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CONTENTS

Research Articles

Performance of laying hens fed diets incorporated with feather-based feed additive — 27-31
Larisa CAISIN, Alla CARA

Use of ridge regression analysis in the multicollinearity in animal science — 32-38
Pınar ÖLMEZ, Aycan Mutlu YAĞANOĞLU

The impact of dynamic meteorological conditions in the ATU Gagauzia on the growth and development of grapevines — 39-46
Serghei CARA

Regarding the prediction of fruit yield dynamics — 47-53
Svetlana CURAXINA, Nadejda IANIOGLO

Review Articles

A review analysis of the degradation of cork oak forests in North Atlantic, Morocco — 54-59
Said LAARIBYA

RESEARCH ARTICLE
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Performance of laying hens fed diets incorporated with feather-based feed additive

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Abstract

A comprehensive and in-depth understanding of modern industrial poultry production technology is a vital condition for the development of poultry enterprises. Among the factors that determine poultry farming's development, the state and development of the feed base are of paramount importance. One of the promising directions for organizing rational poultry feeding based on self-produced feed is the use of new feed sources in compound feeds that have a multifaceted positive impact on poultry health. This study aimed to determine whether feeding feather meal induces changes in the body weight of laying hens, feed consumption, and egg production. The experiment was conducted on laying hens of the Hy-Line Brown W-36 breed without beak trimming, aged from 21 to 34 weeks at an industrial poultry farm. The chickens were placed in standard cages arranged in 6 tiers (with eight chickens per cage) and were distributed into five randomized groups. Four diets were formulated with the inclusion of feather-based feed additives in the base diet at levels of 2.0, 2.5, 3.0, or 3.5 kg per ton, while the control group was maintained on the standard diet. Research results using feather meal as part of the compound feed for laying hens have revealed that the inclusion of this additive had a positive impact on the live weight dynamics of Hy-Line Brown laying hens. Positive trends in absolute live weight gains were observed in the experimental groups compared to the control group, with EG1 showing an increase of 56.78 g (4.8%), EG2 with 43.66 g (3.7%), EG3 with 33.26 g (2.8%), and EG4 with 25.75 g (2.1%). The highest retention rate of laying hens was recorded in the first (EG 1) and second (EG 2) experimental groups: 98.9% and 97.9% respectively. The difference in retention between the first experimental group and the control group was 4.1%, while between the second experimental and control groups, it was 3.1%. The feather meal feed additive is an effective protein supplement, and research has revealed its positive influence on live weight gains and the survival of laying hens. The most effective level is 2 kg per ton of compound feed, which can be explained by the data observed in EG1.

Keywords: Laying hens, Feeding, Feather-based feed additive, Live weight

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1. Introduction

Poultry production ranks first in the world among all livestock sectors in terms of annual growth rate of meat production, and second (36%) after pork (38%) in terms of gross meat production. Beyond the nature of this continuity hides the significant role of poultry farming in the production of meat products. In addition, it is worth considering that eggs are an important component in the world food basket. In total, more than 74 million tons of eggs are produced, which corresponds to more than 1 trillion 360 billion eggs. This fact emphasizes the importance of poultry production as the most successfully developing branch of agriculture capable of providing consumers with biologically nutritious food products.

The feeding ration plays a crucial role in the structure and development of poultry production. Particularly critical is the deficiency of protein and minerals in poultry diets.

The understanding of the importance of protein feeds in diets for farm animals and poultry is very high. Protein feeds are not only scarce but also financially demanding components in diets. Therefore, research to address the problem of protein deficiency continues to evolve and remain relevant (Gavrilova, 2004).

The integration of non-traditional feed ingredients is an innovative approach in poultry production that can significantly improve sustainability and production efficiency. This method offers the opportunity to expand the range of feed ingredients, which not only diversifies poultry diets, but also reduces dependence on expensive protein feeds. This is particularly important in the context of price volatility of classical feeds. The use of non-traditional feeds can help to strengthen the feed base and thus increase productivity in the poultry industry.

In the modern context, when the feed industry is faced with an acute shortage of raw materials, primarily protein, ensuring high quality products and competitiveness of poultry farming becomes an urgent task. Lack of protein in feed entails a decrease in the productivity of poultry and an increase in the cost of production (Egorov et al., 2010).

Therefore, it is now strategically important to look for alternative sources of protein that can compensate for protein deficiency. In this context, the use of non-traditional feed ingredients, such as feather meal, is of great importance

Given the increasing need to reduce dependence on grain in feed production, we are seeing significant interest in researching and implementing alternative sources of nutrients, such as by-products from various industrial sectors. This approach not only enables feed to be enriched with essential nutrients, but also reduces pressure on grain resources, which is relevant when grain reserves are limited.

There are several strategies to address feed protein deficiencies. First and foremost, researchers and the poultry industry are actively seeking alternative sources of protein to supplement or replace conventional feedstuffs. This includes exploring the use of non-traditional feed ingredients, such as feather meal, which can provide a high-protein supplement to poultry diets (Fisinin and Egorov, 2011)

The extraction of protein from poultry feathers represents an important development in the poultry industry. Feathers, previously considered waste, are now becoming a valuable resource. The process of processing feathers, while respecting the technological parameters, allows the protein to be preserved in its most useful form, namely keratin. This keratin is rich in protein, making it highly valuable for poultry feed (Chikov and Kononenko, 2009; Fisinin et al., 2012).

Studies show that when feather meal is introduced into poultry diets, there is an improvement in their overall performance. This includes higher body weight gain and increased protein production. Importantly, this protein has a high biological value and is easily digested by the poultry body.

In recent years, new technologies for feather processing have been actively developed, allowing to obtain a high-protein feed additive from it. Large poultry feathers and waste from feather and down production facilities contain up to 85-88% protein-keratin. Poultry feather processed using the new technology is converted into a feather product (with feather temperature treatment not exceeding 60 °C), which is effectively used by the poultry organism (Caisin et al., 2019).

The study of non-traditional feed ingredients provides unique opportunities to develop more efficient animal diets, including processing technologies that maximize their biological value. This area of research helps to develop strategies for more efficient use of resources and to reduce the environmental impact of agriculture.

Thus, research on non-traditional feed additives not only improves animal performance, but also contributes to a more sustainable and environmentally friendly agriculture, which is an important challenge in today's environment.

In this regard, this study aimed to evaluate the possibility of integrating feathers processed using new technologies into poultry diets. Subjecting the feather to a temperature treatment that did not exceed 60 °C produced a feather product. Our task was to determine the optimal doses of this feather supplementation for poultry diets. We sought to identify doses that would maximize the growth and development of the poultry. This approach is aimed at more efficient utilization of available resources and increasing the productivity of poultry, ultimately contributing to increased production of quality products.

2. Material and Methods

To evaluate the effectiveness of feather meal in the feeding of laying hens, a scientific and economic experiment was conducted. The object of research was laying hens of one-age industrial flock of cross “Hai-Lan-brown”, kept in production buildings equipped with battery type cages. Experiments were conducted by the method of analogues; five groups of laying hens were formed (control and four experimental groups, Table 1) with 96 heads in each (Imangulov et al., 2004).

During the experiment feeding of laying hens was carried out with the same composition of mixed fodder in accordance with the recommended feeding norms (Nadtochiy, 2016), the control group received the main mixed fodder, and the birds of the experimental groups were fed feather meal (FMP) in the diet.

The use of feather feed additive, as investigated in this paper, is a promising solution to strengthen the feeding ration of poultry production. Modern feather processing technologies allow it to maximize its high-protein potential. Waste from feather processing and large poultry feathers, containing up to 85-88% protein, become a source of valuable nutrients.

During the experiment, we carried out the following: determination of optimal doses of feed meal from feathers in diets of laying hens; studied the dynamics of live weight at the introduction of feed additive from feathers in the diet; determination of average daily gains in live weight of hens laying; accounting of safety of birds throughout the experiment. This made it possible to determine how the supplement affected the growth rate of laying hens. Monitoring the safety of poultry in all groups throughout the experiment. This aspect is important to ensure animal health and welfare. In addition, it should be emphasized that the diets of all groups were carefully balanced in terms of nutrients, which contributed to the objective results of the study.

Table 1. Experimental groups

Group	Specific feeding characteristics
Control (CG)	Basic compound feed (OC)
Experimental 1 (EG 1)	OC + KMP* 2.0 kg/ton
Experimental 2 (EG 2)	OC + KMP* 2.5 kg/ton
Experimental 3 (EG 3)	OC + KMP* 3.0 kg/ton
Experimental 4 (EG 4)	OC + KMP* 3.5 kg/ton

**KMP: Feed meal from feathers*

The experimental part of the work was carried out on the basis of the poultry farm of “Floreni” JSC and in the laboratory of the Department of Animal Resources and Quality Control, Technical University of Moldova in 2022.

3. Results and Discussion

The results of the study indicate the intensity of growth and development processes at the introduction of feather additive in the diets of laying hens (Table 2).

The results of our research allow us to identify the optimal dosage range of feather feed additive for laying hens in order to achieve maximum growth intensity. This range is from 2% to 3.5% of the total feed weight. At this dosage, the highest weight gain in poultry was observed. This indicates that feather supplementation has the potential to improve the performance of laying hens.

However, it is important to note that even within the optimum dosage range, the level of feather supplementation should be strictly controlled so as not to lead to overconsumption. It is always necessary to consider the balance of feed components and the poultry's requirements for various nutrients. Nevertheless, our research provides important data for the development of effective strategies for the use of non-conventional feed additives such as feather meal to optimize poultry production.

At the initial oviposition stage at 17 weeks of age, the first experimental group of laying hens showed a significant increase in live weight compared to the control group, by 62 g or 4.4%. The second experimental group showed an increase of 53.86 g or 3.8%. The third experimental group showed an increase of 48.82 g, equal to 3.4% and the fourth group showed an increase of 40.8 g, equal to 2.9%. It is important to note that the initial live weight was almost the same in all groups, with a difference of no more than 1.4 %, which did not exceed the permissible deviation for live weight in the formation of the group, set at 3%.

At the end of the experiment, at the age of 34 weeks, the highest gains were also obtained from laying hens of the experimental groups. Compared to the control, this difference in the 1st, 2nd, 3rd, 4th groups were 61.25;50.46;42.36 and 35.15g, or 3.3; 2.7;2.3 and 1.9%, respectively, which indicates the most intensive growth rate of laying hens from the experimental groups.

Table 2. Dynamics of live weight of laying hens

Age, weeks	Group of laying hens				
	CG	EG1	EG2	EG3	EG4
8	665.00±1.00	669.47±0.57	671.80±1.04	673.87±1.41	674.40±1.01
12	1144.40±2.16	1181.20±1.75	1172.67±3.15	1166.93±3.16	1158.20±3.09
17	1400.80±2.56	1462.80±2.00	1454.66±3.61	1449.62±5.20	1441.60±2.12
22	1710.43±1.47	1773.55±2.40	1761.90±2.36	1752.09±3.31	1747.03±2.03
26	1772.27±4.28	1841.20±0.78	1834.88±4.66	1826.34±8.02	1818.36±4.44
34	1835.87±4.98	1897.12±7.05	1886.33±2.04	1878.23±1.50	1871.02±0.62
Absolute growth, g	1170.87	1227.65	1214.53	1204.13	1196.62
Average daily gain, g	6.43	6.75	6.67	6.62	6.58
Relative growth, %	176.07	183.37	180.79	178.72	177.43
Weight of experimental hens at the end of the experiment in % of the control group	100	103.34	102.75	102.31	101.92

The birds of the first experimental group, which were provided with feather feed supplement in the amount of 2% of the feed weight, achieved the highest live weight gain. In comparison with the control group, the difference was very noticeable: absolute weight gain was 56.78 g (or 4.8%), average daily gain was 0.32 g (or 4.9%), and relative gain reached 7.63%. These data indicate high growth activity and activation of metabolic processes in laying hens receiving the studied supplement.

The increase in live weight gains observed during the study may be attributed to the properties of the feather feed supplement. These properties include normalization of digestive processes, improved conversion of feed intake to body weight and immune support. Together, these factors have a positive effect on the metabolism of laying hens. For a better visualization of the dynamics of poultry growth, we present a diagram illustrating the change in live weight during the whole period of the experiment (Figure 1).

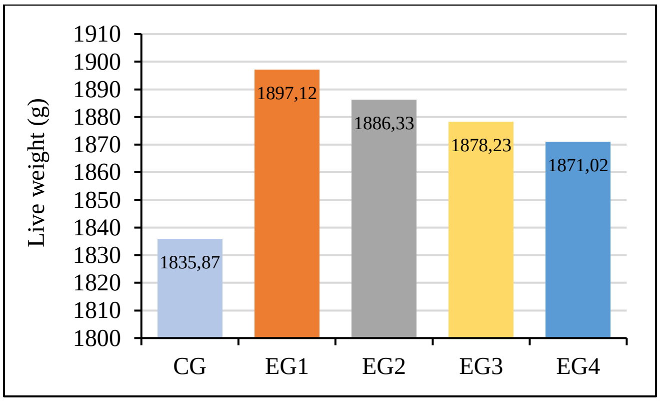

Figure 1. Dynamics of live weight of laying hens at 34 weeks of age

According to the diagram in Figure 1, it can be seen that from weeks 8 to 34 of the study, there are marked differences in the rate of live weight gain of laying hens. These observations can be interpreted as a response of the poultry organism to the inclusion of the investigated supplement, which emphasizes the importance of its effect on the processes of growth and development of poultry.

In spite of similar conditions for poultry in control and experimental groups, significant differences in live weight indicate a profound effect of protein components present in the feather supplement on biochemical and physiological processes in the poultry organism. This may indicate a pronounced biological activity of this supplement, affecting the absorption of nutrients, metabolism, and, as a consequence, the intensity of poultry growth.

Retention is an important indicator characterizing the nutritional adequacy of poultry under optimal housing conditions. To determine the safety of chickens during the experimental period, we recorded the number of fallen stock during the whole period of research (Table 3).

It should be noted that herd safety is a key indicator that evaluates the effectiveness of the studied feather feed additive. The analysis of the livestock safety during the experiment also allows us to identify the optimal dosage of feather feed additive. The greatest increase in safety was observed in the first experimental group, where the dosage was 2% of the feed weight. The difference in safety between this group and the control group was 4.1%, emphasizing the effectiveness of this dosage. The second experimental group, which received 2.5% of feather supplementation, also showed high retention, although slightly lower than the first experimental group.

The difference in preservation between the control group and the second group was 3%. These results suggest that a dosage of 2% to 2.5% of feed weight is optimal to maximize the retention of laying hens. Representation of the percentage of safety during the experiment is given in Figure 2.

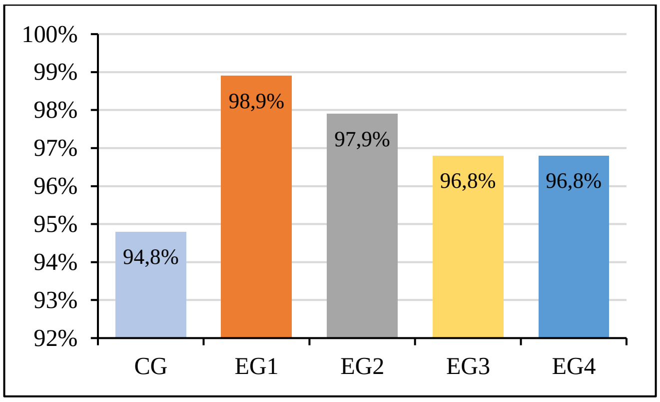

Figure 2. Conservation of laying hens during the experiment period

Table 3. Safety of laying hens for the period of experience

Indicator	Group of laying hens				
	CG	EG1	EG2	EG3	EG4
At the beginning of the experiment, heads	96	96	96	96	96
At the end of the experiment, heads	91	95	94	93	93
Safety, %	94,8	98,9	97,9	96,8	96,8

4. Conclusion

The results of our research provide valuable practical recommendations for poultry farmers and poultry enterprises. In particular, identification of the optimal dosage of feather meal at 2% per 1 ton of mixed feed is important. This dosage has the greatest positive effect on the growth and development of poultry, and also contributes to increasing their productivity.

