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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

**STUDY OF AGROBIOLOGICAL CHARACTERISTICS OF
COMMON LENTIL (*LENS CULINARIS* MEDİK.) CULTIVAR
SAMPLES IN ABSHERON CONDITIONS AND THEIR USE
IN BREEDING**

Specialty: **3103.4 - Breeding and seed production**

Field of science: **Agricultural sciences**

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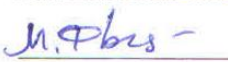
The dissertation work was carried out in 2018-2021 at the Plant Breeding Department of the Agricultural Research Institute of the Ministry of Agriculture of the Republic of Azerbaijan, the Absheron Auxiliary Experimental Farm, and the Jalilabad Regional Experimental Stations.

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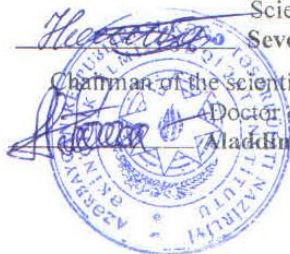
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INTRODUCTION

The actuality and degree of using of the topic. As is known, by the Decree No. 3378 of the President of the Republic of Azerbaijan dated July 22, 2022, the “Socio-Economic Development Strategy of the Republic of Azerbaijan for 2022–2026” was approved. According to Clause 2 of this Strategy, in 2022–2026, the new socio-economic development model will determine a new qualitative level of multisectoral development in Azerbaijan, and at this stage, the main objective has been set as the restoration of high, sustainable, and inclusive economic growth rates, thereby ensuring a stable standard of living for every citizen of the Republic of Azerbaijan.

One of the issues of great importance in achieving the mentioned goals is ensuring the country’s food security. The food security of the country, being an integral part of its economic and national security, is one of the priority directions of state policy.

The collection, multiplication, and inclusion into collections of cultivars, forms, and hybrids of local grain-legume crops widely spread across different regions of the Republic and with high genetic potential, their comprehensive study, and the selection of forms with economically valuable traits to create a source material bank and trait collections for future breeding work are of great importance.

Increasing the production of grain-legume crops which are rich in protein and consumed daily as food by humans is of vital importance. Since ancient times, the Azerbaijani people have used grain-legume products such as chickpeas, lentils, and beans as quality food products. The grains of these crops contain amino acids, fatty acids, vitamins, sugars, and other substances essential for the healthy development of the human body. In rainfed farming, these crops are considered irreplaceable predecessors.

Lentil is primarily a food crop. In terms of protein content, it is second only to soybean. The importance of lentil in the food industry is very high. It is used in the production of coffee, cocoa, confectionery, biscuits, sausages, etc. At the same time, lentil is a valuable predecessor crop. It accumulates free nitrogen from the air in its roots, enriching the soil with nitrogen both for itself and for

subsequent crops, making it a heat-loving plant. Currently, in the world, lentil (*Lens culinaris Medik.*) is the third most produced legume after chickpea (*Cicer arietinum L.*) and pea¹ (*Pisum sativum L.*).

Globally, lentil is highly valued both as a food and feed crop². Taking into account the unfavorable soil-climatic conditions of the Absheron region, creating optimal conditions to increase the yield and quality indicators of the lentil crop, studying the adaptability of appropriate cultivars, and identifying genotypes with high agrobiological characteristics are among the topical issues.

The object and subject of the research. The object of the research is local and introduced (ICARDA) accessions of common lentil (*Lens culinaris Medik.*). The subject of the research is the study of the agrobiological characteristics of these cultivars and their use in breeding.

The purpose and objectives of the research. The main purpose of this dissertation is to identify, among the local and introduced (ICARDA) accessions of common lentil (*Lens culinaris Medik.*), one of the most widely cultivated and consumed food legumes in Azerbaijan, the genotypes with high economic performance, physiological resistance to environmental stress factors, and promising quantitative and qualitative traits by comparatively studying their agrobiological characteristics in two regions (Absheron Peninsula and Jalilabad region), and to select source material for use in breeding-oriented research.

In order to achieve the tasks set within the research, the following main objectives were identified:

- Conducting phenological observations of the common lentil plant;

¹ Timoshenkova, T.A., Mukhitov, L.A. The state and specific features of seed production of cereal crops under the conditions of the Orenburg Pre-Urals steppe // Izvestiya of the Orenburg State Agrarian University, Orenburg: 2017. No. 3(65), pp. 8–11.

