the production of walnuts that are competitive in the domestic and foreign markets, create modern walnut plantations by attracting foreign investment, and widely introduce scientifically based methods and intensive cultivation technologies. In this regard, the Decree of the President of the Republic No. PQ-3025, adopted on June 1, 2017, "On the establishment of an association of producers and exporters of walnuts and the organization of its activities" is of great importance.

3 Results and Discussion

We saw the following results when we studied the analysis of income and expenses from growing walnuts in the family farm "Akramov Olimjon Turgun ogli". Family members 5 people, 3 of them with the possibility of work. The family has 20 hectares of privatized land and is mainly engaged in agriculture. Along with working at state enterprises, family members are engaged in agricultural production in their subsidiary plots. On the farm, products are grown in accordance with market demand and income is generated. The area planted with walnuts in the family is 3 ha. If you pay attention to the result obtained from the farm in 2020 and the number of seedlings, then the income from 6 walnut trees is shown.

Productivity (annual) 1 walnut tree gives 150 kg. Total 6 walnut trees 6 x 150=900 kg of annual production maintenance per walnut tree (50,000 UZS shaping + 20,000 UZS softening + 20,000 UZS watering + 90,000 UZS disease control + 60,000 UZS 4/5 types of application fertilizers + 80 thousand UZS for picking fruits + 15,000 UZS for sorting fruits into commercial types + 10 thousand UZS for transportation of harvested nuts) = 345,000 UZS total expenses.

the harvest from one walnut tree 150 kg is 100,000 UZS, then the result of the harvest in monetary terms will be as follows (150 x 20,000) = 3,000,000 UZS. If we translate the harvest from six walnut trees into monetary value, we get 900 x 20,000 = 18,000,000 UZS. The gross value of the crop (18,000,000 - 2,070,000) = 15,930,000 UZS, and the net profit was 15,930,000 UZS.

The family gives preference to the family business in the labor activity. Because this is somewhat higher than the income of family members working at a state-owned enterprise, that is, employed in non-agricultural sectors.

To sum up, since farms created on the basis of the labor of family members are the starting point of society, its interest and life at a high level is the highest goal of society. The achievement of this goal, the organization of a comfortable life for the people of our society, is determined by the rational use of the available opportunities in Uzbekistan, where market relations are developing. The well-being of the family is determined by the production and consumption of material goods, for which the family income must be high.

Currently, the following types of walnuts are registered in Uzbekistan: Bustonlik variety. The tree is tall and bears fruit in the fourth year. Nuts are large, broadly ovate. This variety is resistant to cold and various diseases.

The fruit of the walnut varieties Tashkent-2, Tashkent-3, Yubileiny is round in shape, the top is slightly visible, the weight of one nut is 11.7 grams, and the kernel yield is 50.4 %. The pulp is tasty, it is somewhat more difficult to separate from the pods, and the variety is high-yielding. Spring frost-resistant, early ripening, grafted seedlings are harvested from the fourth year and ripen in mid-September (Table 2).

It is convenient to grow walnuts on farms and household plots in the Parkent district. Walnut is a moisture-loving, sun- and heat-loving tree, but care requires simple technology.

Table 2. Assessment of the quality of fruits and pulp of walnuts in the world market.

Groups	Walnut weight, g	Ball	Group	Core output, %	Ball
Very small	6.1-8.0	1	He has a very high core	Above 56.0	5
Small	8.1-10.0	2	It has a high core	53.1-56.0	4
Average	10.1-12.0	3	Has an average core	49.1-53.0	3
Big	12.1-14.0	4	He has little bone marrow	45.1-49.0	2
Very big	Above 14.1	5	It has very little nucleus	Below 45.1	1

The local population has repeatedly attempted to isolate forms with valuable economic characteristics in natural walnut groves, and these forms are competitive in the market in terms of determining the quality of walnut fruits, the size and appearance of the fruits are white, the core is white in demand on the world market, and most importantly, it has quality and price indicators and is distinguished by high performance.