In addition, this feed additive represents a potential solution for agricultural enterprises facing the problem of protein deficiency in compound feeds. Its use can lead to improved quality of mixed fodder, reduced costs of feeding poultry and, as a consequence, increased economic efficiency of poultry farming.

Thus, it is recommended to widely implement this practice at the enterprises of poultry farming, taking into account the optimal dosage. This not only helps to increase egg and meat production, but also helps to solve important agricultural problems related to providing consumers with high-quality food products and reducing economic costs.

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A part of this study was presented at the 4th International Congress on Engineering and Life Science held in Comrat/MOLDOVA on November 17-19, 2023.

Conflict of interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

References

Caisin, L., Cara, A., Cojin, A., & Hapko, S. (2019). The Use of Unconventional Feed Additives in Feeding Chickens for Egg Production (R. of Moldova). *International Journal of Anatolia Agricultural Engineering*, *1*(Special Issue), 4-12.

Chikov, A. E., & Kononenko, S. I. (2009). *How to improve the protein nutrition of farming animals*. Krasnodar.

Egorov, I. A., Lenkova, T. N., Rozanov, B. L., & Okoelova, T. M. (2010). *Instruction to use non-conventional fodders in poultry ration*. Sergiev Posad.

Fisinin, V. I., & Egorov, I. A. (2011). Modern Approaches to Poultry Feeding. *Poultry Farming*, *3*, 7-9.

Fisinin, V., Kalashnikov, V., Draganova, I., Amerkhanov, Kh. A., & Degtyarev, V. P. (2012). *A new approach to feeding the broilers*. Moscow.

Gavrilova, M.B. (2004). *Technology of products from skimmed milk, buttermilk and whey*. Barnaul Omsk: AltGTU.

Imangulov, S.A., Egorov, I.A., Okolelova, T.M., et al. (2004). *Methodology of scientific and production research on feeding of agricultural poultry*. Sergiev Posad.

Nadtochiy, A. (2016). Application of Non-traditional Feed Additives in Poultry Farming in the Omsk Region. *National Association of Scientists, 1*(17), 155-156.

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Use of ridge regression analysis in the multicollinearity in animal science

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Abstract

Ridge and basic investment are analysis methods used to guide regression analysis, to make very convenient regression analysis. Although the least squares estimates are unbiased when multicollinearity occurs, the variances of the estimates can be quite far from their true values. Ridge and principal components regression standard errors are reduced by allowing one-level biased regression estimates. Therefore, when multicollinearity is present, the ridge regression method can be used as an alternative to the least squares method. In this study, it was aimed to develop a model that predicts various egg quality criteria obtained from 238 Lohmann LSL-white commercial laying hens at 46 weeks of age. Due to the multicollinearity between egg quality criteria, ridge regression analysis methods, which are alternatives to least squares regression, were applied and these two methods were compared for the same data set. The coefficient of determination (R^2) and coefficient of variation were used as comparison criteria. According to these criteria, it was observed that the least squares (R^2=0.876), ridge (R^2=86.9) methods gave the best fit, respectively. As a result, it was concluded that it would be more accurate to use Ridge regression methods instead of using the least squares method in case of multicollinearity.

Keywords: Multicollinearity, Ridge regression, Least squares method

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1. Introduction

Agriculture is the most basic sector in meeting the nutritional needs of human beings and combining plant and animal production activities. In agriculturally developed countries, animal production comes before plant production. In Türkiye, 65% of the agricultural sector consists of crops, 25% of animal husbandry, 7% of aquaculture and 3% of forestry (Aydın Can, 2019). Despite selection studies, egg production is under the influence of many factors to achieve a good yield. Commercial egg production, it is directly affected by factors such as temperature, lighting, age, nutrition, genetic structure and disease. (Takma et al., 2017). One of the statistical methods used to reveal the cause-effect relationship of economic factors and productivity characteristics that change depending on many factors in the livestock sector is multiple regression analysis. By selecting a large number of independent variables and a dependent variable, regression coefficients that minimize the distance between the actual measurements of the dependent variable and the predictive measurements obtained from the independent variables are estimated by the Least Squares (LS) method. With the regression equation obtained from the sample, in addition to determining the cause-effect relationships between variables, predictions can be made more confidently (Akçay and Sarıözkan, 2015).

2. Material and Methods

2.1. Material

In our study, animal material was created by obtaining 238 Lohmann LSL-white commercial laying hens, aged 46 weeks, raised in the Poultry Unit of Atatürk University Food and Livestock Application and Research Center.

Statistical analysis of the data was done with SPSS and NCSS package programs.

2.2. Methods

In models where multicollinearity problems are identified, it is recommended to bias the regression coefficients without eliminating the variables in the model in order to reduce the negative effects of the multicollinearity problem (Örk Özel and Gezer, 2020).

In case of multicollinearity, it has been determined that using biased estimation methods is a more appropriate approach instead of LS. The first of the biased estimation methods consists of the Ridge Regression (RR) method, in which estimation variances are reduced by adding a small positive number to the diagonal elements of the Principal Component Regression (PCR) and correlation matrix instead of the real variables using orthogonal transformations (Arı and Önder, 2012).

2.2.1. Ridge regression

Ridge regression analysis, which is a method that reveals the cause-effect relationship between a dependent and one or more independent variables, allows prediction of the model. The matrix notation of the function for a multiple regression model with multiple independent variables is expressed as follows:

$$Y = \beta X + \varepsilon \qquad (1)$$

In the above equation; *Y*: $n \times 1$ dimensional dependent variable vector, *X*: n × (*p*+1) dimensional independent variables matrix, *β*: (*p*+1) × 1 dimensional vector of coefficients, and *ε*: *n* × 1 dimensional error vector (Yılmaz et al., 2020).

By making the necessary conversions from the regression prediction Equation 1;

$$\beta^* = (X'X)^{-1}X'Y \qquad (2)$$

In the presence of multicollinearity, if there is a high relationship between independent variables, the variances of the X'X matrix will increase significantly. In this case, important parameter values will become unimportant as a result of the increase in variance. To eliminate the problem, the variance of this matrix is significantly reduced by adding a positive constant *k* to the diagonal elements of the X'X matrix in Equation 2 (Üçkardeşler et al., 2012).

By adding the k constant in Equation 2 for parameter estimation for the RR model;

$$\beta^* = (X'X\ kI)^{-1}X'Y \qquad 0 \le k \le 1$$

It is produced in the form (Üçkardeşler et al., 2012).

β^* in the equation is (*p*-1) × 1 dimensional RR coefficients vector, *I* is a (*p*-1) × (*p*-1) dimensional identity matrix, and *k* is a constant value and mostly between $0 \le k \le 1$. The *k* value, which is the ridge parameter, provides a lower mean square error than the LS method (Yağanoğlu et al., 2010).

2.2.2. Determining the ridge parameter (*k*)

In the Ridge regression, determining the *k* parameter in the model is based on eigenvalues. In the RR process, it is obtained by observing the Ridge trace graph or determining the value of the *k* parameter to determine which point becomes stationary or which point has the eigenvalue closest to 1 (Üçkardeşler et al., 2012). In the ridge trace graph, regression coefficients are expressed as a function of *k*, and the *k* value at which the coefficients remain constant is selected in the graph created by writing regression coefficients on the vertical axis and *k* values on the horizontal axis (Yağanoğlu et al., 2010). Many researchers have recommended different equations to determine the *k* value. By using the condition index in determining the *k* constant suggested which is based on the eigenvalue in the equations;

$$k \le \frac{\lambda_{max} - 100\ \lambda_{min}}{99} \qquad k \ne 0$$

equation has been created. Using this equation, the point where the *k* parameter value approaches the VIF value of 1 is determined (Üçkardeşler et al., 2012).

2.2.3. Ridge trace method

The graphical method used to select *k*, the bias parameter in RR, is called Ridge trace. The biggest advantage of the ridge estimator is that it offers the "ridge trace" method that helps understand which parameter is sensitive to changes in the data. As is known, in the presence of multicollinearity, parameter estimators are sensitive to low changes in the data, and thus simple correlation coefficients are insufficient to reveal the relationship between independent variables (Karakaş, 2008).

In the ridge trace graph, *k* values are on the horizontal axis and ridge regression coefficients are on the vertical axis. As *k* values increase in the ridge trace graph, the mean square error of the ridge regression coefficients decreases. To determine a Ridge estimator that produces results lower than the mean square error of the regression coefficients of the the Linear Combination of Models (LCM) estimator, the *k* value where the regression coefficients become stable despite an increase in the *k* value is selected as the Ridge parameter (Derman, 2019).

3. Results and Discussion

3.1. Descriptive statistics

Descriptive statistics values of the variables used in the study; standard deviation, average, minimum and maximum values are given in Table 1. In the study, the normal distribution of the data was checked and the Kolmogorov-Smirnov test showed that all variables were normally distributed (*p*>0.05).

Table 1. Descriptive statistics

Variable	n	Mean	Std. Dev.	Minimum	Maximum
Egg Weight (EW)	238	66.95	4.60	55.37	82.58
Shape Index (SI)	238	73.93	2.64	67.0	80.5
Breaking Strength (BS)	238	1.29	0.52	0.30	2.80
Shell Thickness (ST)	238	1.10	0.08	0.88	1.36
White Index (WI)	238	8.11	1.36	5.071	11.74
Yellow Index (YI)	238	40.66	2.59	32.35	47.16
Haugh Unit (HU)	238	76.76	5.33	64.47	93.51

Table 2. Correlation coefficients between variables

Variable	EW	SI	BS	ST	WI	YI	HU
EW	1						
SI	0.928**	1					
BS	0.888**	0.930**	1				
ST	0.780**	0.796**	0.782**	1			
WI	0.782**	0.806**	0.832**	0.677**	1		
YI	0.151*	0.189**	0.166*	0.185**	0.117	1	
HU	0.827**	0.893**	0.864**	0.739**	0.771**	0.119	1

*: p<0,05, **: p<0,01

In Table 2, Pearson correlation coefficients and significance levels regarding the correlation coefficients of each independent variable with each other and between the dependent variables are given. The highest correlation coefficient was calculated as 0.930 between breaking strength and shape index and was found to be statistically significant (p<0.01). Correlation Coefficients were calculated as follows: 0.928 between egg weight and shape index, 0.888 between egg weight and breaking strength, 0.827 between egg weight and haugh unit, 0.806 between shape index and albumen index, 0.893 between shape index and haugh unit, 0.832 between breaking strength and albumen index. The correlation coefficient between breaking strength and Haugh unit was calculated as 0.864 and was found to be statistically significant (p<0.01). The lowest correlation was calculated as 0.117 between the white index and the yellow index (p>0.05). High correlations observed between independent variables indicate a potential multicollinearity problem. However, since simple correlation coefficients alone are not sufficient, it is not possible to be sure of the existence of a multicollinearity problem.

3.2. Results of egg weight dependent variable

In our study, egg weight was considered as the dependent variable, shape index, breaking strength, shell thickness, white index, yolk index, and Haugh unit as independent variables. Table 3 gives the analysis results for the least squares regression of the model. According to the variance analysis result, the model created was found to be a significant model (p<0.01), and the R^2 value was found to be 0.872. In other words, the independent variables (shape index, breaking strength, shell thickness, white index, yellow index, haugh unit) explain the change in the dependent variable (egg weight) by 87.2%.

Table 4 shows the least squares regression analysis results, significance value and coefficients of the model. The shape index coefficient was found to be 1.299 and is significant (p<0.01). The fracture thickness coefficient was found to be 5.501 and is important for the model (p<0.01). Among the independent variables, the variance inflation factor value of the shape index independent variables was high (VIF>10). The tolerance value of shape index independent variables with high variance magnification factors is very small.

Eigenvalues and condition indices are given in Table 5. When the eigenvalues are equal to 1, multicollinearity does not occur, but since at least one of the eigenvalues is close to zero, a multicollinearity problem is observed. When Table 5 is examined; a multicollinearity problem was detected in eigenvalues 3, 4, 5, 6 and 7. Eigenvalues 3, 4, 5, 6 and 7 caused strong multicollinearity because multicollinearity problems occurred when the condition indices were greater than 30.

When the methods that detect the multicollinearity problem are examined when looking at the egg quality criterion variables (correlation matrix, variance inflation factor, tolerance, eigenvalues and condition indices), it is seen that the multicollinearity problem occurs between the independent variables. Since unbiased least squares regression cannot eliminate the problem of multicollinearity, the results are inconsistent.

Table 3. Least squares variance analysis

Model	df	Sum of Squares	Mean Squares	*F*	*p*
Regression	6	4374.770	729.128	262.429	<0.001
Residual	231	641.806	2.778		
Total	237	5016.576			
R^2	0.872				
R^2_{Adj}	0.869				

Table 4. Least squares multiple regression analysis results

Variable	Coefficients	Standard Error	*t*	*p*	Tolerance Value	VIF
Constant	-31.320	7.679	-4.079	<0.001		
SI	1.299	0.132	9.817	<0.001	0.096	10.393
BS	1.200	0.629	1.909	0.058	0.111	9.006
ST	5.501	2.246	2.449	0.015	0.350	2.860
WI	0.213	0.147	1.449	0.149	0.295	3.394
YI	-0.051	0.043	-1.193	0.234	0.945	1.058
HU	-0.062	0.047	-1.332	0.184	0.188	5.333

Table 5. Eigenvalues and condition indices of correlations of variables

Number	Eigenvalue	Condition Indices
1	6.884	1.000
2	0.104	8.150
3	0.007	31.251
4	0.003	47.113
5	0.002	67.478
6	0.001	104.111
7	0.00078	295.997

The standardized Ridge parameter (k) is given in Table 6. According to the table, the multicollinearity problem was eliminated by choosing the constant k=0.002 for the independent variables that were expected to be positively related to egg weight.

Table 7 gives the parameters that change depending on the ridge parameter k. Since the R^2 value is largest for the constant k=0, the constant k should be close to zero. According to the expectations of these parameters, the most appropriate k=0.002 was chosen and the R^2 value of our study was found to be 0.8709. Sigma is the square root of the mean square error. Since sigma takes its smallest value in the least squares regression, the k value should not deviate too much from this value. Sigma value was determined as 1.6744. B'B is the sum of squares of the standardized coefficients, this value should become stationary according to the constant k. Our B'B value is 0.5731. The average variance amplification factor is the average of the variance amplification factor values. The largest variance amplification factor gives the largest variance amplification value of the constant k. In our research, our variance expansion factor value was determined as 9.8190.

Table 8 gives the results of ridge regression and least squares regression analysis according to the constant k=0.002. In Ridge regression analysis, the standard error of each variable decreased, eliminating the problem of multicollinearity. As a result of the analysis, the R^2 value was found to be 0.872 for least squares, while it was 0.869 for Ridge regression. In other words, Ridge regression obtained reliable results with lower standard errors without changing R^2.

Table 9 shows that standard errors have decreased and variance expansion factors have fallen below 10.

Tüylüoğlu and Albayrak (2010) examined the cost of living problem and compared the cost of living levels of the provinces within the scope of 26 Level 2 Regions in Türkiye as of 2008. As a result of the least squares regression analysis, the R^2 value was 99.8% and ridge regression. As a result of the analysis, the R^2 value was determined as 98.3% and the findings are compatible with the findings of our study.