² Zamanov, P.B. Efficiency of the use of organic waste for soil fertility and productivity in the agriculture of Azerbaijan // Baku, 2001. pp. 34–35.

- Determining the influence of research years on the structural elements of yield and quality indicators;
- Analysis of lentil plant infection with diseases and its effect on productivity;
- Studying the effect of genotype on yield components and quality traits;
- Comparative study of yield components and quality indicators of common lentil genotypes cultivated in different regions;
- Conducting electrophoretic analysis of storage proteins in common lentil samples.

Research methods. Crop management practices for lentil were carried out in accordance with the agro-rules adopted for grain-legume crops in the region.

To assess the importance of existing plant cultivars in breeding, structural analysis of plants was conducted. Quantitative and qualitative analyses in lentil were determined based on the methods used in this field.

Phytopathological assessment of fungal diseases in lentil under field conditions was carried out using a 9-point scale according to the methodology proposed by ICARDA³.

Globulin reserve proteins electrophoresis in polyacrylamide gel (A-PAGE) was performed based on the methodology of Poperelya and collaborators⁴.

Cluster analysis of storage proteins was carried out based on Nei's genetic distance index using the computer program PowerMarker V3.25, and the dendrogram was constructed using the TreeView program.

Mathematical calculations were performed using the SPSS 16 software.

Main provisions submitted for defense:

1. The agrobiological characteristics, phenological observations, and yield structure indicators of local and introduced

³ Jafarov, I.H. Agricultural Phytopathology // Baku, Sharq-Qarb, 2012, p. 566.

⁴ Poperelya, F.A. Polymorphism of gliadin and its relation to grain quality, productivity, and adaptive properties of soft winter wheat cultivars. Moscow: "Agropromizdat", 1989, pp. 138–149.

lentil samples cultivated in the Absheron Peninsula and the Mughan region were comparatively studied for use in breeding programs;

2. Economically valuable traits of lentil plants were investigated from a genetic perspective, and the genetic features recommended for use in breeding were studied;

3. Local cultivars, introduced accessions, and hybrid materials were tested in different ecological regions, and high-yielding, high-quality, complex-resistant cultivars were identified and found suitable for use as initial material in hybridization programs;

4. Based on the study of the quality indicators of lentil cultivars and accessions cultivated in the Absheron Auxiliary Experimental Farm and the Jalilabad Regional Experimental Station, genotypes were grouped, and adaptive and relatively plastic accessions suitable for the soil-climatic conditions of the regions were selected.

Scientific novelty of the research. In 16 lentil accessions cultivated under different soil-climatic conditions, their agrobiological characteristics, phenology, productivity, and biochemical parameters of promising cultivars, accessions, and hybrid forms were determined according to modern methodologies, methodological guidelines, and instructions. The physical, biochemical, technological, and genetic characteristics of grain quality were established, and recommendations were provided for farms. For the first time, polymorphism was determined by electrophoretic analysis in 14 lentil samples (16 accessions in total, including the standard cultivars Jasmin and Zafar).

During the research, among common lentil (*Lens culinaris Medik.*) cultivars and accessions, samples adapted to the soil-climatic conditions of the studied regions and relatively plastic forms were identified for conducting breeding studies.

Theoretical and practical significance of the research. The results of the study are of scientific and practical importance as initial material in breeding research aimed at creating new high-yielding, high-quality, and disease-resistant lentil cultivars and hybrids. On the other hand, the selected lentil cultivars will ensure high productivity,

thereby contributing to the improvement of farmers' material-technical base and increasing their income.

The approbation and application of the work. The results of the research were discussed at the III Republican Scientific-Practical Conference “Perspectives of the Development of Food and Textile industry in our Republic and the Tasks Ahead” (Azerbaijan State University of Economics, Baku, 21.05.2019); The IX International Scientific Conference “Innovative Approaches in Modern Biology” dedicated to the 100th anniversary of Baku State University (Baku, 24–25.05.2019); The XII International Scientific Conference “Technique and Technology of Food Production” (Mogilev, 23–24.03.2020); The Conference “Modern Problems of Genetics and Biotechnology and Biochemistry of Agricultural Crops” at the National Agrarian Academy of Ukraine (Ukraine, 21.10.2020); The International Conference at Azerbaijan State University of Economics (Baku, 26–29.10.2022); The International Conference of Young Researchers and Students “Achievements of Young Scientists in Solving Food Problems of the 21st Century” at the National University of Food Technologies (Kyiv, Ukraine, 25.10.2022); The International Scientific Symposium “Achievements and Prospects of Advanced Biotechnology” (Moldova, 03–04.10.2022); The Scientific-Practical Conference “Food Products and Their Packaging” (Kyiv, Ukraine, April–May 2022); The International Conference of Young Researchers and Students “Achievements of Young Scientists in Solving Food Problems of the 21st Century” (Kyiv, Ukraine, 03.04.2023); The VIII International Conference in the United Kingdom (Manchester, 10–11.10.2023); The Scientific Seminar of the Research Institute of Crop Husbandry, Ministry of Agriculture of the Republic of Azerbaijan (24 June 2025).

