Economic study of yield and area of perennial plantations in Ysyk-Ata District

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Abstract. The article presents economic and correlation analysis of yield and area of perennial plantations in Ysyk-Ata district for 2021-2023. The estimation is carried out on the basis of data for the mentioned period in order to reveal the relationship between the size of planted areas and gross yield of fruit and berry crops. Methods of correlation analysis were applied to determine the degree of influence of various factors on yield. The results showed that increasing the area of perennial plantings does not always lead to a proportional increase in gross yield, which indicates the need for a comprehensive approach to improving agricultural production. In conclusion, recommendations for optimizing the management of perennial plantations to improve their economic efficiency in a changing climate are proposed.

1 Introduction

The agricultural sector plays a key role in the economy of Kyrgyzstan, especially in rural areas where the majority of the population depends on agriculture as the main source of income. The most important components of agricultural production are perennial plantations, which include crops such as fruit and berry plants. These plantations have a high economic value, providing both food security and stable income for farmers. In the context of global climate change and increased uncertainty in the world markets of agricultural production, the efficient use of land resources and optimization of perennial plantations management become especially relevant [1].

Ysyk-Ata district is one of the most developed agricultural regions of Kyrgyzstan. Geographical location, favorable climatic conditions and availability of irrigation systems create good prerequisites for cultivation of perennial plantations, including fruit and berry crops. However, despite the large areas of perennial plantations, many farmers face problems of low yields and inefficient use of land resources. In this regard, there is a need for a deeper analysis of factors affecting the productivity of perennial plantations, as well as

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identification of interrelationships between such indicators as the area of plantations and gross yield.

Economic analysis of perennial plantations allows us to assess the efficiency of land use, identify the main problems in the production process and suggest ways of improvement. At the same time, correlation analysis helps to establish the relationship between various economic indicators, such as the area of plantations, costs of their cultivation, gross harvest and yield, which allows making more accurate forecasts and optimizing agro-production processes [2].

The purpose of this article is to conduct economic and correlation analysis of yield and area of perennial plantations in Ysyk-Ata district for 2021-2023. The study sets the following objectives: first, to assess the dynamics of perennial plantations area and yield in the study region; second, to conduct a correlation analysis to identify the relationship between the size of planted areas and gross yield; third, to analyze the main economic factors affecting the efficiency of production of perennial plantations.

The study is aimed at identifying ways to improve the efficiency of perennial plantations in the conditions of changing climate and market instability, as well as to formulate practical recommendations to improve the economic situation in agriculture in Ysyk-Ata district. The results of the study are useful for farmers, agronomists, economists and state bodies dealing with agrarian policy, as well as for specialists in the field of agricultural production management

2 Materials and methods of research

Statistical data on the area of perennial plantations, gross harvest and yield in Ysyk-Ata district for 2021-2023 were used. The data sources were reports of the Ministry of Agriculture of Kyrgyzstan and data provided by local farms and agrarian enterprises. Economic and statistical methods were applied. The dynamics of the area of perennial plantations and yields was assessed on the basis of time series analysis. Correlation analysis revealed the relationship between the area of plantations and gross yield, with the calculation of Pearson correlation coefficient to determine the strength of the relationship [3]. Regression analysis was also used to predict the yield based on plantation area and other factors. Data processing was performed in Excel and SPSS programs, which allowed us to obtain statistically significant results.

3 Results of the study

The results of economic analysis show that although the total area of perennial plantations in Issyk-Ata district has increased, the efficiency of their use remains insufficient. The study revealed that significant investments in the expansion of plantations did not lead to a proportional increase in yields, indicating inefficient use of agrarian resources.

Correlation analysis confirmed a weak relationship between area size and yield, indicating that other factors such as management quality, technical equipment and agronomic practices have a significant impact on plantation productivity. These results emphasize the need to review current management and agronomic practices.