In a study conducted by Yavuz (2017) using eggs taken from randomly mated Japanese quails that were not subjected to selection between the ages of 20-24 weeks, the R^2 value was 76.8% as a result of least squares regression analysis and 73.8% as a result of ridge regression analysis. and the results were found to be compatible with our study.

In a study by Öztürk (2014) in which data on the factors affecting the carcass weights of 30 broilers at Harran University research and application farm were discussed, the R^2 value was 99.2% as a result of the least squares regression analysis and the R^2 value was 97% as a result of the ridge regression analysis. It was determined as 8 and the results are similar to the results of our study.

Table 6. Standardized ridge regression values

k	SI	BS	ST	WI	YI	HU
0.001	0.7378	0.1377	0.0982	0.0632	-0.0285	-0.0693
0.002	0.7310	0.1404	0.0989	0.0635	-0.0282	-0.0664
0.003	0.7243	0.1431	0.0995	0.0639	-0.0279	-0.0635
0.004	0.7179	0.1456	0.1002	0.0643	-0.0275	-0.0607
0.005	0.7116	0.1481	0.1008	0.0646	-0.0272	-0.0579
0.006	0.7054	0.1504	0.1015	0.0650	-0.0269	-0.0552
0.007	0.6995	0.1527	0.1021	0.0654	-0.0266	-0.0526
0.008	0.6936	0.1549	0.1027	0.0658	-0.0263	-0.0500
0.009	0.6880	0.1569	0.1033	0.0662	-0.0260	-0.0475
0.01	0.6824	0.1590	0.1039	0.0665	-0.0257	-0.0450
0.02	0.6336	0.1755	0.1093	0.0704	-0.0231	-0.0230
0.03	0.5942	0.1871	0.1138	0.0743	-0.0208	-0.0048
0.04	0.5617	0.1955	0.1177	0.0779	-0.0189	0.0106
0.05	0.5343	0.2016	0.1210	0.0814	-0.0172	0.0236
0.06	0.5108	0.2061	0.1240	0.0847	-0.0157	0.0349
0.07	0.4905	0.2094	0.1265	0.0878	-0.0143	0.0447
0.08	0.4727	0.2119	0.1288	0.0907	-0.0131	0.0533
0.09	0.4570	0.2136	0.1308	0.0934	-0.0120	0.0610
0.1	0.4429	0.2149	0.1326	0.0959	-0.0110	0.0677
0.2	0.3553	0.2155	0.1432	0.1136	-0.0037	0.1083
0.3	0.3110	0.2100	0.1472	0.1230	0.0008	0.1259
0.4	0.2831	0.2040	0.1483	0.1281	0.0039	0.1347
0.5	0.2634	0.1983	0.1481	0.1309	0.0062	0.1392
0.6	0.2483	0.1931	0.1470	0.1323	0.0080	0.1414
0.7	0.2363	0.1882	0.1456	0.1327	0.0094	0.1422
0.8	0.2262	0.1837	0.1439	0.1325	0.0105	0.1422
0.9	0.2176	0.1795	0.1420	0.1319	0.0114	0.1416
1	0.2101	0.1755	0.1401	0.1309	0.0122	0.1406

Table 7. Ridge regression *k* analysis table

k	R^2	SIGMA	B'B	Mean VIF	Max VIF
0.001	0.8715	1.6707	0.5826	5.2318	10.0996
0.002	0.8709	1.6744	0.5731	5.1269	9.190
0.003	0.8703	1.6781	0.5639	5.0259	9.504
0.004	0.8698	1.6817	0.5552	4.9287	9.933
0.005	0.8692	1.6853	0.5467	4.8349	9.468
0.006	0.8687	1.6888	0.5386	4.7445	8.104
0.007	0.8681	1.6922	0.5308	4.6572	8.837
0.008	0.8676	1.6956	0.5232	4.5729	8.659
0.009	0.8671	1.6989	0.5159	4.4915	8.567
0.01	0.8666	1.7022	0.5089	4.4128	7.557
0.02	0.8618	1.7324	0.4502	3.7492	6.103
0.03	0.8575	1.7590	0.4071	3.2519	5.438
0.04	0.8536	1.7829	0.3741	2.8656	4.845
0.05	0.8500	1.8047	0.3482	2.5571	3.318
0.06	0.8466	1.8249	0.3275	2.3050	3.235
0.07	0.8435	1.8438	0.3104	2.0953	2.192
0.08	0.8404	1.8616	0.2962	1.9182	2.990
0.09	0.8375	1.8784	0.2841	1.7666	2.483
0.1	0.8347	1.8944	0.2738	1.6355	1.9366
0.2	0.8106	2.0279	0.2178	0.9088	1.0257
0.3	0.7902	2.1345	0.1934	0.6067	0.7173
0.4	0.7717	2.2268	0.1783	0.4448	0.5355
0.5	0.7544	2.3094	0.1672	0.3456	0.4458
0.6	0.7382	2.3846	0.1581	0.2793	0.3906
0.7	0.7227	2.4538	0.1504	0.2323	0.3451
0.8	0.7081	2.5180	0.1435	0.1975	0.3072
0.9	0.6940	2.5778	0.1373	0.1709	0.2752
1	0.6806	2.6338	0.1316	0.1499	0.2480

Table 8. Comparison of ridge regression and least squares for ridge coefficient *k*=0.002

Variable	RR Coefficients	LS Coefficients	Std. RR	Std. LS	SE (RR)	SE (LS)
Constant	-28.561	-31.320				
SI	1.241	1.299	0.712	0.745	0.125	0.132
BS	1.318	1.200	0.148	0.135	0.598	0.629
ST	5.692	5.501	0.101	0.098	2.231	2.246
WI	0.219	0.213	0.065	0.063	0.145	0.147
YI	-0.048	-0.051	-0.027	-0.029	0.043	0.043
HU	-0.050	-0.062	-0.058	-0.072	0.046	0.047
R^2	0.869	0.872				
SIGMA	1.685	1.667				

SE: Standard Error

Table 9. Ridge regression coefficients

Variable	Coefficient	Standard Error	Std. Reg. Coefficient	VIF
Constant	-28.561			
SI	1.241	0.125	0.712	9.047
BS	1.318	0.598	0.148	7.963
ST	5.692	2.231	0.101	2.760
WI	0.219	0.145	0.065	3.244
YI	-0.048	0.043	-0.027	1.045
HU	-0.050	0.046	-0.058	4.951

The findings of our study were reported by Yılmaz et al. (2020) in their study, using the 56th day data of wither height, body length, rump height and chest circumference measurements of the Saanen (59) kid raised at Tokat Gaziosmanpaşa University research and application farm, applying Ridge regression analysis by determining the multicollinearity problem and determining the smallest As a result of square regression analysis, the R^2 value was determined as 66.0% and as a result of the ridge regression analysis, the R^2 value was determined as 65.9%, which is compatible with the study findings.

Tırınk et al. (2020) compared the LS method used in multicollinearity determined by the VIF value with the ridge regression method to estimate body weight, and the RR method was based on some body measurements (spine length, rump height, body length, chest depth, The findings of our study are similar to the findings of our study, where the R^2 value was found to be 88.0% as a result of the least squares regression analysis and the R^2 value was found to be 87.6% as a result of the ridge regression analysis.

Yağanoğlu et al. (2010) determined that the model obtained according to the least squares method gave the best fit, but in cases where multicollinearity was detected between independent variables, the principal component regression method, which is an alternative to the least squares method, was more appropriate. As a result of the least squares analysis, R^2 value was obtained as 90.5% and the R^2 value as a result of the PCR analysis was obtained as 87.8%, which is in agreement with our study.

In the study by Çankaya et al. (2019) where they compared the least squares method, Ridge Regression (RR), Principal Component Regression (PCR) estimation methods to estimate the parameters of the multiple regression model if the assumptions underlying the LCM estimation are untenable due to multicollinearity, the most as a result of the least squares regression analysis, the R^2 value was obtained as 63.4% and as a result of the PCR analysis, the R^2 value was obtained as 62.3%, and the results are similar to the results of our study.

It has been shown that if there is multicollinearity between variables in data sets where cause and effect relationships between variables are investigated, using biased regression methods instead of least squares regression normalizes the standard errors of the regression coefficients and therefore gives more reliable results.

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Conflict of interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

References

Akçay, A., & Sarıözkan, S. (2015). Yumurta Tavukçuluğunda Gelirin Ridge Regresyon Analizi İle Tahmini. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, *62*(1), 69-74. (in Turkish) https://doi.org/10.1501/Vetfak_0000002660

Arı, A., & Önder, H. (2013). Farklı Veri Yapılarında Kullanılabilecek Regresyon Yöntemleri. *Anadolu Tarım Bilimleri Dergisi*, *28*(3), 168-174. (in Turkish) https://doi.org/10.7161/anajas.2013.28.3.168

Aydın Can, B. (2019). Türkiye'de Yumurta Üretimi, Tüketimi, İhracatı ve Geleceği. International Marmara Sciences Congress (Autumn) 2019, İzmit, Türkiye. (in Turkish)

Çankaya, S., Eker, S., & Abacı, S. H. (2019). Comparison of Least Squares, Ridge Regression and Principal Component Approaches in the Presence of Multicollinearity in Regression Analysis. *Turkish Journal of Agriculture - Food Science and Technology*, *7*(8), 1166-1172. https://doi.org/10.24925/turjaf.v7i8.1166-1172.2515

Derman, D. A. (2019). *Çoklu bağlantı durumunda yanlı regresyon yöntemlerinin incelenmesi* [Master's thesis, Ordu University]. (in Turkish)

Karakaş, S. (2008). *Çoklu doğrusal bağlantı problemi ve yanlı regresyon tahmincileri*. [Master's thesis, İstanbul University]. (in Turkish)

Örk Özel, S., & Gezer, F. (2020). Çoklu Doğrusal Bağlantı Problemi Altında Tahmin Edicilerin Karşılaştırılması: Genelleştirilmiş Maksimum Entropi, Ridge, Liu. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, *66*, 82-96. (in Turkish)

Öztürk, İ. (2014). Hayvansal Üretim Verilerinde Çoklu Bağlantı Probleminin Yanlı Regresyon Yöntemi ile Çözümlenmesi. *KSÜ Doğa Bilimleri Dergisi*, *17*(3), 1-12. (in Turkish) https://doi.org/10.18016/ksujns.77504

Takma, Ç., Gevrekçi, Y., Karahan, A. E., Atıl, H., & Çevik, M. (2017). Yumurta Verimi Üzerine Bazı Özelliklerin Etkisinin Regresyon Ağacı Analizi İle Belirlenmesi. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, *54*(4), 459-463. (in Turkish) https://doi.org/10.20289/zfdergi.386597

Tırınk, C., Abacı, S. H., & Önder, H. (2020). Comparison of Ridge Regression and Least Squares Methods in the Presence of Multicollinearity for Body Measurements in Saanen Kids. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *10*(2), 1429-1437. https://doi.org/10.21597/jist.671662

Tüylüoğlu, Ş., & Albayrak, A. S. (2010). Hayat Pahalılığı ve Türkiye'de İllerin Hayat Pahalılığı Sıralamasını Belirleyen En Önemli Faktörlerin Ridge Regresyon Analiziyle İncelenmesi. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *15*(2), 63-91. (in Turkish)

Üçkardeş, F., Efe, E., Narinç, D., & Aksoy, T. (2012). Japon Bıldırcınlarında Yumurta Ak İndeksinin Ridge Regresyon Yöntemiyle Tahmin Edilmesi. *Akademik Ziraat Dergisi*, *1*(1), 11-20. (in Turkish)

Yağanoğlu, A. M., Eyduran, E., Topal, M., Sönmez, A. Y., & Keskin, S. (2010). Çoklu Doğrusal Bağlantı Durumunda Ridge ve Temel Bileşenler Regresyon Analiz Yöntemlerinin Kullanımı. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *41*(1), 53-57. (in Turkish)

Yavuz, E. (2017). *Çoklu doğrusal bağlantı ve yanlı tahmincileri*. [Master's thesis, Kahramanmaraş Sütçü İmam University]. (in Turkish)

Yılmaz, F., Bayyurt, L., Abacı, S. H., & Tahtalı, Y. (2020). Comparison of Least Squares and Some Bias Estimators in Multicollinearity. *Turkish Journal of Agriculture -Food Science and Technology*, *8*(3), 793-799. https://doi.org/10.24925/turjaf.v8i3.793-799.3405

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The impact of dynamic meteorological conditions in the ATU Gagauzia on the growth and development of grapevines

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Abstract

The southern region of the Republic of Moldova, specifically ATU Gagauzia, offers highly favourable conditions for cultivating diverse grape varieties with multiple harvest utilization options, including wine, brandy, juices, and fresh or dried consumption. Grapevines, adaptable yet sensitive to environmental changes, were the focus of our analysis regarding meteorological fluctuations' impact on the growth of grape shoots and the development of leaf surfaces. Our research aimed to assess the changes in meteorological conditions in the ATU Gagauzia and their impact on the growth dynamics of grapevine shoots, as well as the development of leaf surfaces, yields of introduced clones of European selection. Temperature and precipitation levels significantly impacted the growth of grapevine shoots and the development of shoot leaf surfaces, vines, and vineyards. Aligning these factors with the requirements of grapevines optimizes the growth and development of the annual grapevine growth. Meteorological conditions varied across study years, benefiting grapevine growth in certain years (2017-2018) but proving less favourable in others due (2019-2020) to reduced precipitation and higher temperatures during the growing season. The research findings indicate that the growth parameters of shoots, the development of leaf surfaces, LAI, and yield of clone R5 Cabernet Sauvignon in the agroecological conditions of ATU Gagauzia depend on both the rootstock variety and the fluctuating meteorological conditions. It has been established that when grafting the investigated clone onto RxR 101-14, growth indicators, the development of annual shoot growth, leaf surface and yields were lower compared to the vines grafted onto BxR Kober 5BB. This difference was evident throughout the entire research period but was particularly pronounced during periods of adverse meteorological conditions. Specifically, in 2020, these indicators decreased by 1.1-1.2 times compared to the experimental option BxR Kober 5BB.

Keywords: Gagauzia, Grapevines, Growth, Development, Meteorological Conditions

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1. Introduction

The viticulture restoration program at ATU Gagauzia aims to build a contemporary grape industry, focusing on high-quality grape production that can compete in markets while ensuring strong economic viability. Its primary focus is to realign the industry by expanding vineyard areas with superior planting material of enhanced biological value, emphasizing the adoption of innovative techniques for vine plantation establishment (Cara, 2023).

The current viticulture production potential remains underutilized due to various factors, leading to a financial crisis within both the viticulture and winemaking sectors that do not align with their potential. Many viticulture enterprises became unprofitable and shifted to less resource-intensive industries, resulting in a decreased vineyard area in agricultural enterprises. This reduction in vineyard acreage was a consequence of unprofitability, leading to enterprises opting for less labour and energy-intensive alternatives (Parmacli and Cara, 2021).

In the Autonomous Territorial Unit of Gagauzia, as well as in the entire Republic of Moldova, European-introduced clones of grape varieties are actively being implemented. These clones demonstrate their highest productive potential in the areas where they were originally developed. However, when introduced to different locations, they may change their positive and negative characteristics. Therefore, to minimize potential production and economic risks, it is essential to study how these introduced clones adapt to new growing conditions (Cara, 2022).

Physical and geographical factors constantly influence the grapevine (Chisili et al., 2008). Therefore, scientists have repeatedly explored the correlation between grape productivity, harvest quality, and climatic and placement conditions, considering them primary environmental influencers (van Leeuwen et al., 2004).

They aimed to find a precise quantitative expression of this relationship. However, it would be premature to consider this issue definitively resolved, as it continues to be a pertinent subject of research in numerous grape-growing and winemaking countries worldwide (Perstniov and Cara, 2015; Cara, 2021).