Based on the results of the research, 21 scientific works reflecting the main provisions of the dissertation were published, including 10 articles and 11 conference papers.

Institution where the dissertation was conducted. The dissertation was conducted at the Plant Breeding Department of the Research Institute of Crop Husbandry of the Ministry of Agriculture of the Republic of Azerbaijan, at the Absheron Auxiliary

Experimental Farm, and at the Jalilabad Regional Experimental Station.

The total volume of the dissertation with a sign indicating the volume of the structural sections of the dissertation separately. The dissertation consists of an introduction, four chapters, conclusions, recommendations, a list of 200 references. It includes 20 tables and 22 figures and 27 pages of appendices.

The structure of the dissertation is as follows: title and table of contents 3 pages (4323 characters), the introduction in the content of the dissertation is 16 pages (30804 characters), Chapter I is 32 pages long (58790 characters), Chapter II is 14 pages long (22401 characters), Chapter III is 48 pages long (72334 characters), Chapter IV is 17 pages long (29720 characters), Conclusions are 1 pages long (1717 characters), Recommendations are 1 page long (688 characters), References are 20 pages (32602 characters). The total text (excluding figures, tables, references, and appendices) amounts to 112 pages of computer print or 201909 characters.

MAIN CONTENT OF THE STUDY

The introduction presents the relevance of the topic and the general characteristics of the dissertation.

Chapter I. LITERATURE REVIEW

In this chapter, the origin, distribution, and systematics of lentil, its breeding, productivity, weeds, pests, and control methods are studied with reference to scientific research conducted both in the Republic and abroad.

Chapter II. CONDITIONS, MATERIAL AND METHODOLOGY OF THE RESEARCH

The research work was carried out during 2018–2021 at the Absheron AEF of the Research Institute of Crop Husbandry and at the Jalilabad RFS. Considering the specificity of the topic, regions with different stress factors were selected for the study.

The average annual air temperature in the Absheron Peninsula is 22-23°C. Based on long-term indicators, the average temperature in Absheron in January is 3,8°C, and in July 27,8°C, which does not significantly differ from multi-year averages.

The irrigated gray-brown soils of the Absheron Peninsula, where the research was conducted, vary in granulometric composition, being mainly clayey. The pH is close to neutral, fluctuating between 6,98 and 7,08.

This chapter also discusses a brief description of the soil and climatic conditions of the Mughan region. The territory of the Jalilabad region consists of plains and low mountains, in the eastern part some areas lie below sea level. Jalilabad, located in the southern part of Mughan, belongs to the central desert climatic zone, with hot and dry summers and mild winters. The average long-term annual temperature in Southern Mughan is 14,0°C. The highest average monthly temperature is observed in July (30,1°C), while the lowest is in January (-2,5°C).

The soils of the region are alluvial-meadow, chestnut, brown mountain-forest, etc. In the arable layer of the experimental field, the total humus content is 2,07-2,91%, nitrogen content is 0,14-0,16% per kg of soil, decreasing with soil depth. The total phosphorus content in the arable layer is 0,12-0,14%, while potassium varies between 2,96-3,03%.

As research material, in addition to the lentil cultivars *Jasmin* and *Zafar*, eight introduced accessions (LIEN-LS-17(1), LIEN-LS-17(8), LIEN-LS-17(9), LICTN-17(16), LIEN-LS-17(18), LIEN-MH-17(19), LIEN-MH-17(28), LIEN-LS-17(34)) and six hybrid samples (6002/LRIL18-50/9-6, 6002/LRIL18-50/34-2, 6002/LRIL18-50/33, 6002/LRIL18-50/11-7, X2011 S 63-18, “X2013-119-14”) were included in the study. The sample X2011 S 63-18 belongs to *microsperma* (small-seeded) lentils.