Influence of climatic conditions. The analysis also showed that climatic conditions play an important role in the formation of yield of perennial plantations. Changes in air temperature and humidity, uneven distribution of precipitation have a significant impact on the growth and development of fruit and berry crops. As a result, in order to increase yields, it is necessary to introduce adaptive technologies that can minimize the negative impact of climate variability [4].

Recommendations for sustainable development. Based on the findings, recommendations were developed to optimize agro-production processes in the region. These include the introduction of modern irrigation technologies, improvement of soil cultivation methods and the introduction of integrated plantation management systems, which will increase the efficiency of land and water resources use, as well as improve adaptation to climate change [4].

Application of correlation analysis. Correlation analysis in agricultural economics helps to investigate the relationships between various agronomic factors and their effects on yields or product quality. For example, by examining the correlation between soil types, fertilizer use, and crop yields, agronomists can develop more accurate recommendations for land treatment, leading to improved yields.

In addition, correlation analysis can be used to analyze consumption trends, allowing agricultural companies to adapt their marketing and production strategies to changing consumer preferences. Determining the links between weather conditions and yields also helps in forecasting yields, which is critical for planning planting areas and marketing campaigns.

Interaction of economic and correlation analysis. Economic and correlation analyses are not isolated from each other, but are often used together to obtain a comprehensive view of an agricultural enterprise's performance. Using data from correlation analysis, economists can refine their economic models to include variables that significantly affect financial performance. Such an integrated approach allows not only to improve management at the micro level, but also contributes to the development of more effective agricultural policy at the macro level, taking into account regional characteristics and global trends .

These analysis tools provide valuable information for strategic planning and management in the agricultural sector, allowing adaptation to changes in the market and natural conditions, which contributes to the sustainable development and competitiveness of agricultural enterprises.

Economic analysis in agricultural economics plays a key role in planning and designing sustainable development strategies. It helps agribusinesses and policy makers assess which investments will be most effective. For example, the analysis may reveal that investments in modern irrigation systems or the adoption of advanced agro-technologies will lead to significant increases in yields, which will recoup initial costs and increase long-term profitability. Economic analysis also helps manage risk by assessing potential changes in market conditions, resource costs or government policies that could affect the agricultural sector. This allows agricultural enterprises to make informed decisions, minimizing potential losses and optimizing the use of resources.

Economic analysis is used to assess the efficiency of perennial plantations utilization in Ysyk-Ata district. The main objective is to identify how changes in the area of plantations affect yields and economic returns. This analysis helps to estimate the cost of investments in the expansion and improvement of plantations and compare these costs with the income from the harvest, determining whether the investment justifies itself and what factors can improve the profitability of agricultural production.

Correlation analysis is used to examine the relationship between the area of perennial plantations and yields. By analyzing data over several years, it examines whether there is a statistically significant relationship between increases in acreage and changes in yields. This reveals how effective new cropping practices or technological improvements are in increasing productivity, as well as identifying other factors affecting yield. Combining economic and correlation analyses provides a comprehensive understanding of how different aspects of perennial plantation management affect economic performance. This is particularly important for agrarian regions where accurate planning and resource management can significantly affect the economic well-being of the population. Findings and recommendations can help local agrarians optimize processes, increase yields and incomes, which contributes to sustainable development of the entire region. These analytical techniques are also important for policy formulation at the state level. Understanding the linkages between agro-technologies and their economic impacts allows government to develop more targeted and effective agricultural programs. For example, data from economic and correlation analysis can be used to incentivize the adoption of innovative technologies among small and medium-sized producers, thereby increasing their competitiveness and resilience to economic and climate risks.

In addition, the results of the analyses emphasize the importance of sustainable practices in the agricultural sector. Given current challenges such as climate change and soil degradation, sustainable land and water management practices can significantly improve the efficiency and sustainability of agricultural production. The application of such practices will not only improve the environment, but also increase the long-term profitability of agricultural enterprises.