Climate change impacts the grape cultivation processes (Küpe and Köse, 2015), affecting growth (Küpe and Köse, 2019), yield, and product quality (Küpe, 2012). Microclimate refers to the fluctuations in climatic elements within a specific area, typically at the plot level or within a canopy. These conditions can be intentionally altered or managed through canopy management techniques (Smart and Robinson, 1991).

The Leaf Area Index (LAI) is one of the most used parameters in viticulture. It is used to assess the vineyard canopy area (Delrot et al., 2010). He is an important indicator since leaf area parameters affect the processes of transpiration, root growth, and the photosynthetic potential of grapevines (Keller, 2015). The LAI is affected by the management of agronomic practices such as irrigation, nutrient and grapevine training systems (Oliveira and Santos, 1995).

The growth and productivity of vine canopies, operating as an optical-biological system, hinge upon the rhythm of physiological phenomena linked to shoot development and Leaf Area functionality (Amirdzhanov, 1980).

Key life-sustaining processes like photosynthesis, transpiration, and respiration occur predominantly in the leaves. Their efficiency relies on the plant's genetic makeup and adaptability to environmental factors. The cumulative Leaf Surface Area of shoots, vines, rows, and vineyards is a resultant effect of individual leaf activity (Smirnov et al., 1998).

The dimensions, structure, and environmental context influencing Leaf Surface regulate the magnitude of both biological and economic yield, directly impacting grape quality (Stirbu, 2012).

The increase of the Leaf Surface in vine plants throughout their development is crucial for the efficient assimilation of CO_2 during photosynthesis. According to studies by Poenaru and Beznea (1977) and Naumenko (2001, 2004), the rates at which Leaf Area develops in vine plants vary. These disparities are contingent upon the inherent biological traits of the varieties and their adaptability to the prevailing growth conditions.

In this context, it is pertinent to investigate the impact of changing meteorological conditions on the ATU Gagauzia and rootstock varieties on the growth and development of grapevines.

2. Material and Methods

2.1. Plant material and experimental design

The research material was provided by the R5 clone of the Italian-selected Cabernet Sauvignon variety, which was grafted onto the rootstock variety BxR Kober 5BB and RxR 101-14. The experiments were conducted on vineyards planted in 2005 in the village of Tomai, Ceadir-Lunga district. The experimental plot of the vineyard was arranged according to the following scheme: a distance of 2.75 meters between rows, 1.5 meters between vines (density 2424 vines per hectare). The soil of the experimental vineyard is calcareous chernozem. The vines were shaped into a bilateral horizontal cordon form. They were trained in a Vertical Shoot Position and supported by a trellis consisting of four wires positioned at heights of 0.8, 1.0, 1.4, and 1.8 meters above the ground. Pruning the vines was used-cane pruning. The scheme of the experiment consisted of two variants of the experiment - two rootstock varieties. Each experiment variant consisted of four repetitions. In each repetition, there were 10 grapevines, and 80 experimental vines in total.

2.2. Shoot growth

The vine's growth was expressed linearly in m/vine and volumetrically in dm^3/vine. Linear Annual Growth was calculated by multiplying the number of shoots on the vine by their average length, expressed in m/vine. Volume of Annual Growth: for this purpose, the Average Shoot Diameter was used to calculate the Average Shoot cross-sectional area by the equation $S = \pi * d^2/4$, where, d - Shoot Diameter, π - 3.14. The equation determined the Shoot Growth: $G = l * S$, where, G - Shoot Growth, l - Shoot Length, S - Average Shoot Area. The total vine growth - Volume of Annual Growth, was calculated as the sum of all shoots and expressed dm^3/vine (Melnik, 1959).

2.3. Leaf surface area

The Leaf Area of a shoot was calculated by multiplying the Leaf Area – S by the number of leaves on the shoot the Leaf Area – S, expressed in dm^2/shoot. The total Leaf Area of a vine was calculated by multiplying the Shoot Leaf Area by the number of shoots per vine, expressed in m^2/vine. The total Leaf Area of the vineyards was calculated by multiplying the vine Leaf Area by the number of vines per hectare (2424), expressed in thousands of square meters per hectare (thousand m2/ha) (Melnik et al. 1957). The Leaf Area Index was calculated as the ratio of of Leaf Surface Area of a vine to its ground surface area, expressed in m^2/m^2 (Laman et al., 1996).

2.4. Meteorological conditions

The analysis of meteorological conditions during the study years (2015-2021) was conducted using data from the Ceadir-Lunga meteorological station. This included calculating monthly precipitation in mm, calculating the annual sum of precipitation for each study year in mm, computing average monthly air temperature values for each study year in °C, and determining the average annual air temperature for each study year in °C.

2.5. Statistical analysis

Effects of rootstock and year were determined by performing a Two-way Analysis of Variance (ANOVA). Differences between the means of years in each rootstock were evaluated according to Tukey's posthoc test (HSD).

3. Results and Discussion

The research scrutinized the evolving meteorological conditions in ATU Gagauzia and their influence on the development and harvest of grapevines. Temperature and precipitation are environmental factors that influence the development and growth of plants and the quantity and quality of the harvest. The closer these factors align with the requirements of the grapevine at different stages of its development, the better the growth of all its organs will proceed, ultimately resulting in higher crop yields and grape quality.

We have analyzed meteorological conditions from 2003 to 2022 (Figure 1). It was revealed that the climate in ATU Gagauzia is warm, with temperatures of 10 °C and above lasting for 179-187 days, significantly longer than in other parts of the Republic of Moldova. The sum of active temperatures is 3300 °C. The annual amount of atmospheric precipitation varies from 258.9 mm (in 2022) to 569.3 mm (in 2016). It is noted that meteorological conditions in recent years of the study have changed towards an increase in the average annual temperatures and a decrease in precipitation. Thus, compared to the long-term average temperature of 9.8 °C, there has been an increase of this indicator by 2.8 °C in the last years of the study. In 2016, the average annual temperature was 13.2 °C, 12.5 °C in 2017, 11.5 °C in 2018, 12.5 °C in 2019, 13.1 °C in 2020, 11.1 °C in 2021, and 12.3 °C in 2022.

We have established that recent years are also characterized by a lower amount of precipitation compared to the long-term averages. For example, in 2018, the annual precipitation amounted to 431.4 mm, in 2019 it was 380.6 mm, and in 2022, it was 258.9 mm, which is less than the long-term average values by 34.6 mm, 85.6 mm, and 207 mm, respectively. Along with this, there has been a change in the distribution of precipitation during the grapevine's growth and dormancy periods. It has been noted that grapevines experienced a moisture deficit during critical growth and development stages, which hurt the growth, development, and yield of the plants.

It is important to highlight that meteorological conditions varied throughout the study years. They favoured the growth and development of grapevines in 2003, 2004, 2005, 2010, 2013, and 2017 but were less conducive in 2011, 2019, and 2020. This was attributed to a notable reduction in precipitation and elevated temperatures during the summer growing seasons.

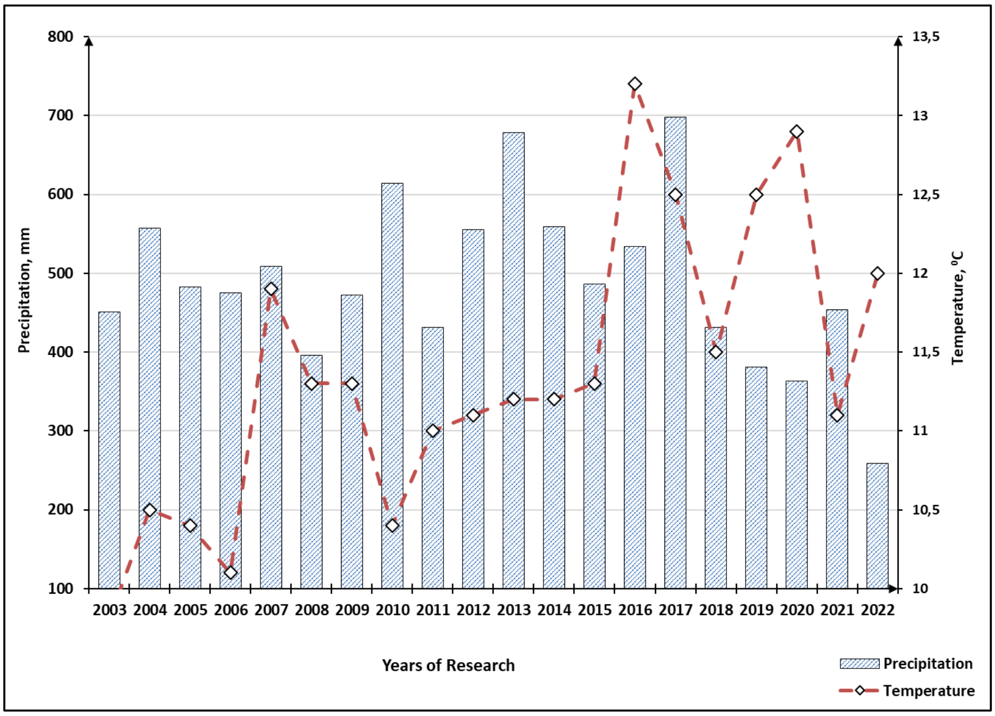

Figure 1. Meteorological conditions during the study years (according to the Ceadir-Lunga Meteorological Station data)

Table 1. Growth and development parameters of grapevine shoots in the conditions of ATU Gagauzia

Experiment Options	Year	Number of Shoot, pcs.	Annual Growth, m/vine	Volume of Annual Growth, dm^3/vine
Cl R5 Cabernet Sauvignon onto Kober 5 BB	2015	40.4±0.34 cde	129.1±2.10 d	2.72±0.02 e
	2016	41.0±0.31 bcd	134.8±2.34 cd	2.99±0.02 d
	2017	44.2±0.26 a	152.3±2.04 a	4.47±0.03 a
	2018	43.1±0.20 a	149.8±1.92 ab	3.49±0.03 c
	2019	41.2±0.19 bc	125.5±1.90 def	2.73±0.03 e
	2020	31.5±0.25 h	63.5±0.60 h	0.51±0.01 i
	2021	37.5±0.20 f	76.2±0.65 g	1.13±0.02 g
Cl R5 Cabernet Sauvignon onto RxR 101-14	2015	37.3±0.23 f	119.2±2.14 ef	2.35±0.02 f
	2016	40.0±0.20 de	126.7±2.41 de	2.68±0.02 e
	2017	41.9±0.24 b	141.5±2.42 bc	3.77±0.03 b
	2018	41.0±0.24 bcd	139.8±2.12 c	3.03±0.03 d
	2019	39.5±0.23 e	117.1±2.02 f	2.38±0.02 f
	2020	28.2±0.22 i	61.1±1.45 h	0.42±0.01 i
	2021	34.2±0.21 g	73.9±1.76 g	0.97±0.02 h
Options	Kober 5 BB	39.8±0.48 A	118.7±3.96 A	2.58±0.15 A
	RxR 101-14	37.4±0.54 B	111.3±3.60 B	2.23±0.13 B
Years	2015	38.9±0.41 D	124.2±1.85 C	2.54±0.05 D
	2016	40.5±0.21 C	130.8±1.88 B	2.83±0.04 C
	2017	43.1±0.32 A	146.9±1.97 A	4.12±0.08 A
	2018	42.1±0.29 B	144.8±1.80 A	3.26±0.06 B
	2019	40.4±0.24 C	121.3±1.66 C	2.55±0.04 D
	2020	29.9±0.41 F	62.3±0.81 E	0.47±0.01 F
	2021	35.9±0.40 E	75.1±0.95 D	1.05±0.02 E
ANOVA	$F_{Options}$	347.30^{***}	51.62^{***}	785.06^{***}
	F_{Year}	703.74^{***}	594.74^{***}	5785.82^{***}
	$F_{Options*Year}$	6.69^{***}	1.72ns	35.77^{***}

*Different letters in the same column indicates signifcant differences according to Tukey's HSD (p≤0.05). ns: not significant (p>0.05), *** indicates significance at p<0.001.*

The number of shoots varied throughout the research period (Table 1). We found that during the study period, an average of 39.8±0.48 shoots formed per vine of the Clone R5 Cabernet Sauvignon onto the Kober 5 BB when grafted onto RxR 101-14 decreases to 37.4±0.54 shoots per vine. The highest average number of shoots was observed in 2017 (43.1±0.32), while the lowest was in 2020 (29.9±0.41). Statistically significant differences were found in the number of shoots depending on the rootstock variety (347.30***), the year of study (703.74***), and the interaction between rootstock and the year of study (6.69***).

It has been established that the R5 clone of the Cabernet Sauvignon variety grafted onto Kober 5 BB rootstock is characterized by the formation of a larger Volume of Annual Growth, which amounts to 2.58±0.15 m/vine. It was found that the meteorological conditions prevailing during the study years systematically influence the development of the Volume of Annual Growth. For instance, higher precipitation in 2017 leads to an increase in this indicator to 4.12±0.08 m/vine, while in the drought year of 2020, this indicator significantly decreases to 0.47±0.01 m/vine.

Significant differences in the development of the Annual Growth Volume of vines were found depending on the rootstock variety, the year of the study, and the interaction between these factors. Furthermore, these variations were indicative of distinct impacts on the growth patterns of the vine stock, showcasing the nuanced influence of rootstock variety and annual conditions of study on their development. The observed significant differences in the growth patterns of vine stock based on rootstock variety, study year, and the interaction between these factors emphasize the dynamic and intricate nature of their influence on the overall growth and development of the vines.

Table 2. The development of grapevine Leaf Surface in the conditions of ATU Gagauzia

Experiment Options	Year	Number of Leaves on Shoot	Leaf Area			
			cm^2/leaf	dm^2/shoot	m^2/vine	th.m^2/ha
Cl R5 Cabernet Sauvignon onto Kober 5 BB	2015	26.4±0.16 cd	116.6±0.56 d	30.8±0.50 e	12.4±0.23 f	30.2±0.36 f
	2016	27.5±0.11 bc	133.1±0.41 bc	36.6±0.20 c	15.0±0.15 d	36.4±0.19 d
	2017	31.1±0.25 a	144.6±0.43 a	45.0±0.18 a	19.9±0.11 a	48.2±0.29 a
	2018	30.6±0.29 a	138.6±0.35 abc	42.4±0.31 b	18.3±0.13 b	44.3±0.32 b
	2019	25.6±0.22 de	116.5±0.41 d	29.8±0.50 ef	12.3±0.23 f	29.8±0.36 f
	2020	22.6±0.23 gh	85.1±0.31 f	19.2±0.19 i	6.1±0.07 j	14.7±0.18 j
	2021	26.0±0.34 cde	97.8±0.31 e	25.4±0.25 h	9.5±0.08 h	23.1±0.32 h
Cl R5 Cabernet Sauvignon onto RxR 101-14	2015	24.4±0.35 ef	115.7±1.92 d	28.2±0.42 fg	10.5±0.33 gh	25.5±0.37 g
	2016	25.9±0.53 cde	131.8±2.38 c	34.1±0.55 d	13.7±0.27 e	33.1±0.61 e
	2017	28.9±0.50 b	141.0±2.57 ab	40.7±0.16 b	17.1±0.17 c	41.4±0.26 c
	2018	28.6±0.42 b	131.6±3.25 c	37.7±0.53 c	15.4±0.26 d	37.4±0.39 d
	2019	23.9±0.35 fg	115.3±2.67 d	27.6±0.31 g	10.9±0.25 g	26.4±0.29 g
	2020	21.8±0.38 h	84.1±2.96 f	18.3±0.32 i	5.2±0.23 j	12.5±0.39 k
	2021	25.2±0.28 def	96.7±2.59 e	24.4±0.41 h	8.3±0.07 i	20.2±0.45 i
Options	Kober 5 BB	27.1±0.34 A	118.9±2.43 A	32.7±1.03 A	13.4±0.54 A	32.4±1.31 A
	RxR 101-14	25.5±0.32 B	116.6±2.47 B	30.1±0.88 B	11.6±0.47 B	28.1±1.13 B
Years	2015	25.4±0.30 C	116.2±0.98 C	29.5±0.43 D	11.4±0.30 D	27.9±0.59 D
	2016	26.7±0.32 B	132.4±1.19 B	35.3±0.41 C	14.3±0.21 C	34.8±0.49 C
	2017	30.0±0.37 A	142.8±1.33 A	42.9±0.51 A	18.5±0.34 A	44.8±0.80 A
	2018	29.6±0.34 A	135.1±1.78 B	40.0±0.62 B	16.9±0.36 B	40.9±0.83 B
	2019	24.7±0.28 C	115.9±1.32 C	28.7±0.38 D	11.6±0.23 D	28.1±0.46 D
	2020	22.2±0.24 D	84.6±1.45 E	18.8±0.21 F	5.7±0.15 F	13.6±0.32 F
	2021	25.6±0.23 C	97.3±1.28 D	24.9±0.26 E	8.9±0.15 E	21.7±0.43 E
ANOVA	$F_{Options}$	80.15***	5.20*	174.63***	276.06***	513.27***
	F_{Year}	135.64***	248.06***	1067.65***	999.15***	1851.12***
	$F_{Options*Year}$	1.36ns	1.72ns	7.98***	7.87***	14.06***

*Different letters in the same column indicates signifcant differences according to Tukey's HSD ($p\leq0.05$). ns: not significant ($p>0.05$), * and *** indicate significance at $p<0.05$ and $p<0.001$, respectively.*

In the course of our research, we established the fluctuations in Leaf Blade development data related to inconsistent meteorological conditions observed during the study period (Table 2). The Leaf Area during growth on different rootstocks varies from 116.6±2.47 cm^2/leaf to 118.9±2.43 cm^2/leaf. Favorable years (2017-2018) saw Leaf Areas of 135,1±1,78 cm^2/leaf - 142,8±1,33 cm^2/leaf. Subsequently, a steady decline in the Leaf Area occurred, attributed to reduced precipitation and higher average monthly air temperatures during the growth season. For instance, in 2020, Leaf Areas decreased by 1.6-1.7 times compared to 2017-2018.