Crop management practices for lentil were carried out in accordance with the agrotechnical rules adopted for grain-legume crops in the region⁵.

⁵ Musayev, A.C., Mahmudov, F.M., Khudayev, F.A. [et al.]. Some conclusions on the breeding of autumn soft wheat studied under non-irrigated rainfed conditions in various nurseries and comparative variety trials // Collection of Scientific Works of the Azerbaijan Research Institute of Crop Husbandry, Baku, 2014, Vol. 25, pp. 33–37

Methodology of the research. To study the importance of existing cultivars in breeding, structural analysis of plants was conducted. Biochemical analyses: The nitrogen content was determined using the modified Kjeldahl micromethod with the Kjeltec™ 8200 device produced by FOSS⁶. To calculate the protein content, the conversion factor ($N \times 6.25$) was used.

Determination of the oil content of lentil extract, the amount of oil in the grain and other organs of plants is based on the Soxhlet method, dissolving it in various solvents (ethyl ether, petroleum ether, gasoline, benzene, chloroform, etc.) and weighing the mass.

The amount of starch was determined by the "Evers" method by converting starch to sugar through hydrolysis under the influence of hydrochloric acid⁷.

The moisture content was determined according to the accepted methodology. A certain amount of grain is ground into flour and its mass is determined by weighing it. Then it is dried in a drying cabinet at a temperature of 100-105⁰C for 3-4 hours. After drying, it is weighed again until it reaches a constant weight and the mass is calculated as a percentage.

Phytopathological assessment of fungal diseases in lentil plants in field conditions is carried out using a 9-point scale using the methodology proposed by ICARDA.

Electrophoresis analysis of reserve proteins Globulin electrophoresis was performed on polyacrylamide gel (A-PAGE). After globulin is extracted from the grain, it is put into electrophoresis. After keeping for 5 hours, the electrophoregram is stained. The dye of the electrophoregram is a specially prepared coloring substance and is added to the gel and kept in a glass container for one day. The next day, the stained gel in the glass container must be washed with water for 3 days.

Cluster analysis of reserve proteins was constructed using the Power Marker V3.25 computer program based on the Nei genetic distance index, and the dendrogram was constructed using the Treeview program.

⁶ Pleshkov, B.P. Practical Course in Plant Biochemistry // Moscow: "Kolos", 1976, p. 252.

Mathematical calculations were performed using SPSS 16 computer software.

Chapter III. AGROBIOLOGY OF VARIETAL SAMPLES OF LENTIL PLANT AND STUDY OF PHENOLOGICAL OBSERVATIONS

3.1.1. Analysis of the phenological observations of lentil.

Based on the results of three years of phenological observations of the research material cultivated in Absheron, it was determined that in 2020, the Zafar variety started flowering on April 24, while the Jasmin variety flowered on April 18. Full maturity occurred on June 4, 2020 in Zafer and on May 27, 2020 in Jasmin.

The earliest flowering was observed in LIEN-MH-17(28) on April 17, 2020. Despite their early flowering, these samples did not always result in early maturity. Thus, of the early flowering specimens, only LIEN-MH-17(28) fully matured early in 2020 (27.05.2020).

It was determined that in 2020, compared to other years, more samples showed early maturity. Among them, Jasmin and LIEN-MH-17(28) matured on May 27, 2020, while three other samples (LIEN-MH-17(1), LIEN-MH-17(8), LIEN-MH-17(16)) reached full maturity on May 30, 2020. In 2021, two samples (LIEN-MH-17(8) and LICTN-17(16)) and LIEN-MH-17(34) matured early (on May 30 and May 31, respectively).

Although flowering in Zafar and Jasmin occurred on April 22 in 2019, full maturity was reached on June 5 (Zafar) and June 3 (Jasmin). In 2021, despite flowering on April 19, Zafar reached full maturity only on June 5.

As mentioned, the same samples were cultivated in the Jalilabad region. Comparison of the phenological observations showed that in 2020, the number of early flowering samples (LIEN-LS-17(1), LIEN-MH-17(28), 6002/LRIL18-50/9-6) was higher than in 2019 and 2021.