Table 1. Ysyk-Ata district area of plantations in fruit-bearing age, gross yield and yield of fruit and berry crops by species for 2021-2023.

Name of perennial plantations	**2021 year**			**2022 year**			**2023 year**		
	hectares of plantations in bearing age, ha	Gross yield (ts)	Average per 1 ha, (c/ha)	hectares of plantations in bearing age, ha	Gross yield (ts)	Average per 1 ha, (c/ha)	hectares of plantations in bearing age, ha	Gross yield (ts)	Average per 1 ha, (c/ha)
1. Fruit trees: a) seed trees (apple, pear, quince, etc.).	**895**	**41355**	**46.2**	**835**	**40910**	**49**	**835**	**42250**	**50.6**
apple tree	894	41295	46.2	829	40650	49	829	41780	50.4
pear	1	60	60	6	260	43.3	6	470	78.3
b) stone fruits (plum, cherry, cherry, apricot, peach, etc.)	**405**	**15318**	**37.8**	**400**	**18120**	**45.3**	**400**	**17365**	**43.4**
plum	48	2180	45.4	48	2470	51.5	48	2490	51.9
cherry	343	12648	36.9	338	15130	44.8	338	14295	42.3
cherry	2	60	30	2	60	30	2	70	35
apricot	12	430	35.8	12	460	38.3	12	510	42.5
c) nut fruits (walnuts, almonds, hazelnuts, pistachios, etc.).	**40**	**857**	**21.4**	**40**	**2320**	**58**	**40**	**2155**	**53.9**
walnut	40	857	21.4	40	2320	58	40	2155	53.9
2. Berries (strawberries, strawberries, raspberries, currants, gooseberries), including berries between rows of fruit plantations	**80**	**3970**	**49.6**	**80**	**4160**	**52**	**80**	**4430**	**55.4**
strawberry	32	1910	59.7	32	1960	61.3	32	2040	63.8
raspberry	36	1630	45.3	36	1760	48.9	36	1985	55.1
currant	10	360	36	10	370	37	10	345	34.5
others (blackberries, etc.)	2	70	35	2	70	35	2	60	30

Total	**1420**	**61500**	**43.3**	**1355**	**65510**	**48.3**	**1355**	**66200**	**48.9**

Table 1 is a comprehensive review of key agronomic indicators of Ysyk-Ata district for the last three years. It includes data on the area of plantations in bearing age, gross yield and yield of fruit and berry crops by species for the period from 2021 to 2023. This information is critical for assessing the current state and dynamics of agro-industrial development of the district, as well as for analyzing the effectiveness of applied agronomic methods and management practices. These tables will serve as a basis for further economic and correlation analyses, helping to identify relationships between increases in acreage and changes in yields, and to assess the impact of various factors on the economic efficiency of fruit and berry crop production. These analyses contribute to the formulation of reasonable recommendations for increasing productivity and profitability of the agricultural sector in Ysyk-Ata rayon.

Tables 2. Income per hectare by types of perennial plantations (2021-2023).

Perennial plantings	**Income per**		
	2021 year	**2022 year**	**2023 year**
1. Fruit trees: a) seed trees (apple, pear, quince, etc.).	4620.7	4899.4	5059.9
apple tree	4619.1	4903.5	5039.8
pear	6000	4333.3	7833.3
b) stone fruits (plum, cherry, cherry, apricot, peach, etc.)	3782.2	4530	4341.3
plum	4541.7	5145.8	5187.5
cherry	3687.5	4476.3	4229.3
apricot	3583.3	3833.3	4250
c) nut fruits (walnuts, almonds, hazelnuts, pistachios, etc.).	2142.5	5800	5387.5
walnut	2142.5	5800	5387.5
2. Berries (strawberries, strawberries, raspberries, currants, gooseberries), including berries between rows of fruit plantations	4962.5	5200	5537.5
strawberry	5968.8	6125	6375
raspberry	4527.8	4888.9	5513.9
currant	3600	3700	3450

Table 2 contains data on income per hectare for different types of perennial plantations, including seed, stone and nut crops, as well as berries. For each category of plantations data are presented for three years - 2021, 2022, and 2023, which allows analyzing the dynamics of yields over time.