The Leaf Area of shoots, vines, and vineyards gradually expands, influenced by the number of shoots (load) and the corresponding leaf growth on these shoots. The growth of the Leaf Area on the vines shows variations due to a myriad of internal and external factors. These include the number of shoots developed on the vines, the number of leaves that have emerged on these shoots, the area occupied by the leaf blades, and the spatial arrangement of the vines, among other factors. The Leaf Area of the R5 clone of the Cabernet Sauvignon variety grafted onto BxR Kober 5BB measured 45.0±0.18 dm^2 per shoot and 19.9±0.11 m^2 per vine by the conclusion of the 2017 growing season.

Interestingly, the increase of the Leaf Area on vines is notably influenced by the specific rootstock variety they are grafted onto. For instance, when grafted onto RxR 101-14, the Leaf Area of both the shoot and vine decreases by 1.1-1.2 times compared to BxR Kober 5BB, amounting to 40.7±0.16 dm^2 per shoot and 17.1±0.17 m^2 per vine.

The Leaf Surface Area stands as a pivotal factor influencing the photosynthetic activity within plants. The growth in biomass and productivity of plant organs hinges upon its robust development. Measurements of the Leaf Surface Area within the vineyard plots of the examined clone grafted onto BxR Kober 5 BB and RxR 101-14, revealed variations influenced by the rootstock variety and the amalgamation of meteorological factors during their growth. In 2017, the Leaf Area indicator of the grapevine plantations reached 44.8±0.80 thousand m^2 per hectare; in 2018, it decreased to 40.9±0.83 thousand m^2 per hectare, and in 2020, it dropped to 13.6±0.32 thousand m^2 per hectare, which is 3.3 times less than in 2017.

When considering the experiment options, it was established that under favourable conditions, particularly in 2017, the Leaf Area peaked at 48.20±0.29 thousand m^2 per hectare when grafted onto BxR Kober 5 BB. Conversely, when grafted onto RxR 101-14, this area reduced to 41.40±0.26 thousand m^2 per hectare.

It has been established that the inhibition of Leaf Area growth occurred due to high temperatures and insufficient moisture during unfavourable years (2020-2021). This resulted in a reduction in the Leaf Area across the shoot, vine, and vineyard plantations.

It has been established that the Leaf Area Index (LAI) parameters of the R5 clone of the Cabernet Sauvignon vary when grafted onto different rootstocks (Figure 2a).

Specifically, this indicator is higher when grafted onto BxR Kober 5BB, ranging from 1.47 to 4.82 m^2/m^2, and when grafted onto RxR 101-14, it ranges from 1.25 to 4.14 m^2/m^2. Research has shown that LAI varies over the study years and is influenced by the amount of annual precipitation. The highest values for this parameter were recorded in 2017. As the annual precipitation decreases, there is a decline in LAI to 1.25 m^2/m^2 (RxR 101-14) and 1.47 m^2/m^2 (BxR Kober 5BB) in 2020.

The clone R5 Cabernet Sauvignon, when grafted onto BxR Kober 5BB rootstock and cultivated in the agro-ecological conditions of ATU Gagauzia, demonstrates a yield ranging from 1.82 to 6.11 kg/vine (Figure 2b). When grafted onto RxR 101-14, the yield ranges from 1.48 to 5.69 kg/vine. It has been observed that the grapevine yield of the R5 Cabernet Sauvignon clone is also influenced by the rootstock variety and meteorological conditions during the years of the research.

Direct correlational dependence has been established between the development of the LAI and the yield of the grapevines. The correlation coefficient of 0.98±0.27 demonstrates a high level of association between the LAI and the yield of grapevines. This indicates that the development of leaf area directly impacts grape production, serving as a key factor in optimizing and enhancing grape cultivation techniques. The data obtained, showing a strong correlation between the LAI and grapevine yield, suggests that effective leaf area development is crucial for ensuring a good harvest. Therefore, the LAI of the vine can be considered an indicator for predicting grape yield. Such relationships can be utilized in developing vineyard management strategies, including optimizing canopy management and selecting rootstocks to improve grape yields.

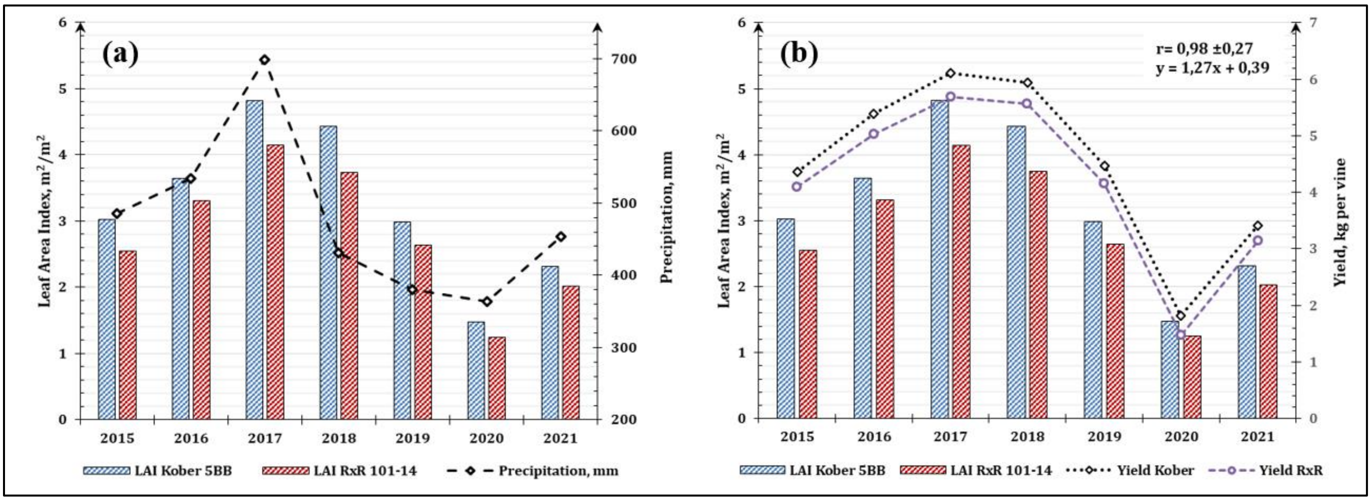

Figure 2. Leaf Area Index, a) Dependence of the LAI on the amount of precipitation, b) Dependence of the yield grapevines on the LAI

4. Conclusion

The meteorological conditions across the ATU Gagauzia, fluctuated significantly throughout the research period. The years 2017-2018 were notably more favourable, contrasting with the less conducive conditions experienced in 2019-2020. These shifts were characterized by a considerable decline in rainfall and soaring temperatures during the growth season. Consequently, this natural phenomenon directly impacted the growth and development of grapevines, on the Annual Growth, Leaf Area and Yields parameters.

The study revealed noteworthy disparities in the Annual Growth volume of vines linked to rootstock variety and study year interactions. These significant differences emphasize the complex influence these factors wield over the overall growth and development of vines, showcasing the dynamic nature of their impact.

The development of Leaf Area in clone R5 Cabernet Sauvignon is reliant upon both the rootstock variety and prevailing meteorological conditions. In more favourable meteorological years, exemplified by 2017, the Leaf Area of clone R5 Cabernet Sauvignon onto BxR Kober 5BB achieves 144.6±0,43 cm^2/leaf, 45.0±0.18 dm^2/shoot, 19.9±0.11 m^2/vine and 48.2±0,29 thousand m^2 per hectare, LAI of 4.82 m^2/m^2. However, when cultivated onto RxR 101-14 in the arid conditions of ATU Gagauzia, there is a significant reduction of 1.1-1.2 times in the Leaf Area parameters.

The R5 Cabernet Sauvignon clone, in the agroecological conditions of ATU Gagauzia, exhibits a high yield during favourable years, ranging from 5.69 to 6.11 kg per vine. A direct correlation relationship of 0.98±0.27 has been established between LAI and the yield of vines. It has been established that the yield of the investigated clone is influenced by the rootstock variety and meteorological conditions, which vary throughout the study years. Grapevines of the R5 Cabernet Sauvignon clone grafted onto BxR Kober 5BB demonstrate increased resilience to unfavourable environmental conditions compared to those grafted onto RxR 101-14. This is evident in the better development of Annual Shoot Growth and Leaf Area, ultimately contributing to higher grapevine yields.

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Conflict of interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

References

Amirdzhanov, A. (1980). *Solar radiation and vineyard productivity*. Leningrad: Gidrometeoizdat.

Cara, S. (2021). *Growth and productivity of vineyards depending on planting material quality*. Comrat State University, A&V Poligraf SRL.

Cara, S. (2022). *Development of the leaf surface the Clone R5 Cabernet Sauvignon variety in the southern region of the Republic of Moldova* [Oral presentation]. 5th International Agriculture Congress, Bolu, Türkiye.

Cara, S. (2023). *The present condition and prospects for development of the viticulture industry in the Autonomous Territorial Unit of Gagauzia* [Oral presentation]. VI. International Scientific and Practical Conference "Biotechnology: Achievements and Prospects of Development", Pinsk, Republic of Belarus.

Chisili, M., Rapcea, M., & Chisili, S. (2008). The Influence of Environmental and Anthropogenic Factors on Grapevine Productivity. Scientific Papers State Agrarian University of Moldova, Chisinau, Vol.16, p. 255-258.

Delrot, S., Medrano, H., Or, E., Bavaresco, L., & Grando, S. (2010). *Methodologies and results in grapevine research*. Springer.

Keller, M. (2015). *The science of grapevines: Anatomy and physiology* (2nd ed.). Elsevier.

Küpe, M., (2012). Küresel İklim Değişikliğinin Bağcılık Üzerindeki Etkileri. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *43*(2), 191-196. (in Turkish)

Küpe, M., & Köse, C. (2015). Karaerik Üzüm Çeşidinde Kış Soğuklarından Sonra Zarar Düzeyine Bağlı Olarak Uygun Budama Seviyelerinin Tespit Edilmesi. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *46*(1), 21-28. (in Turkish)

Küpe, M., & Köse, C. (2019). Determination of Cold Damage in Field and Laboratory Conditions in Dormant Buds of Karaerik Grape Cultivar. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *50*(2), 115-121.

Laman, N., Samsonov, V., & Prokhorov, V. (1996). *Methodological Guide for the Study of Mixed Agrophytocenoses*. Minsk: Science and Technology.

Melnik, S. (1959). *Methods for determining the growth strength of grapevines*. Proceedings of the Odessa Agricultural Institute, 1, 23-26.

Melnik, S., & Shchiglovskaia, V. (1957). *Ampelometric method for determining the leaf surface area of grapevines*. Proceedings of the Odessa Agricultural Institute, 8, 82-88.

Naumenko, V. (2001). Simplified Definition of Photosynthetic Potential of Vineyards. *Winemaking and Viticulture, 4,* 33.

Naumenko V. (2004). Dynamics of Growth of the Leaf Surface of Grapes on the Tersko-Kuma Sands. *Winemaking and Viticulture*, *7*, 38-39.

Oliveira, M. & Santos, M. (1995). A Semi-Empirical Method to Estimate Canopy Leaf Area of Vineyards.

American Journal of Enology and Viticulture, *46*(3), 389-391. https://doi.org/10.5344/ajev.1995.46.3.38

Parmacli, D., & Cara, S. (2021). Analysis of the State of Grape Cultivation in ATU Gagauzia. *Vector European*, 2, 113-125. https://doi.org/10.52507/2345-1106.2021-2.22

Perstniov, N., & Cara, S. (2015). *Ampeloecology*. Comrat State University, A&V Poligraf SRL.

Poenaru, L., & Beznea, G. (1977). The Influence of the Climate and the Culture System on the Production and Profitability of the Merlot Variety. *Researcher Viticulture and Winemaking, Valea Călugărească*, *VIII*, 167-186.

Smart, R., & Robinson, M. (1991). Sunlight into wine. In S. A. Adelaide (Ed.), *A handbook for winegrape canopy management*.

Smirnov, K., Maltabar L., Radjabov A., & Matuzok N. (1998). *Viticulture*. Moscow: MSHA.

Stirbu, A. (2012). *Physiological and biochemical particularities of growth and productivity of table grape varieties, depending on scion-rootstock combinations*. [Doctoral dissertation, State Agrarian University of Moldova].

van Leeuwen, C., Friant, P., Chone, X., Tregoat, O., Koundouras, S., & Dubourdieu, D. (2004). Influence of Climate, Soil, and Cultivar on Terroir. *American Journal of Enology and Viticulture*, *55*(3), 207-217. https://doi.org/10.5344/ajev.2004.55.3.207

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Regarding the prediction of fruit yield dynamics

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Abstract

Pomology serves as a source of essential food products and raw materials for industry. Fruits possess unique medicinal properties, offering undeniable nutritional and dietary benefits due to their content of fructose, glucose, organic acids, vitamins, pectins, and mineral salts. The function of the fruit is to preserve the seeds that contribute to the spread of flowering plants, i.e. the seeds are a way of propagating plants. Fruit is a valuable food containing an irreplaceable complex of vitamins, enzymes and other biologically active substances necessary for maintaining human health. This study covers the period of fruit growing in farms of all categories of autonomy for the years 1995-2018, i.e. the last 24 years. A brief analysis of production indicators shows that from 1995 to 2018, with an increase in yield by 119.4 c/ha, the cultivated area decreased by 58.4%, while the gross grain harvest increased by more than 3.7 times. The positive dynamics in fruit production are not only due to their social significance, which allows for assessing the country's food security, but also to their reasonably acceptable efficiency in the food market.