Qualitative indicators of fruits of walnut forms selected from existing walnut plantations of Bostonlik, Parkent, Kibray, Okhangaron, Baysun and Zomi districts of Tashkent, Surkhandarya, Jizzakh provinces were evaluated.

For example, the Chandler walnut variety, which can be grown on the world market, has large fruits, a thin shell and a white core, and today fully satisfies the demand of the world market. Typically, when creating a garden based on this variety, 200 trees per hectare are placed.

After planting two-year-old seedlings, they begin to harvest in three years, and by the age of 8, each tree begins to produce an average of 40 kilograms. So, from one 1 hectare of a walnut grove, you can get an average of 8 tons of crops. If we take into account that the average market price of walnuts is 20,000 UZS, then on one hectare of land in the mountainous area, which has not yet been used, it is possible to grow products worth 160 million UZS. After 15-20 years, trees of this variety begin to produce a high-quality harvest of up to 180-200 kilograms per bush.

Today, it is appropriate to organize walnut groves (walnut plantations) based on the needs of the market, and not the needs of the family. As a result, both the family and the market will benefit.

Our monographic research was mainly carried out in farms and family farms in the Parkent district of the Tashkent province. Analysis of indicators of economic efficiency of growing walnuts by farms in the district in 2017-2020 showed that as a result of the reforms carried out and the consistent implementation of a number of decisions aimed at the development of walnut growing, the area allocated for walnut trees has been expanded and productivity has increased. If in 2017 the area of cultivated orchards was 4653 hectares, by 2020 it will be 5916 hectares. The yield also increased from 72.2 t/ha to 79.8 t/ha in these years. In 2016, the profit from growing fruits amounted to 13 billion 809 million 705 thousand UZS, and by 2020 it will amount to 27 billion UZS, 609 million 42 thousand UZS or twice. The rate of return increased during this period from 28 to 36 % (Table 3).

Table 3. Analysis of indicators of economic efficiency of growing walnuts by farms and family farms in the Parkent district in 2017-2021.

Indicators	Years				
	2017	2018	2019	2020	2021
Number of walnut seedlings in farms and subsidiary farms (bushes)	602	1806	2167	2408	3612
Average return, q/1 bush	0.6	0.7	0.8	0.8	0.9
Gross value of products, million UZS	1806	7585	13870	23116	48762

The areas under cultivation of a walnut have increased, productivity has increased. If in 2017 the number of walnut seedlings in farms and household plots was 602, then by 2021 this figure will be 3612. The yield also increased in these years from 0.6 q/1 bush to 0.9 q/1 bush. In 2017, the profit from walnut seedlings in farms and private households amounted to 1 billion 806 million 038 thousand UZS, and by 2021 it will increase to 48 billion UZS. 762 million 099 thousand UZS or increased by 27 times.

Based on the data obtained, we will create an ICF network for growing walnuts in the farms of the Parkent district. To do this, the logarithmic values of the data are calculated due to the fact that the units of measurement of the data presented in the table are different.

First of all, we determine the relationships between factors. To do this, we calculate the correlation coefficients between the factors. "MATLAB" calculates correlation coefficients between factors (Table 4).

Table 4. Matrix of correlation coefficients calculated between the gross agricultural product and the factors influencing it.

	Gross value of products , mln.UZS, *lnY*	The cost of mineral fertilizers , mln.UZS, *lnK*	Average return lik q/ha , *lnL*	Walnut grove, *lnN*
Gross value of products, million UZS, *lnY*	1			
The cost of mineral fertilizers, million UZS, *lnK*	0.9769	1		
Average yield q/ha , *lnL*	0.9816	0.9724	1	
Area of walnut plantations, ha, *lnN*	0.9742	0.9461	0.9667	1

It shows that there is a close relationship between the value of gross agricultural product (*lnY*) and the value of mineral fertilizers (*lnK*) (0.9769). There is a strong relationship between the value of gross farm product (*lnY*) and average walnut yield (*lnL*) (0.9816), and between the value of gross product (*lnY*) and walnut area (*lnN*) (0.9742).