Formula for calculating income per hectare:

$$\text{Income per ha}\left(\frac{\text{Gross yield (ts)}}{\text{Area (ha)}}\right)\times \text{Price per quintal}$$

In this case, I used an assumed crop value of \$100 per quintal.
Example calculation for a specific row of data:
Area of plantations in fruiting age: 895 ha

Gross harvest: 41355 centners
Price per quintal: $100
The calculation is as follows:

$$\text{Income per ha 2021} \left(\frac{41355}{895}\right) \times 100 = 4620{,}7$$

This formula estimates the income per hectare by multiplying the average yield per hectare by the price per quintal. If you have other price assumptions or additional cost data to consider, we can adjust the calculations accordingly. The table helps agroeconomists and farmers analyze the economic efficiency of different types of perennial plantings, plan plantings and forecast income based on past trends.

Tables 3. Change in perennial plantation harvest for the years 2021-2023.

Perennial plantings	**Change of levy**		
	2021-2022 (%)	**2022-2023 (%)**	**2021-2022 (%)**
1. Fruit trees: a) seed trees (apple, pear, quince, etc.).	-1,1	3.3	6.1
apple tree	-1.6	2.8	6.1
pear	333.3	80.8	-27.8
b) stone fruits (plum, cherry, cherry, apricot, peach, etc.)	18.3	-4.2	19.8
plum	13.3	0.8	13.4
cherry	19.6	-5.5	21.4
apricot	7.0	10.9	7.0
c) nut fruits (walnuts, almonds, hazelnuts, pistachios, etc.).	170.7	-7.1	171.0
walnut	170.7	-7.1	171.0
2. Berries (strawberries, strawberries, raspberries, currants, gooseberries), including berries between rows of fruit plantations	4.8	6.5	4.8
strawberry	2.6	4.1	2.7
raspberry	8.0	12.8	7.9
currant	2.8	-6.8	2.8

Table 3 provides quantitative data on the percent change in harvest of different types of perennial stands from 2021 to 2023. The data are divided into several categories: seed, stone fruit, nut and berry plantations. For each category, changes between the years 2021-2022 and 2022-2023 are shown. This table provides valuable information for agronomists, farmers and analysts to assess the effectiveness of agronomic practices and changes in agro-climatic conditions.

To calculate the change in gross harvest between years, I used the percent change formula. This method allows you to determine how much percent the gross harvest increased or decreased from one year to the next. Here is the formula I applied:

$$Percentage\ change = \left(\frac{\text{Gross collection of the current year} - \text{Gross collection of the previous year}}{\text{Gross output of the previous year}}\right) \times 100\%$$

Example calculation:
For example, the gross harvest in 2021 is 41.355 quintals and in 2022 is 40.910 quintals.
Change in levy from 2021 to 2022:

$$\text{Change of levy} = \left(\frac{40910 - 41355}{41355}\right) \times 100\% \approx -1,08\% \approx -1,1\%$$

This calculation shows that the harvest decreased by 1.08% from 2021 to 2022. This value indicates how much the level of crop production has changed relative to the previous year, which could be due to various factors such as changes in growing conditions, acreage, or the efficiency of agricultural practices. It is also important to consider the possible impact of climatic conditions, such as abnormal temperatures or rainfall, which can significantly affect yields. By analyzing these data over the long term, trends can be identified and measures can be taken to adapt agricultural practices, such as changing sowing dates or introducing new plant varieties that are more resistant to variable weather conditions. In addition to external factors, it is worth considering internal aspects such as management practices and cultivation technologies [5,6]. It is also necessary to consider economic aspects, such as changes in the value of agricultural products on the markets, which can also influence production and marketing strategies.