In this region, full ripening was observed in May only in the 6002/LRIL18-50|11-7 and X2013 -119-14 cultivars. In 2019, one sample (X2011 S 63-18) matured earliest on June 1. in 2020, two

samples (LIEN-LS-17(1) and LIEN-LS-17(28)) matured on June 1 and in 2021, the earliest maturing samples were 6002/LRIL18-50/33 and LIEN-MH-17(19), on June 2. The only introduced sample, LIEN-MH-17(19), displayed nearly identical flowering and maturity times under both conditions and in all three years (2019, 2020, and 2021), with very minor differences.

Jasmin and Zafar showed different flowering and maturity times in both regions, although the differences were minimal. Thus, conditions and years have had an effect, even if it is a little.

Thus, the varieties and varietal samples demonstrated different flowering and full maturity times depending on soil conditions and annual weather conditions that is, the difference was mostly slight and close results were observed in both regions. However, the influence of soil-climate conditions was minimal, while the effect of annual weather conditions was more pronounced.

3.1.2. Effect of cultivation years, region, and genotype on the height of lentil plant under Absheron and Jalilabad conditions. A three-year field analysis revealed differentiation of certain breeding traits among lentil samples. Analysis of plant height showed relative genotypic variability, which in turn provides opportunities for selecting samples suitable for breeding objectives.

Among the samples, X2011 S 63-18 (microsperma) showed low results in previous years (34,6 cm and 34,4 cm, respectively), but this increased to 38,3 cm in 2021.

Overall, there was no significant difference between the results of all three years, but the results of 2020 and 2021 are closer. Thus, while the annual average value was 39,5 cm in 2019, these results in 2020 and 2021 showed slightly higher and closer figures (40,3 cm and 40.4 cm, respectively) (Table 1).

Of the fourteen samples, nine had an average plant height of 40 cm or higher, with the highest average value recorded in LICTN-17(16) (44,539 cm).

In eight samples, the lowest plant height values were still relatively high, ranging from 40,6 to 44,3 cm. The differences among the average results were not large.

Table 1.

Variation table of the effect of cultivation years, region, and genotype factors on the plant height of common lentil (*Lens culinaris* Medic.) accessions

Source	Sum of squares SS	df	Mean Square MS	F	Sig. (P value)	Total squares value, %
Years of cultivation	7,621	2	3,811	100,238	0,000	54,4
Region	0,917	1	0,917	24,117	0,000	12,6
Genotype	2387,871	13	183,682	4831,729	0,000	99,7
Years *	0,627	2	0,313	8,246	0,000	8,9
Region						
Years *	105,120	26	4,043	106,352	0,000	94,3
Genotype						
Region *	352,464	13	27,113	713,193	0,000	98,2
Genotype						
Years *	103,579	26	3,984	104,793	0,000	94,2
Region *						
Genotype						
Error	6,387	168	0,038			
Sum	414834,700	252				

LICTN-17(16) also had the highest mean plant height (44,6 cm). This specimen has a relatively tall height, regardless of the year or regional factors, so it is appropriate to select and use it in future breeding based on its height. Among these samples, in addition to the LICTN-17(16) genotype, we can mention the samples 6002/LRIL18-50/33(44,428cm), 6002/LRIL18-50/34-2 (42,939 cm) and LIEN-MH-17(19) (42,978 cm).

The lowest value, 34,93 cm, once again belonged to the sample X2011 S 63-18. As seen from the table, the effect of region on plant height was 12,6%, while the effect of genotype was 99,7%.

Although genetics is the most important factor influencing plant height in lentils, environmental factors such as precipitation, length of the growing season, climatic conditions, and cultural practices (e.g., pest control measures) may positively or negatively influence plant growth. Therefore, when using plant height as a trait in lentil breeding, special attention should be paid to genotype selection.

3.1.3. The influence of cultivation years, region and genotype factors on the height of the first bean from the ground, one of the structural elements of lentil plant productivity in Absheron and Jalilabad conditions. In grain-legume breeding, studying the interaction between the plant and soil is of particular importance. This is because the agrochemical and physico-chemical properties of the soil play a crucial role in increasing yield and quality, both in the application of mineral and organic fertilizers and in the performance of other agrotechnical practices.

Studies have shown that the height of the first bean above the soil surface is average in autumn sowings. In spring sowings, these figures are relatively low, of course, the influence of weather and regional conditions must also be taken into account.

According to the results of our research, the average annual values of the first bean height from the ground for the samples cultivated in both regions over three years showed that, under Absheron conditions, LIEN-LS-17(1), LICTN-17(16), and 6002/LRIL18-50/33 demonstrated higher and more stable values. The LICTN-17(16) sample produced the highest results according to the height of the first bean from the ground: 22,4 cm in 2019, 22,5 cm in 2020, and 21,8 cm in 2021.