Keywords: Yield, Fruit, Production potential, Land productivity potential

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1. Introduction

Agriculture is a vital part of the national economy for the Republic of Moldova, as well as for the Autonomous Territorial Unit of Gagauzia, serving as one of the primary sources of employment in both the country and the autonomous region.

The effectiveness of agriculture depends on socio-economic factors such as land use patterns, the extent of agricultural lands, and the level of development and implementation of scientific advancements and technology (Siptits, 2017).

Fruits will never lose their popularity. After all, they contain so many vitamins, and no modern consumer dish can do without them. Fruits have always been considered a decoration for a festive table. There has been consistently high demand for fruits throughout the year (Parmakli, 2016).

The domestic production of fruits is a crucial component of the Republic of Moldova's food security. Fruits have consistently maintained a high demand over many years. Consumers are increasingly concerned about the safety and quality of fruit and vegetable products. Therefore, during the research, an analysis was conducted and calculations were made regarding the growth (or decline) rates of harvesting areas, gross fruit harvest, and yield (Parmakli et al., 2017).

For the Republic of Moldova, whose economy is predominantly determined by agricultural development, forecasting the dynamics of fruit yields is of vital importance. Consequently, research aimed at analyzing and calculating the dynamics of fruit yields remains highly relevant.

Studies by various authors indicate that increased fruit consumption contributes to an extended lifespan. Presently, the fruit-growing industry, with products in constant demand, faces certain challenges (Bajura et al., 2018).

2. Material and Methods

In this study, fruit trees grown in the Gagauz autonomous region of Moldova were used as material.

Scientific research is based on the utilization of individual methods. The following methods were utilized during the research: statistical-economic, economic-mathematical, analysis and synthesis, calculation formulas, and trend dynamics.

One of the simplest, most visual, and accessible methods is the graphical method. Forecasting results are obtained through trend analysis over the last 5 years or more.

To use the graphical analytical method for forecasting, the graph should display two types of trends: linear and polynomial, along with equations and approximation coefficients for each. It is known that the polynomial trend better reflects the growth trend of indicators due to its higher approximation coefficient. With this trend, fluctuations in the indicator are smoother, the approximation coefficients are significantly higher, thus the equations more objectively reflect the trend, resulting in more accurate predictions based on this graph (Doga and Bajura, 2016).

Since the indicators for the two trend lines (linear and polynomial) differ, we take the average values as predictive. Therefore, for forecasting indicators for the next two years (2019 and 2020), we utilize both polynomial and linear trends.

During the analysis, calculations were made for the rates of increase (decrease) in harvesting areas, gross fruit yield, and productivity. In absolute terms, the average annual increase in harvesting areas ($\Delta S_{\text{ср}}$) is calculated using the equation:

$$\Delta S_{\text{ср}} = \frac{S_{\text{к}} - S_{\text{н}}}{n-1} \qquad (1)$$

Where: $S_{\text{к}}$ and $S_{\text{н}}$ are indicators of harvesting areas at the end and beginning of the period, respectively, and *n* is the number of years in the studied period.

In relative terms, the increase is estimated according to the expression:

$$\Delta S_{\text{ср}}^{\text{от}} = \sqrt[n-1]{\frac{S_{\text{к}}}{S_{\text{н}}}} \qquad (2)$$

The increase in areas according to Equation 1 amounted to:

$$\Delta S_{\text{ср}} = \frac{2138-5141}{24-1} = -130.5 \text{ hectares.}$$

The growth in areas according to Equation 2 will be:

$$\Delta S_{\text{ср}}^{\text{от}} = \sqrt[n-1]{\frac{2138}{5141}} = 0.96$$

Therefore, on average per year, the fruit harvesting area decreased by 130.5 hectares or 4.0%.

The average annual increase in produced grain was:

$$\Delta Q_{\text{ср}} = \frac{Q_{\text{к}} - Q_{\text{н}}}{n-1} = \frac{36265 - 9808}{24-1} = 1150{,}3 \text{ ton}$$

In accordance with Equation 2:

$$\Delta Q_{\text{ср}}^{\text{от}} = \sqrt[n-1]{\frac{Q_{\text{к}}}{Q_{\text{н}}}} = \sqrt[n-1]{\frac{36265}{9808}} = 1.06$$

Thus, fruit production increased annually by 1150.3 tons or 6.0%.

The yield of fruits per hectare in 1995 was 19.1 quintals, and by the end of the period in 2018, it was 138.5. According to formula 3, the average annual increase amounted to 5.19 quintals/hectare. In relative terms, the increase was 1.09 or 9% per year.

The established indicators of the average annual yield and their annual increases for all crops in the studied regions over the 24 years are presented in Table 1. It is worth noting the rapid pace of yield growth for most cultivated crops by Moldovan farmers, trailing only in vegetables in this aspect. The data from Table 1 is visually represented in the graph (Figure 1).

Table 1. Changes in fruit production indicators on an average annual basis in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for the years 1995 to 2018

Indicators	Average Annual Indicator	Growth per Year	
		Total	%
Harvesting Area, ha	3245.5	-130.5	-4.0
Gross Yield, tons	9762.4	1150.3	6.0
Yield, quintals per ha	37	5.19	9.0

Source: Conducted according to the methodology presented above (Anonymous, 2023a)

The described methods in this scientific study (economic, sociological, physical, etc.) operate in synergy. Analysis elements are an integral part of this research, transitioning from describing fruit yield to identifying its structure, characteristics, and attributes.

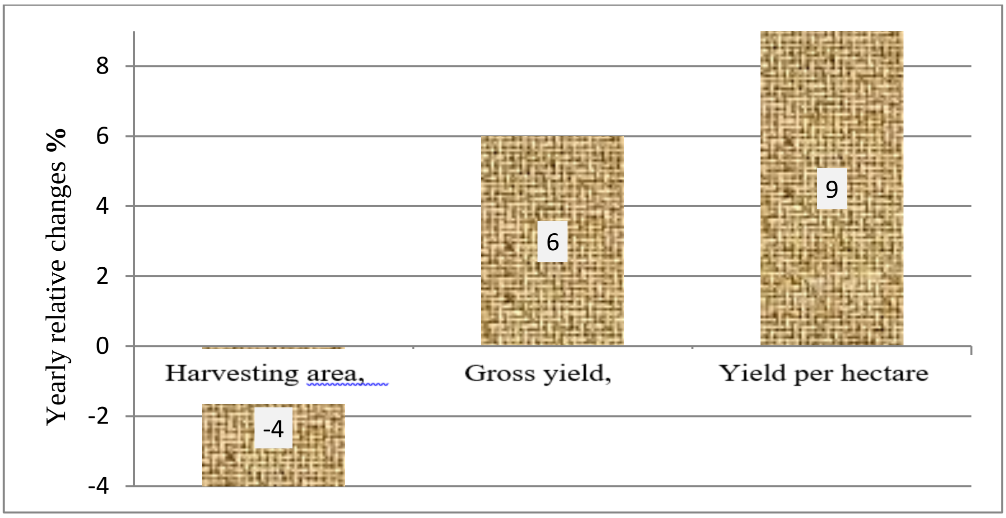

Figure 1. Average annual growth of fruit production indicators in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for 1995-2018 (*Source: compiled from Anonymous (2023b)*)

3. Results and Discussion

The research has indicated that with roughly equal yield values, the economic evaluation can significantly differ. Hence, giving an economic assessment based solely on the absolute magnitude of yield values is inappropriate. The above explanation will enable agricultural specialists, as well as educators and students in educational institutions, to justify the economic evaluation of the obtained yield indicators for each cultivated crop on the farm (Anonymous, 1994).

We calculated harvesting area, gross yield, and fruit yield indicators using the moving average method. We have chosen a 4-year moving average.

The data in Table 2 show that using a 4-year moving average reduces the coefficient of variation for harvested areas from 45.3% to 44%, or by a factor of 1, for gross yield from 81.8% to 50.7%, or by 1.6 times, and for yield from 95% to 76.8%, or more than 1.2 times. Naturally, the range of variation values decreases by a factor of 1 for harvested areas, by more than 1.8 times for gross yield, and by more than 1 time for yield.

To partially neutralize the influence of natural factors on the instability of production, we will calculate forecast indicators using the method of finding the moving average. For this purpose, we will utilize the average values of the four-year moving averages, as presented in Table 2. Figure 2 illustrates the dynamics of gross fruit yield over the investigated period, indicating two trend options: linear and polynomial.

Calculate the forecasted gross fruit yield using the linear trend equation ($y = 139.29x + 7008.8$):

Gross fruit yield in 2019:
$y = 139.29 * 22 + 7008.8 = 10074$ tons

Gross fruit yield in 2020:
$y = 139.29 * 23 + 7008.8 = 10213$ tons

Calculations based on the polynomial trend line equation ($y = 98.252x^2 - 2022.3x + 15295$):

Gross fruit yield in 2019:
$y = 98.252 * 22^2 - 2022.3 * 22 + 15295 = 18358$ tons

Gross fruit yield in 2020:
$y = 98.252 * 23^2 - 2022.3 * 23 + 15295 = 20757$ tons

Therefore, the forecasted gross fruit yield in 2019 will be 14216 tons (= (18358 + 10074) / 2), and in 2020 will be 15485 tons (= (20757 + 10213) / 2) (Figure 3).

4. Conclusion

In Moldova, two decades ago, cooperatives of small farmers were purposefully created, with the organizational and financial support of international donors, as socio-economic clusters to combat poverty in rural areas of Moldova. But large volumes of products of uniformly high quality (from the point of view of the strictest standards of international supermarket chains) can be obtained by agricultural producers only if their plantations are under a single agronomic management. If their products are sorted and packed in a uniform container, and it will be sold by a highly qualified sales department. Even wealthy farmers will be able to afford all this only by joining together in a cooperative, making joint investments in production/export infrastructures and a staff of specialists. It is obvious that such associations will have a synthesis character, combining the features of both entrepreneurial and production cooperatives, industry associations, and marketing groups (Curaxina, 2015).

Table 2. Annual and average annual fruit production indicators in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for the years 1995-2018

Year	Harvested area, ha		Gross yield, t		Yield, c/ha	
	per year	for the last 4 years	per year	for the last 4 years	per year	for the last 4 years
1995	5141		9808		19.1	
1996	5127		5398		10.5	
1997	5609		21208		37.8	
1998	5046	5231	13020	12359	25.8	23.3
1999	4970	5188	1246	10218	2.5	19.2
2000	4539	5041	4985	10115	11.0	19.3
2001	4265	4705	8725	6994	20.5	15.0
2002	4059	4458	4842	4950	11.9	11.5
2003	3808	4168	15403	8489	40.4	21.0
2004	4098	4058	6007	8744	14.7	21.9
2005	3935	3975	10202	9114	25.9	23.2
2006	3956	3949	6937	9637	17.5	24.6
2007	3249	3810	3724	6718	11.5	17.4
2008	2442	3396	7141	7001	29.2	21.0
2009	2733	3095	1581	4846	5.8	16.0
2010	2080	2626	3625	4018	16.6	15.8
2011	958	2053	2735	3771	24.5	19.0
2012	1042	1703	4309	3063	41.4	22.1
2013	1333	1353	7753	4606	58.2	35.2
2014	1533	1217	10596	6348	69.1	48.3
2015	1716	1406	12481	8785	72.7	60.4
2016	1847	1607	23084	13479	124.9	81.2
2017	2269	1841	13222	14846	58.3	81.3
2018	2138	1993	36265	21263	138.5	98.6
On average	3245.5	3184	9762.4	8541	37	33
Range of variations	4651	4014.3	35019	18200.5	136	87.1
Annual average deviation	1470.8	1393.8	7984.8	4333.8	35.2	25.4
Coefficient of variation, %	45.3	44	81.8	50.7	95	76.8

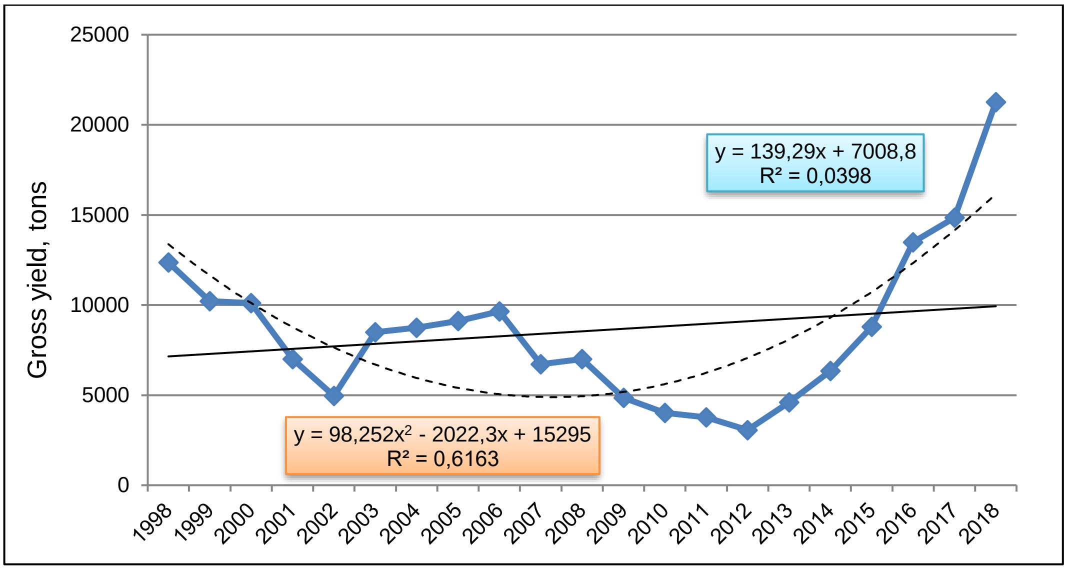

Figure 2. Dynamics of the four-year moving average of gross fruit yield in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for 1998-2018

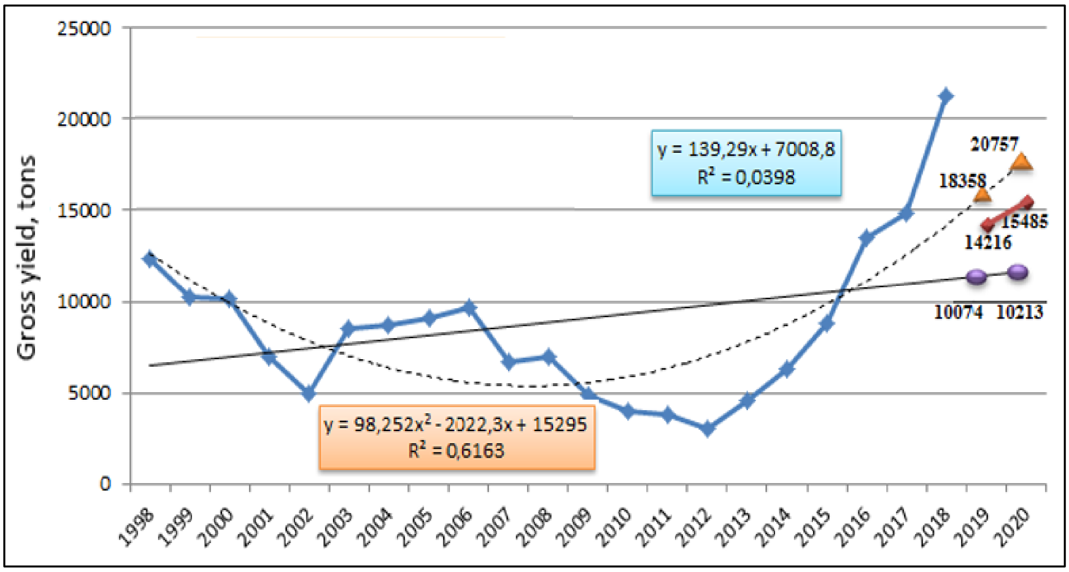

Figure 3. Forecast indicators of gross fruit yield in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for 2019-2020

As the experience of such a developed country as Germany shows, cooperation in agriculture is more relevant than ever, and this phenomenon is much broader than the unification of peasant farms. Intensive farming and the need for the use of new technologies require deep knowledge in a variety of fields. However, despite the fact that the introduction of a scientific approach from management to biotechnology is an impossible task even for the largest farms, cooperatives and their associations manage to solve issues on the application of advanced scientific methods for all members, as well as on training and retraining of personnel. They provide their members with all available scientific and technical potential on equal terms, regardless of the size of the farm and the share of the contributor (Parmakli and Todorich, 2013). To conduct forecast calculations of land productivity, let's construct graphs illustrating the dynamics of yield based on the moving averages for the years 1998-2018 (Figure 4), indicating two trend options: linear and polynomial (Timofti and Popa, 2009).