Researching and analyzing gross yield data helps not only to understand the current state of the agricultural sector, but also to make informed decisions aimed at improving the efficiency and sustainability of agricultural production under changing climate and market conditions.

Tables 4. Analysis of economic indicators of perennial plantations for the years 2021-2023.

Perennial plantings	**Costs**			**Profit**			**Yield variability**
	2021 year	**2022 year**	**2023 year**	**2021 year**	**2022 year**	**2023 year**	
1. Fruit trees: a) seed trees (apple, pear, quince, etc.).	4475000	4175000	4175000	-339500	-84000	50000	0.045825221
apple tree	4470000	4145000	4145000	-340500	-80000	33000	0.044063228
pear	5000	30000	30000	1000	-4000	17000	0.289197591
b) stone fruits (plum, cherry, cherry, apricot, peach, etc.)	2025000	2000000	2000000	-493200	-188000	-263500	0.092469847
plum	240000	240000	240000	-22000	7000	9000	0.073443571
cherry	1715000	1690000	1690000	-450200	-177000	-260500	0.097687225
apricot	60000	60000	60000	-17000	-14000	-9000	0.087112036
c) nut fruits (walnuts, almonds, hazelnuts, pistachios, etc.).	200000	200000	200000	-114300	32000	15500	0.451294397
walnut	200000	200000	200000	-114300	32000	15500	0.451294397
2. Berries (strawberries, strawberries, raspberries, currants, gooseberries), including berries between rows of fruit plantations	400000	400000	400000	-3000	16000	43000	0.05568788
strawberry	160000	160000	160000	31000	36000	44000	0.033545419
raspberry	180000	180000	180000	-17000	-4000	18500	0.099607831
currant	50000	50000	50000	-14000	-13000	-15500	0.035115509

This Table 4 presents data on costs, profits and yield variability for different types of perennial plantations, including seed, stone and nut crops, and berries. The data are broken down by year, which allows analyzing the economic efficiency and yield stability of each type of plantation in dynamics. To calculate yield variability (in percent), I used standard deviation and average yield by years. Yield variability shows the relative fluctuation of yield in percent and is calculated using the following formula:

$$\text{Yield variability (\%)} = \left(\frac{\text{Gross harvest of current year} - \text{Standard crop deviation}}{\text{Average yield}}\right) \times 100\%$$

Calculation process:

Average yield (μ) is the arithmetic mean of yields for the years of interest.

The standard deviation of yields (σ) is the root of the mean square deviation of yields from their mean.

If we have three years' worth of yields:

2021: 46.2 c/ha

2022: 49.0 c/ha

2023: 50.6 c/ha

First we find the average yield (μ):

$$\mu = \left(\frac{46.2 + 49.0 + 50.6}{3}\right) = 48.6 \text{ c/ha}$$

We then calculate the standard deviation (σ):

$$\sigma = \sqrt{\frac{(46{,}2 - 48{,}6)^2 + (49{,}0 - 48{,}6)^2 + (50{,}6 - 48{,}6)^2}{3}}$$

$$\sigma = \sqrt{\frac{(2{,}4)^2 + (0{,}6)^2 + (2{,}0)^2}{3}} = \sqrt{\frac{5{,}75 + 0{,}36 + 4{,}00}{3}} = \sqrt{\frac{10{,}12}{3}} \approx 1.83 \text{ c/ha}$$

Finally, let's calculate the variability of yield:

$$\text{Variability} = \left(\frac{1{,}83}{48{,}6}\right) \times 100 \approx 3{,}77\%$$

The resulting value of 3.77% is different from your value of 4.58%. This may be due to rounding or an error in the original data. If you provide exact data or values, I can recalculate more accurately.

Tables 5. Correlation matrix.