In Jalilabad conditions, the samples LIEN-LS-17(9), LICTN-17(16), LIEN-MH-17(19), 6002/LRIL18-50/33, and X2013-119-14 consistently exhibited the highest values for first bean height from the ground over three years.

The analysis revealed that the effect of cultivation years on the height of the first bean from the ground was determined to be 50,3%. Also, the significant effect of the region factor and the height of the first bean from the ground was 83,2%. The effect of the genotype factor on the height of the first bean from the ground was determined to be 98,1% (Table 2, Figure 1).

The height of the first bean from the ground of the samples cultivated in the Absheron region was approximately 1,2 cm higher than that of the samples cultivated in the Jalilabad region over three years.

Table 2.

Variation table of the effect of cultivation years, region, and genotype factors on the height of the first bean from the ground in lentil samples

variable: Height of the first bean from the ground						
Source	Sum of squares, SS	df	Mean square MS	F	Sig. (P value)	Total squares value, %
Yeras	18,554	2	9,277	84,856	0,000	50,3
Region	91,080	1	91,080	833,113	0,000	83,2
Genotype	966,784	13	74,368	680,245	0,000	98,1
Years * Region	8,146	2	4,073	37,256	0,000	30,7
Years * Genotype	57,238	26	2,201	20,137	0,000	75,7
Region * Genotype	237,930	13	18,302	167,411	0,000	92,8
Years *Region* Genotype	63,455	26	2,441	22,324	0,000	77,6
Error	18,367	168	0,109			
Sum	94654,750	252				
Editted sum	1461,555	251				
a. R Square = 0,987 (Corrected R square =0 ,981)						

Thus, while the average annual value of the samples was 20,26 cm in Absheron in 2019, this indicator was 18,95 cm in the Jalilabad region in the same year. In 2020, this indicator was 19,89 cm in Absheron, 18,31 cm in the Jalilabad region, and finally in 2021, it was 19,34 cm in the Absheron region, and 18,62 cm in Jalilabad.

The effect of cultivation years, region and genotype factors on the height of the first bean from the ground of lentil variety samples was studied. The genotype factor is the factor that most affects the height of the first bean from the ground. In general, the genotype factor occupies one of the first places in the selection of lentil plant breeding material.

As can be seen from the figure, the indicator for the height of the first bean from the ground over the years was stable in two samples, LIEN-LS-17(18) and 6002/LRIL18-50/34-2.

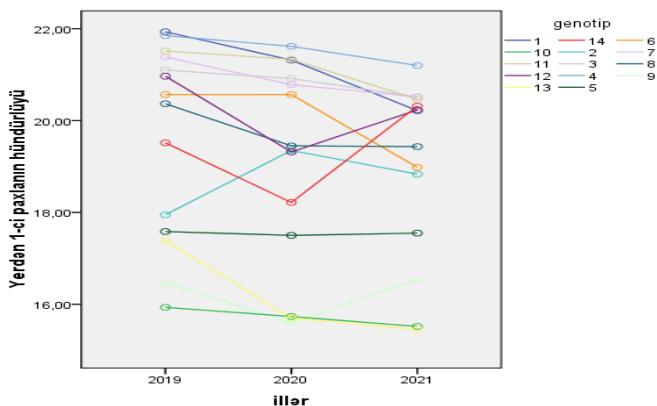


Figure 1. Effect of genotype factor on the height of the first bean from the ground by years

Thus, samples LIEN-LS-17(18) and 6002/LRIL18-50/34-2, which have a relatively stable height indicator of the first bean from the ground, were identified.

3.4. The influence of cultivation years, region and genotype factors on the number of beans, one of the structural elements of the yield of common lentil (*Lens culinaris Medic.*) cultivars. In modern times, leguminous plants are widely cultivated all over the world. These plant products are used both to meet the basic food needs of humans and to meet the feed base of livestock and poultry farming, and also as raw materials in industry.

As we know, one of the productivity elements of the lentil plant is the number of beans in the plant. The ratio of the number of beans was between 24 and 46, that is, the average limit was 34,9 units depending on the years and regions. It should be noted that the lowest limit was 34,903 units, and the highest was 34,975 units.