Moldova has accumulated a certain experience of cooperation among producers of table grapes. The total area under the vineyards is 1.5 thousand hectares, the members of the cooperative have plots under grapes of different sizes-from 0.2 to 30 hectares. Previously, they exported grapes “from the wheels”, that is, they sent their products directly from the field to the consumer without any storage. Over time, agricultural producers realized that by uniting in cooperatives, it is possible to increase the area of vineyards and create storage facilities and on this basis ensure higher efficiency of agribusiness. In such cooperatives, grapes are harvested and immediately placed on rapid cooling to preserve the quality of the products. Modern cooling rooms are an important link in the process of storing the crop, here the products are cooled from +40 to + 4-6 degrees in 4 hours. Introducing modern technologies, specializing in the production of table grapes, today, on average, cooperatives collect up to 20 kg of grapes from one bush. Its own packaging in the form of boxes is designed for 9 kg of product. Let's calculate the forecasted yield values using the linear trend equation ($y = 3.0993x - 0.9961$):

Yield in 2019:
$y = 3.0993 * 22 - 0.9961 = 67$ c/ha

Yield in 2020:
$y = 3.0993 * 23 - 0.9961 = 71$ c/ha

Calculations based on the polynomial trend equation ($y = 0.4366x^2 - 6.5051x + 35.821$):

Yield in 2019:
$y = 0.4366 * 22^2 - 6.5051 * 22 + 35.821 = 105$ c/ha

Yield in 2020:
$y = 0.4366 * 23^2 - 6.5051 * 23 + 35.821 = 117$ c/ha

Thus, on average, the forecasted yield for 2019:
$(67 + 105) / 2 = 86$ c/ha,

and for 2020:
$(71 + 117) / 2 = 94$ c/ha.

To visualize the forecasted yield indicators, we will depict them on the graph for clarity (Figure 5).

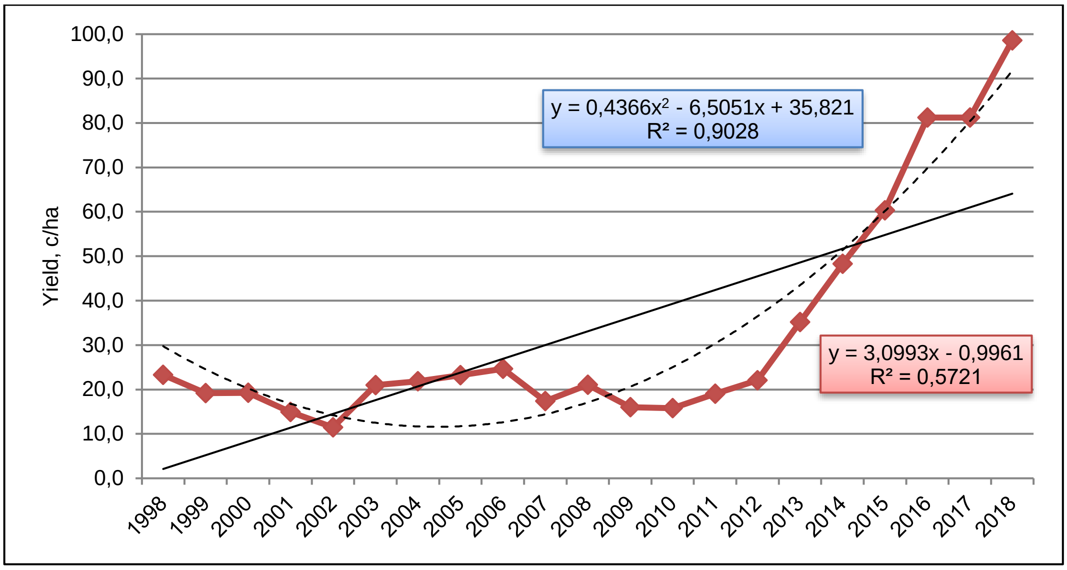

Figure 4. Dynamics of the four-year moving average of fruit yield in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for 1998-2018

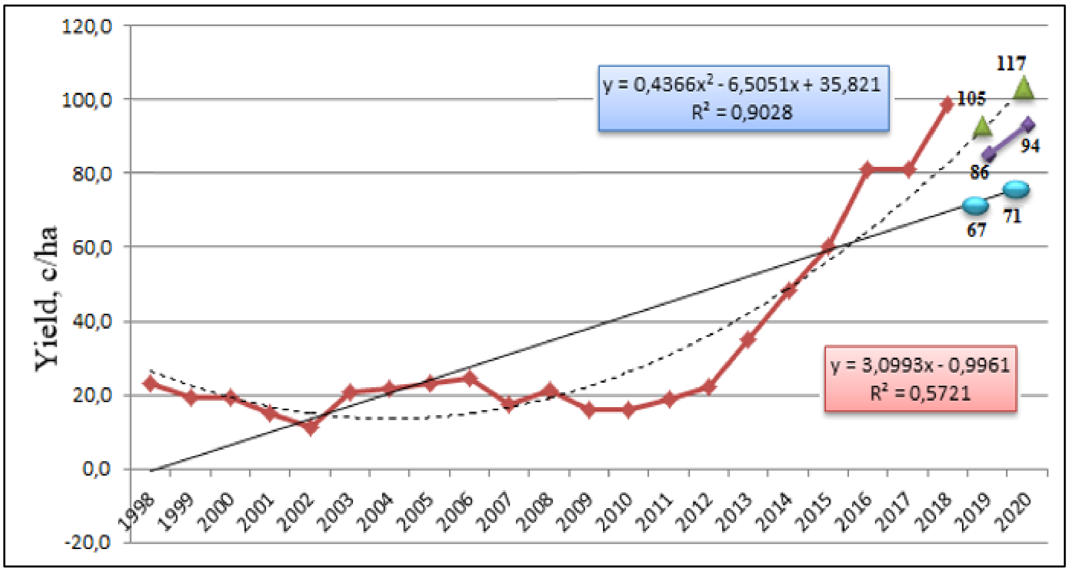

Figure 5. Forecast indicators of fruit yield in agricultural enterprises of the Autonomous Territorial Unit of Gagauzia for 2019-2020

To employ the graph-analytical method of forecasting, the graph should display two types of trends: linear and polynomial, along with the equations and coefficients of approximation for each. It's known that the polynomial trend better reflects the upward trend of indicators due to its higher coefficient of approximation. In this trend, fluctuations in the indicator are smoother, the approximation coefficients are significantly higher, thus the equations more objectively reflect the trend, resulting in a more accurate forecast based on this graph (Altukhov, 2016).

As the indicators from the two trend lines (linear and polynomial) differ, the average values are taken as predictive. Therefore, for forecasting indicators for the next two years (2019 and 2020), we utilize both polynomial and linear trends.

Conflict of interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

References

Altukhov, A. I. (2016). Improvement of the Organizational-Economic Mechanism for Sustainable Development of Agro-industrial Production. *Economics of Agricultural and Processing Enterprises, 7*, 2-11.

Anonymous (1994). *Law on the Special Legal Status of Gagauzia (Gagauz Yeri)*. No:344-XIII dated 23.12.1994.

Anonymous (2023a). Data from the Department of Agriculture, Environment, and Agribusiness of the Autonomous Territorial Unit of Gagauzia.

Anonymous (2023b). Data from the Main Department of Agriculture of the Autonomous Territorial Unit of Gagauzia.

Bajura, T., Stratan, A., & et al. (2018). *Ghidpractic (Culegere de materiale informative) "Tarife de costuriînagricultură"*. INCE. (in Romanian)

Curaxina S.S. (2015) *Main Directions for Exiting the crisis of the agricultural sector of the Autonomous Territorial Unit of Gagauzia: Monograph*. Comrat State University, Research Center "Progress".

Doga, V., & Bajura, T. (2016). Strategia de Dezvoltare a Sectorului Agroalimentar in Perioada Anilor 2006–2015. *Economie si Deyvoltare Rurala Imdrp, 24*, 74. (in Romanian)

Parmakli D., & Todorich L. (2013). *Problems of economic sustainability of agricultural enterprises in the Republic of Moldova (Monograph)*. Self-published.

Parmakli, D. M. (2016) Methodology for Grading Crop Yield Levels and Efficiency Zones in Crop Production. *Agriculture: Economics, Management, 3*, 86-91.

Parmakli, D. M., Todorich, L. P., Dudoglo, T. D., Curaxina, S. S., & Yaniglo, A. I. (2017). *Land productivity in agriculture: Monograph*. Comrat State University, Research Center "Progress".

Siptits, S. (2017). Methods of Designing Efficient and Sustainable Options for Agricultural Production Placement. *International Agricultural Journal, 6*, 56-59. (in Russian)

Timofti, E., & Popa, D. (2009). *Eficienţamecanismului economic însectorulagrar: Monografie*. Chişinău: Complexul Editorial al IEFS. (in Romanian)

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A review analysis of the degradation of cork oak forests in North Atlantic, Morocco

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Abstract

Like Mediterranean forests, Morocco's forest formations are highly diverse and comprise many species. Among the noble species, the cork oak (*Quercus suber* L.) is important in the Moroccan forest landscape. However, anthropogenic and natural pressures have almost completely degraded cork oak ecosystems. This study was conducted on the Maamora cork oak forest in north-west Morocco. The methodology adopted was based on a bibliographic review, GIS cartographic and teledetection analysis of the forest area, in order to assess the state of degradation of the forest areas and their evolution and to investigate the causes about anthropic pressure and the climate change factor. Progressive degradation results from a combination of climatic and anthropogenic factors that continue to intensify. The lack of natural regeneration is one of the most worrying problems, requiring advanced reforestation and sustainable development.

Keywords: Anthropogenic pressure, Maamora, Morocco, *Quercus suber*, Regeneration

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1. Introduction

Cork oak (*Quercus suber* L.) is an endemic species in the Mediterranean bioclimatic zone, especially on the Atlantic coasts of Morocco, Portugal, Spain, southwestern France, and the Bay of Biscay. Its distribution has been greatly reduced primarily due to human activities but also because of significant historical variations in climatic conditions (De Sousa et al., 2008).

In Morocco, cork oak forests extend across the North-Western part of the country, from the coastal plains to the Central Rif and the Middle Atlas region. Cork oak, which covers an area of almost 384200 ha, is a remarkable species, given its ecological and socio-economic roles. Unfortunately, the area covered by cork oak continues to decline under the influence of anthropogenic degradation, as well as damage caused by several insect pests, including Lepidoptera, and climate change. All these factors essentially threaten the world's most extensive lowland Cork oak forest (Maamora forest) with inevitable disappearance in the near future (Laaribya et al., 2021).

The study area was carried out in the Maamora cork oak forest, the largest lowland cork oak forest in the world, covering an area of 133000 ha, including 64000 ha of pure cork oak. On the one hand, it is a major recreational area for the population of the major urban agglomerations (Rabat, Salé, Khémisset, and Kénitra), and on the other, the primary source of income for a user population of around 300000 (Laaribya et al., 2014). This forest has been the subject of several development plans and research and development programs, but it does not enjoy its rightful place in the national forestry plan. Despite the efforts made by the public authorities to safeguard and conserve this forest, its degradation continues to cause concern.

2. Material and Methods

2.1. General characteristics of the study area

The roles played by this forest go beyond the tripolar framework recognized for other Moroccan forest areas. We are witnessing a significant heterogeneity in the demand for forest products, with intra- and extra-forest

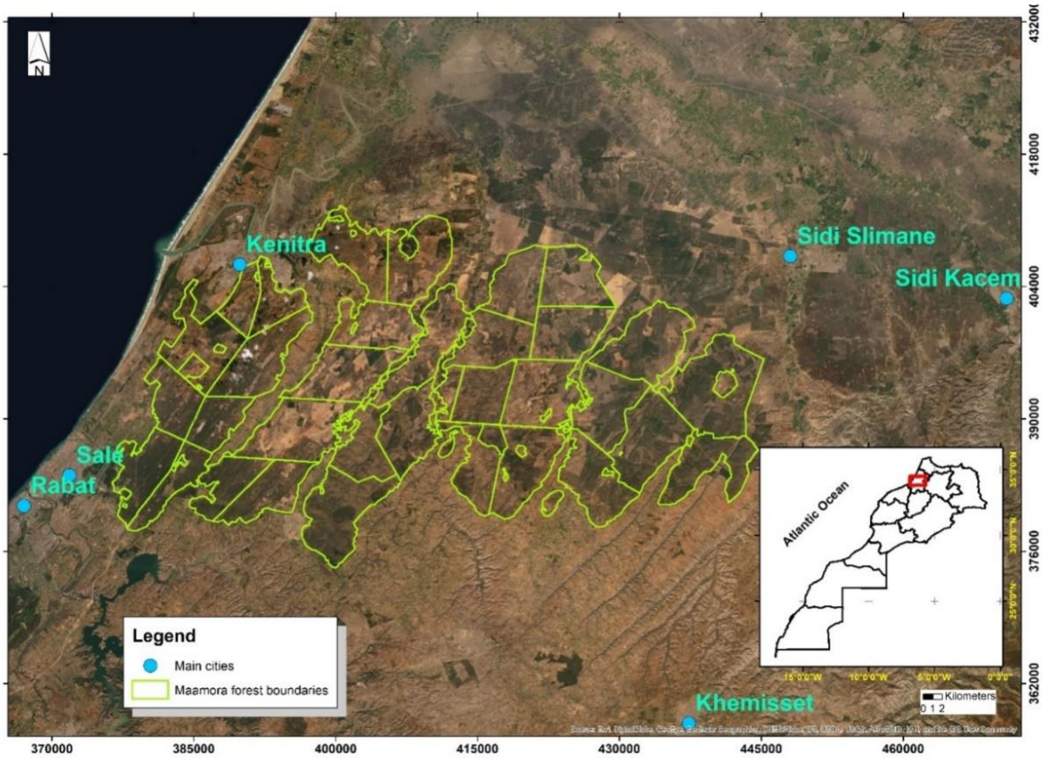

Figure 1. Cork oak forest study area

pressure suffocating this important cork oak area. Figure 1 shows the study area (Maamora forest in Morocco).

The Maamora Forest is situated in the northwest of Morocco close to the Atlantic Ocean, between 6° and 6°45′ W, and 34° and 34°20′ N. The forest occupies a sub-humid bioclimatic zone in its western part and a semi-arid zone in its central and eastern part (Figure 1). In terms of its social role, the Maamora forest is a source of income for the local population, which raises extensive livestock and harvests firewood, acorns and mushrooms. The forest's economic role is illustrated by the revenue it generates from selling forest products (wood and cork), estimated at several hundred million Dirhams per year, which is paid into the coffers of the user rural communities. In addition to its contribution to maintaining the region's ecological and biological balance, the Maamora represents a recreational area for an urban population of over two million. The distribution of the studied cork forests among porvinces are given in Table 1.