Pair correlation coefficients (i.e., *lnK* and *lnL*, *lnK* and *lnN*, *lnL* and *lnN*) were calculated to indicate the relationship between influencing factors.

It can be seen from the table that between the value of mineral fertilizers (*lnK*) and the average yield of walnuts (*lnL*) (0.9724) the correlation between the consumption of mineral fertilizers (*lnK*) and the area of walnut crops (*lnN*) is quite close (0.9461) is presented in At the same time, the correlation coefficient between the average walnut yield (*lnL*) and walnut area (*lnN*) is high (0.9667).

The production function of the Cobb-Douglas level and all its calculated parameters, based on the gross agricultural product and factors affecting it, were tested using the Fisher F-test, Student's t-test and Durbin-Watson DW-test and fully meet the requirements from all the criteria (Figure 1).
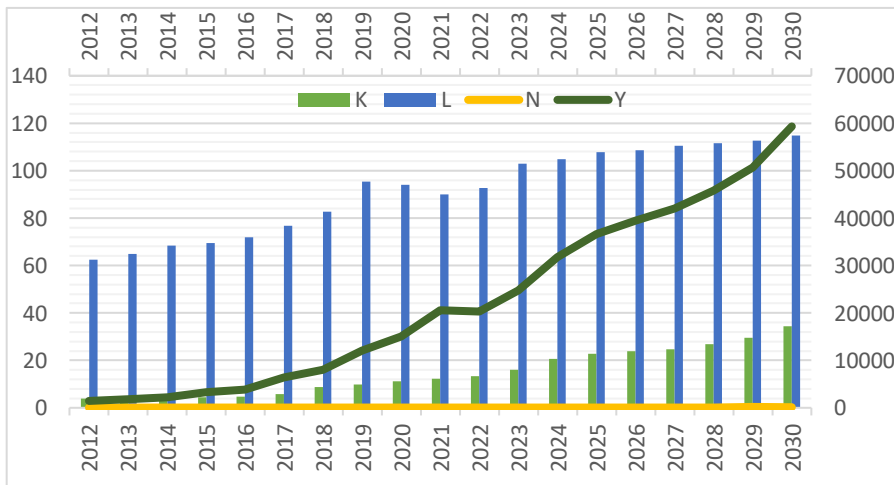

Fig. 1. Graph of actual and partial model-forecast values of gross agricultural output.

It is also important to calculate the approximation error, coefficient of variation, auto correlation coefficient, and normality coefficients. The values of the above criteria are presented in Table 5.

Table 5. Criteria for checking the quality and significance of a multivariate econometric model.

M/t	n	D_{res}	$D_{avg.}$	F_{calc}	F_j	R_m	ε_c	υ	r_f	K_N	$F_{calc.}$ >F_j
Non-linearity	11	0.03	3.12	121.14	4.35	0.99	1.31	1.63	0.46	0.95	Made

Analysis of the dynamics of the yield of cultivated walnuts based on mathematical modelling, covering all factors affecting yields, forecasting yields for the coming years and a realistic assessment of the dynamics of yield growth, in general, in the future, the practice of economic analysis of the development processes of the walnut growing network in farms creates a number mitigating options.