Among the samples selected in both regions in three years in terms of the number of beans, which is one of the structural elements of productivity, LIEN-LS-17(1) (average 40,8 pcs.), LIEN-LS-17(28) (average 40,0 pcs.) and 6002/LRIL-18-50/ 33 (average 41,4 pcs.) can be cited.

The results of the statistical analysis showed that the LIEN-MH-17(28) (43,500 pcs.) sample gave the highest average result in

terms of the number of beans over the years. The 6002/LRIL18-50|34-2 (26,500 pcs.) sample was distinguished by the lowest average value (Figure 2).

According to the results of statistical analyses, the effect of the year factor on the number of beans was determined to be 67,9%, and the significant effect of the genotype factor of the region was 99,8%.

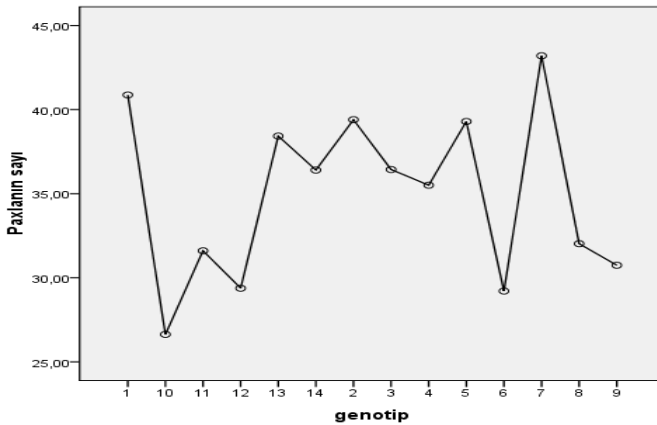


Figure 2. The effect of genotype factor on bean number indicator

3.5. Disease infection of lentil plants and the relationship between quality indicators of yield. In our research, the level of infection of lentil varieties and cultivars and the effect of ascochyta and fusarium root rot on yield were studied. The degree of infection also varied depending on the natural climatic conditions and the biological characteristics of the varieties. These diseases are widespread in years with high rainfall and relative humidity.

Thus, when comparing the 16 varieties and cultivars studied by year, the yield was relatively high in 2021 due to the low level of disease infection. In 2020, the yield was low due to the high level of disease infection of the samples compared to other years, which is explained by the fact that it depends on climatic conditions and the level of disease infection. The highest results in terms of disease resistance and productivity were obtained in both regions in samples LIEN-LS-17 (18), LIEN-MH-17(19), 6002/LRIL18-50|33,

6002/LRIL18-50|11-7. This is explained by the biological characteristics of the samples and their tolerance to diseases.

According to the results of the dendrogram consisting of three clusters under Absheron conditions, it is noticeable that while Zafar variety is located near more samples, Jasmin variety is associated with only two samples. However, in the second cluster, LIEN-LS-17(1) sample is located in the same cluster as Jasmin variety. However, in the second cluster, the LIEN-LS-17(1) sample was in the same cluster as the Jasmin variety, and in the first cluster with the Zafar variety. Under Absheron conditions, only a low-significant correlation of $r=0.29^*$ was found between the number of beans and the protein index.

In Absheron conditions, the highest yielding sample 6002/LRIL18-50|11-7 was selected with an indicator of 21,1 c/ha.

In Jalilabad BTS, LIEN-LS-17 (18) and 6002/LRIL18-50| 33 samples demonstrated the highest yield with the same result (16,5c/ha). A relatively high yield indicator of 16,0 c/ha was found in the 6002/LRIL18-50| 11-7 sample. The lowest yield indicator in Jalilabad RES is found in the 6002/LRIL18-50| 9-6 sample, 12,1 c/ha.

According to mathematical calculations, a correlation of $r=0.49^{**}$ was observed between the number of beans and the protein index in Jalilabad conditions.

According to the results of the dendrogram consisting of three clusters in Jalilabad conditions, the Zafar variety fell into the same first cluster with four samples (X2011 S 63-18, X2013 -119-14, LIEN-LS-17(34) and LICTN-17(16)). The Jasmin variety was found to be combined (LIEN-LS-17(9) in the first cluster and with one sample (LIEN-LS-17(8) in the second cluster.