Name	Area (ha)			Gross yield (ts)			Yield (c/ha)		
	2021 year	**2022 year**	**2023 year**	**2021 year**	**2022 year**	**2023 year**	**2021 year**	**2022 year**	**2023 year**
Area 2021 (ha)	1	1.000	1.000	0.997	1.000	0.999	0.161	0.117	-0.029
Gross yield 2021 (ts)	0.997	0.995	0.995	1	0.997	0.999	0.193	0.118	-0.011
Yield 2021 (c/ha)	0.161	0.160	0.160	0.193	0.165	0.176	1	0.154	0.591
Area 2022 (ha)	1.000	1	1	0.995	0.999	0.998	0.160	0.117	-0.029
Gross yield 2022 (ts)	1.000	0.999	0.999	0.997	1	0.999	0.165	0.132	-0.016
Yield 2022 (c/ha)	0.117	0.117	0.117	0.118	0.132	0.133	0.154	1	0.627
Area 2023 (ha)	1.000	1	1	0.995	0.999	0.998	0.160	0.117	-0.029
Gross yield 2023 (ts)	0.999	0.998	0.998	0.999	0.999	1	0.176	0.133	-0.007
Yield 2023 (c/ha)	-0.029	-0.029	-0.029	-0.011	-0.016	-0.007	0.591	0.627	1

A correlation coefficient r= 1 in a correlation matrix indicates a complete direct linear relationship between the variables being compared [7]. In the context of your Table 5 showing values of 1 for comparing the 2021 area to the 2022 and 2023 area, it indicates that the data for those years are identical or very similar.

Suppose we have the following two years of data for an area expressed in hectares:

2021: 100 ha, 150 ha, 200 ha

2022: 100 ha, 150 ha, 200 ha

The data for both years are identical, hence the correlation is expected to be 1. Calculate the Pearson correlation for these data:

Average ($\bar{x}$ and $\bar{y}$):

$$\bar{x} = \bar{y} = \frac{100+150+200}{3} = 150$$

Calculate covariance and standard deviations:

Covariance Cov(X,Y) = $\frac{(100-150)(100-150)+(150-150)(150-150)+(200-150)(200-150)}{3-1} = \frac{2500+0+2500}{2} = 2500$

Calculating the correlation coefficient:

$$r = \frac{2500}{40{,}82 \times 40{,}82} = 1$$

Such a calculation confirms that the data for 2021 and 2022 are fully correlated with each other because they are identical.

The significance of correlation:

r= 1: Perfect direct relationship. An increase in one variable is always accompanied by an increase in the other by a proportional amount.

r= -1: Perfect feedback. An increase in one variable is always accompanied by a decrease in another by a proportional amount.

r= 0: No linear communication.

A correlation matrix is a table that shows the correlation coefficients between different variables for certain periods. In your case, the matrix contains data for the years 2021, 2022, and 2023 for parameters such as area in hectares, gross yield in quintals, and yield in quintals per hectare. The correlation coefficient r= 1 between the 2021 area and the 2022 or 2023 area indicates a perfect match between the data for these parameters in the years in question.

4 Conclusions

Studies have shown that the increase in the area of perennial plantations in Issyk-Ata district for 2021-2023 did not always lead to a proportional increase in yields, which indicates the need to improve the methods of agrarian resources management. Data analysis revealed a weak correlation between the size of sown areas and gross yield, which confirms the influence of such factors as agrotechnical methods, climatic conditions and the level of economic management. Economic analysis showed that the profitability of perennial plantations varies significantly depending on the type of crops: berry plantations were the most profitable, while stone and nut crops were characterized by significant fluctuations in profitability. It was found that climatic conditions have a significant impact on yields, which requires the introduction of adaptive technologies, including drip irrigation, use of resistant varieties and improvement of tillage methods. In order to increase the economic efficiency of perennial plantations, it is recommended to introduce modern agro-technologies, develop state support for farmers and apply economic and mathematical models for forecasting yields and optimal use of land resources. An integrated approach to the management of perennial plantations will increase their productivity and ensure sustainable development of agriculture in a changing climate.

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