It should be noted that the development of walnut cultivation depends on many factors. Therefore, among a number of methods of economic analysis, the use of mathematical modelling methods makes it possible to realistically assess the dynamics of development, covering the factors influencing it. Based on the regression analysis model (trend models) and multifactorial production functions, a forecast up to 2030 was developed to predict the yield of walnut fruits in walnut orchards. The result of the calculated coefficient of determination R^2 on the change in yield during the cultivation of walnuts is 0.9807, which indicates a strong relationship between the effective indicator and the factors included, and the remaining share of 0.0193 can be considered as the influence of factors that have not been taken into account (Figure 2).
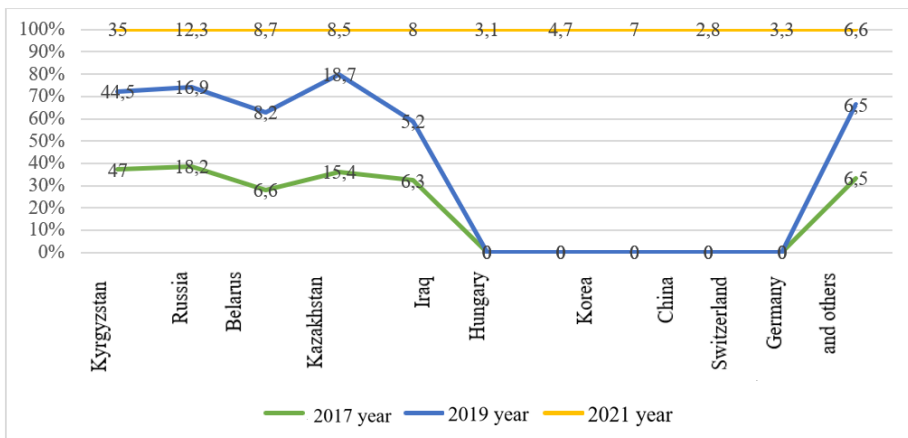

Fig. 2. Walnuts are exported from our republic share of countries, %.

According to the State Customs Committee, in 2017, 47% of walnut exports were to Kyrgyzstan, 18.2% to Russia, 6.6% to Belarus, 6.38% to Iraq, by 2021 - 35% to Kyrgyzstan, 12.3% to Russia 8.7 % were sent to Belarus, 8.0 % to Iraq and 8.5 % to Kazakhstan. Also, in 2021, 2,800 tons of walnuts worth 10.8 million USD were exported to 36 foreign countries, and as of May 20, 2022, for the first time in 2022, 1.3 thousand tons of walnuts were exported from Uzbekistan exported to Hungary, Korea, China, Switzerland and Germany.

Growing walnuts in Uzbekistan is effective in the Bostonlik, Parkent, Okhangaron provinces of the Tashkent province, the Ferghana Valley and the mountainous provinces of

the Jizzakh province, the mountainous provinces of Andijan, Samarkand, Surkhandarya, Navoi and Kashkadarya provinces. If you pay attention to the harvest in the newly created gardens. Based on the variety of walnut "Shandler", bred in California (USA), walnut plantations have been created in all provinces and districts. Due to its yield, good fruit quality, adaptability to climate, this variety is currently cultivated in various countries of the world, such as Turkey, Iran, China, India, USA, France, Romania, Bulgaria, Ukraine, Australia, Chile. When selling a new crop, 1,000 tons of walnuts worth 3.5 million USD were exported from the country to foreign markets. According to official statistics, compared to the same period last year, the export of walnuts increased by 285%.

4 Conclusions

As a result of our monographic studies, having studied the areas and hectares of walnut plantations, we came to the conclusion that plantations in Uzbekistan are only now giving their results. Business and has the following important economic features:

- firstly, walnut production does not require large initial investments from farms;

- secondly, walnut seedlings are resistant to weather stresses and do not require high costs associated with the care of seedlings, protection from insects;

- thirdly, it is believed that farmers have a highly profitable business and have created the basis of a profitable economic activity that provides a guaranteed return for several generations in the future;

- fourthly, caring for walnut plantations is simple, does not require complex labor, and a long service life (250-350 years) provides a return on investment for many years;

- fifthly, as with other agricultural products, there is little noticeable deterioration in quality after harvesting, loss of marketable characteristics, and inconvenience during transportation of the crop.

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