Table 1. Distribution of the study area forests

Provinces	Number of rural communes	Forest area (ha)	%
Kénitra	5	35 704	27
Sidi Slimane	3	28 006	21
Kémisset	7	54 516	42
Salé	3	13 533	10

The local population highly values the Maamora cork oak for the diversity of its products. In addition to cork and wood, the cork oak produces non-timber forest products (NTFPs), including acorns, and has abundant foliage, much appreciated by livestock, particularly during famine (Laaribya, 2023). The shrub-based undergrowth provides a haven for wildlife. For forage production, the undergrowth of the Maamora cork oak is renowned for its wealth of pastoral plants (grasses and legumes). Fodder production is enriched by acorns, consumed by humans, livestock and game, and branches harvested directly by herders during periods of drought and dearth.

In addition, the forest area produces quality mushrooms, in particular truffles, sweet acorns for human consumption, lichens, honey, aromatic and medicinal plants (Laaribya et al., 2022), and attract many small and big game hunters.

Estimates of non-timber forest products in the Maamora forest:

- Truffles: 85 tons/year,
- Other mushrooms, lichens: 30 tons/year,
- Medicinal plants and tannin: 5000 tons/year,
- Honey: 1000 tons/year,
- Forage production: 24 million forage units/year for 250000 head of sheep and cattle (75% of the area's livestock needs),
- Cork oak acorns: 3000 tons of sweet acorns,
- Cork: 6000 tons (47% of national production),
- Acacia flowers: 400000 tons/year.

Indicators for wood-based forest products are as follows:

- Industrial wood: 300000 m^3 (85% of national production), mainly eucalyptus for pulp,
- Fuelwood: 600000 m^3/year (87% of the area's needs),
- The jobs generated in rural areas for both non-timber and timber forest products amount to 300000 working days per year.

These products are mobilized mainly by (1) forestry companies, (2) timber harvesters, and (3) forestry cooperatives.

2.2. Approach and data used

The approach adopted was based on a bibliographic review, GIS cartographic and teledetection to analyse and estimate cork oak forest area for a period from 1986 to 2016 from a comparison of the state of the most recent forest cover and its reference state. The method used is based on the comparison of two digital forest map files from the National Forest Inventory and that compiled in this study from the most recent aerial photography (IFN, 2005, 2020). A detailed diagnosis was carried out with all the stakeholders concerned by the problem of degradation in the area. These stakeholders are as follows: Foresters, local populations, associations and cooperatives, NGOs, local management administrations, and scientific researchers. The results of my work in the study area were also used as a basis for the diagnosis (Laaribya, 2006; Laaribya et al., 2014; Alaoui et al., 2020; Laaribya et al., 2021; Laaribya et al., 2022).

3. Results and Discussion

The main factors of degradation of this forest are linked to chronic human pressure in Maamora. This pressure has resulted in deterioration and increasing degradation of the cork oak forest, including:

- Recurrent droughts: The droughts of recent decades have had a negative impact on Maamora's forest stands, which have become fragile. Indeed, the drought of recent years, the irregularity of rainfall, and its chronic deficit, combined with their effects and those of the nature of the Maamora's sandy soil, further aggravate the situation. Most areas with currently suitable conditions for *Quercus suber* were located in the western and central Maamora Forest regions, which enjoy a humid bioclimate and receive significant sea-spray from the Atlantic Ocean. Moving away from the ocean, the humidity decreases, and the temperature increases, so cork oak has difficulty adapting and regenerating (Laaribya et al., 2021). The maximum-entropy algorithm (MaxEnt) was applied to predict the current and potential distribution of cork oak in the Maarmora Forest (Figure 2). Indeed, it was used field-based spatial records of cork oak locations, altitude, and bioclimatic environmental variables to model this potential distribution of the cork oak under climate change. Figure 2 shows the MaxEnt model's representation of suitable/unsuitable potential future areas for cork oak distribution. Green colours show areas with predicted moderate- and good- conditions.

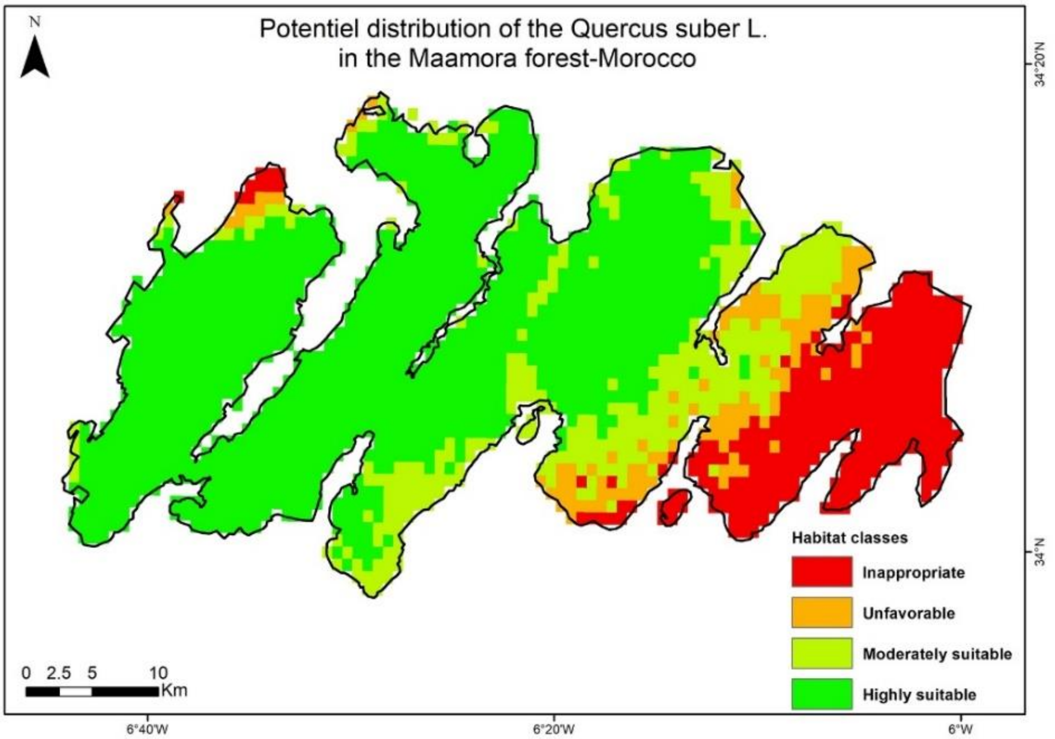

Figure 2. Potential distribution of the cork oak in the study area (Laaribya et al., 2021)

- The regression of the cork oak area: The history of this forest reminds us that the problem of its reconstitution and the regeneration of the cork oak is not new. It goes back to the beginning of the century. Indeed, the absence of natural regeneration led the Forestry Administration between 1920 and 1951 to undertake a vast cork oak rejuvenation program by recutting a large part of the forest. Faced with this situation, the Administration paid particular attention to this cork oak forest, implementing three management plans in 1952, 1972, and 1992. The inventory carried out in the Maamora forest showed that the area under cork oak decreased by around 35% between 1952 and 2016 (Figure 3).

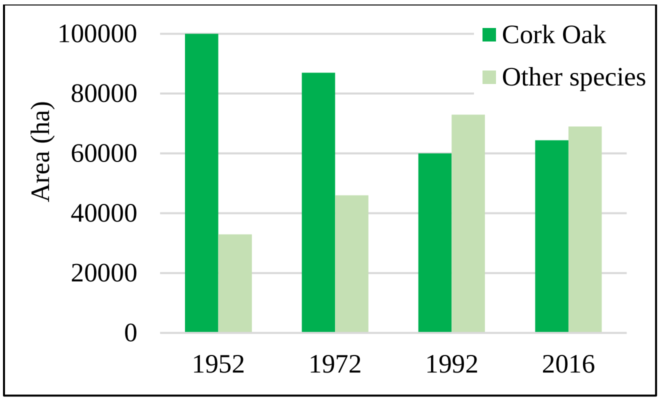

Figure 3. Evolution of cork oak forest area

- Age class imbalance: In addition to the damage caused by dieback, age class imbalance is very apparent, giving the cork oak forest the appearance of aged trees. Over and above the ecological and densitometric imbalance associated with this condition, the economic consequences are likely to be disastrous in the medium term. In the concise term, considerable areas of cork oak will have to be regenerated (over 2000 hectares/year) (Laaribya, 2006). Attempts have been made to regenerate the cork oak forest (Figure 4). Several studies have shown that climate change and reduced germination capacity affect the preservation and regeneration of cork oak (Laaribya 2006; Alaoui et al., 2020). The current challenge is to restore this cork oak ecosystem and confront the problems of tree mortality, lack of regeneration, and the effects of climate change (Laaribya et al., 2014; Oubrahim et al., 2015; Alaoui et al., 2020).

- Demographic growth: which has increased the number of users and thus the pressure on the forest. In fact, since 1971, the number of local residents has risen from 212000 to over 470000. This is one of the reasons for the explosion in forest harvesting. In addition, population growth, the accelerated settlement of populations in the enclaves and on the edge of the forest, and the transformation of the modes of exploitation of the spaces of pastoral societies to sedentary human groups have accelerated the phenomenon of degradation through clearing of land, fire, grazing and cutting of trees.

Figure 4. Cork oak regeneration patch (by Laaribya, April 2021)

- Deliberate harvesting of forest products: This is almost universal and is practiced by most households. All of the population's needs for forest products are met from this forest, which is a significant drain on existing capital. Other illegal harvests are intended for sale to meet the needs of local households.

- Acorn harvesting: Most households harvest acorns for livestock feed or for sale for human consumption, as the Maamora acorns are of the sweet “balata” variety (Figure 5). This harvest, which is close to the forest’s total production, is often sold along main roads, towns, and souks. Local residents and their livestock consume the rest. The early harvesting of acorns causes injuries and promotes decay.

Figure 5. Acorns (sweet fruit) of cork oak (by Laaribya, October 2021)

- Overgrazing: The livestock grazing in the forest, made up of sheep (200000 head) and cattle (50000 head), stays in the forest all year round (Table 2). The pastoral load likely to be borne by the forest is excessive. The presence of these livestock, often in association with non-users, prevents any possibility of natural regeneration by compacting the soil, consuming acorns, and browsing the few seedlings that have managed to germinate. The overgrazing coefficient for the cork oak species was calculated at 78% in the Maamora forest (Laaribya et al., 2014). There is a worrying disproportion between the pastoral possibilities under cork oak forest and the actual load to which it is subjected.

Table 2. Herd forage calendar in the Maamora forest

Livestock	September	October	November	December	January	February	March	April	May	June	July	August
Cattle	FP	F	FP	FS	FS	FSP	FP	F	F	FSt	StP	PS
Sheep	F	F	F	FS	FS	FP	FP	FP	F	FSt	FSt	FSt
Goats	St	F	FP	FP	FP	FP	FP	P	FStP	St	St	St

F: Forest, P: Pasture, S: Supplementation, St: Stubble

- Deadheading and delimbing: The practice of deadheading and delimbing to feed livestock during periods of hunger and famine affects more than 1/3 of the trees. In times of drought, this practice is widespread throughout the forest. These anarchic practices cause injury, physiological stress, and predispose stands to parasitic attack, leading inevitably to dieback and death (Figure 6).

Figure 6. Collecting wood in cork oak forest (by Laaribya, March 2021)

- Cork harvesting: The harvesting of cork by unskilled workers leads to injuries that weaken the trees and cause them to wither.

- Public infrastructures and urbanization: Due to its proximity to major urban areas, the Maamora forest is considered a land reserve, quickly mobilized to meet the expansion needs of these towns and villages. For example, the Rabat-Tangier freeway cut through much of the forest.

- Lack of supervision of users: Cattle grazing in the Maamora is carried out without any load limitation. Safeguarding this subalpine forest requires the management and organization of users, as stipulated by law.

4. Conclusion

Let's look at the history of this forest. We can see that the problem of degradation of the cork oak goes back a long way, particularly in terms of regeneration, reconstitution. Over the decades, the forest has undergone a regressive evolution due to constraints that have constantly evolved in line with the socio-economic development of neighbouring regions and the evolution of local practices in the forest area.

Although the cork oak species is a source of income for rural people and an essential role in ecological processes, there is population fragmentation and a reduction in its natural distribution areas due to long-term overgrazing and utilization, fire, low germination-regeneration problems, and climate change.

The development of the cork oak forests in the North Atlantic cannot be considered in isolation from its socio-economic environment, which is a fundamental support for local development and biodiversity in the region. Moreover, man is a crucial factor in any development program.

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Conflict of interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

References

Alaoui, A., Laaribya, S., & Ayan, S. (2020). The Evolution of the Forest Cover with the Effect of Anthropic Pressure (The Case Study of Sehoul Cork-Oak Forest in Morocco, North Atlantic). *Kastamonu University Journal of Forestry Faculty*, *20*(1), 62-73. https://doi.org/10.17475/kastorman.705872

De Sousa, E., El Antry, S., Atay Kadiri, Z., & Abourouh, M. (2008). Problematique des Suberaies Dans le Bassin Mediterraneen. *Annales de la Recherche Forestière au Maroc*, *39*, 63-73. (in French)

IFN (2005). Données de l'Inventaire Forestier National. Haut-Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification. (in French)

IFN (2020). Données de l'Inventaire Forestier National. Haut-Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification. (in French)

Laaribya, S. (2006). Il Faut Sauver la Forêt de la Maamora (Maroc). *Revue de la Forêt Méditerranéenne*, *27*(1), 65-72. (In French)

Laaribya, S., Alaoui, A., Gmira, N., & Gmira, N. (2014). Contribution à l'Evaluation de la Pression Pastorale Dans la Forêt de la Maamora. Parcours Forestiers et Surpaturage. *Nature et Technologie C- Sciences de l'Environnement*, *10*, 39-50. (In French)

Laaribya, S., Alaoui, A., Ayan, S., Benabou, A., Labbaci, A., Ouhaddou, H., & Bijou, M. (2021). Prediction by Maximum Entropy of Potential Habitat of the Cork Oak (*Quercus suber* L.) in Maamora Forest, Morocco. *Forestist*, *71*(2), 63-69. https://doi.org/10.5152/forestist.2021.20059

Laaribya, S., Alaoui, A., & Azmi, R. (2022). Contribution to the Identification of Medicinal Plants Used Against COVID-19 in North-West Morocco. *Regulatory Mechanisms in Biosystems*, *13*(4), 339-345. https://doi.org/10.15421/022244

Laaribya, S. (2023). Analysis of the Non-Wood Forest Products Sector in Morocco-Case Study: The Itzer Forest. *SilvaWorld*, *2*(2), 75-82. https://doi.org/10.61326/silvaworld.v2i2.5

Oubrahim, H., Boulmane, M., Bakker, M. R., Augusto, L., & Halim, M. (2015). Carbon Storage in Degraded Cork Oak (*Quercus suber*) Forests on Flat Lowlands in Morocco. *iForest*, *9*, 125-137. https://doi.org/10.3832/ifor1364-008

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Book:

Husch, B., Beers, T. W., & Kershaw, J. A. (2003). *Forest mensuration* (4th ed.). Wiley.

Chapter in an edited book:

Köhl, M. (2004). Forest inventory and monitoring. In J. Burley, J. Evans, & J. A. Youngquist (Eds.), *Encyclopedia of Forest Science* (pp. 403-409). Elsevier.

Conference Presentation or Proceeding:

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Dissertation or Thesis:

Saglam, F. (2016). *Constructing of above-ground biomass tables and developing of compatible biomass-volume equations for black pine (Pinus nigra J.F. Arnold) stands in Taskopru Forest Enterprise* [Master's thesis, Kastamonu University].

Web:

General Directorate of Forestry (2013). Forest atlas. https://www.ogm.gov.tr

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