Chapter IV. RESEARCH OF QUALITY INDICATORS OF LENTIL PLANT CULTIVARS

4.1. Study of the quality indicators of lentil plant samples cultivated in the Absheron and Jalilabad regions. In Absheron, the average protein content was 24,4%, and in the Jalilabad region it was 24,8%. According to the results of 2020, these figures were 24,32% in Absheron and 24,45% in Jalilabad. In 2021, the average

protein yield indicator was relatively lower in both regions compared to previous years. In Absheron AEF, this value was 24,09%, and in Jalilabad RES cultivated samples, it was 24,24%.

When comparing the results over 3 years, sample 6002/LRIL18-50|11-7 showed higher than average results in terms of starch, protein and fat content in the Absheron and Jalilabad regions.

According to the results of cluster analysis of the quality indicators of common lentil (*Lens culinaris Medic.*) cultivar samples, when looking at the first line of the dendrogram, it is possible to see that the samples of the first cluster No. 3 (LIEN-LS-17(1)) and the second cluster No. 10 (LIEN-LS-17(34)) are the closest to each other. Similarly, it is clear that the samples of the first cluster No. 2 (Jasmin) and the second cluster No. 7 (LIEN-LS-17(18)), the first cluster No. 8 (LIEN-MH-17(19)) and the second cluster No. 16 (X2013-119-14), and the first cluster No. 3 (LIEN-LS-17(1)) and the second cluster No. 6 (LICTN-17(16)) are compatible with each other.

As can be seen from Figure 3, the samples of the first cluster were closer to the Jasmin variety, and the samples of the second cluster were closer to the Zafar variety. Looking at it this way, it was not a coincidence that the first cluster No. 11 (6002/LRIL18-50| 9-6) and the second cluster No. 12 (6002/LRIL18-50| 34-2) fell together. Thus, in both regions, over three years, these samples sometimes did not differ much according to many parameters, and sometimes the difference was large. Mathematical and statistical analysis was conducted based on the results of three-year quality indicators of common lentil (*Lens culinaris Medic.*) variety samples. According to the results of cluster analysis of variety samples, in the first row of the dendrogram, samples No. 1; No. 8 and No. 4 were included in the first group of the first cluster, and samples No. 12 and No. 8 were also included in the first group (Figure 3).

In the second cluster, the samples of the first, second and third groups were closer to the Jasmin variety, and the samples of the fifth, sixth and seventh groups were closer to the Zafar variety.

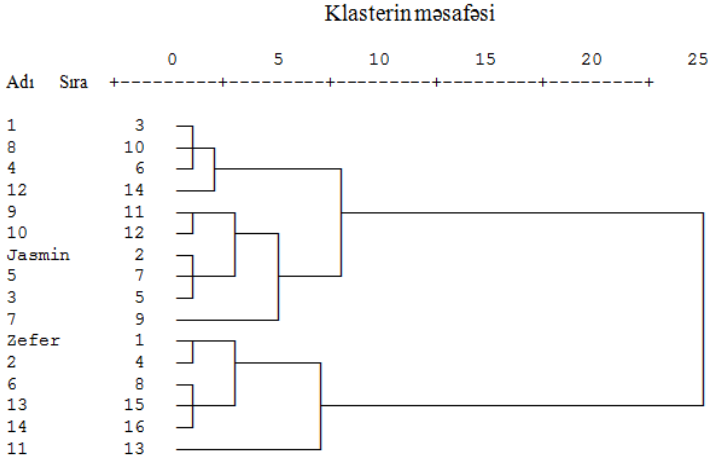


Figure 3. Dendrogram of quality indicators

In this way, it was not accidental that the first cluster No. 9 (LIEN-MN 17(28)) and the second cluster No. 11 (6002/LRIL18-50/34-2) formed separate groups, since in both regions, over three years, these samples sometimes differed greatly and sometimes slightly according to many parameters. The distance between the samples is shown in the coefficient column with numbers. As the distance increases from the first row to the last row, the value of the numbers also increases. In general, the results of this dendrogram reflect the closeness and difference of the Jasmin and Zafar cultivars, and the distribution of the samples relative to these cultivars demonstrates the difference in their quality indicators.

4.2. Results of electrophoretic analysis of lentil samples. It is known that electrophoresis of reserve proteins is one of the methods used in breeding programs and its use as a marker for future breeding work is recommended. In general, the use of reserve proteins as genetic markers in the study of polymorphism solves very important scientific, theoretical and practical issues.

In our study, for the first time, the Jasmin variety was adopted as the standard and electrophoretic analysis of fourteen lentil samples was performed (Figure 4, Table 3).

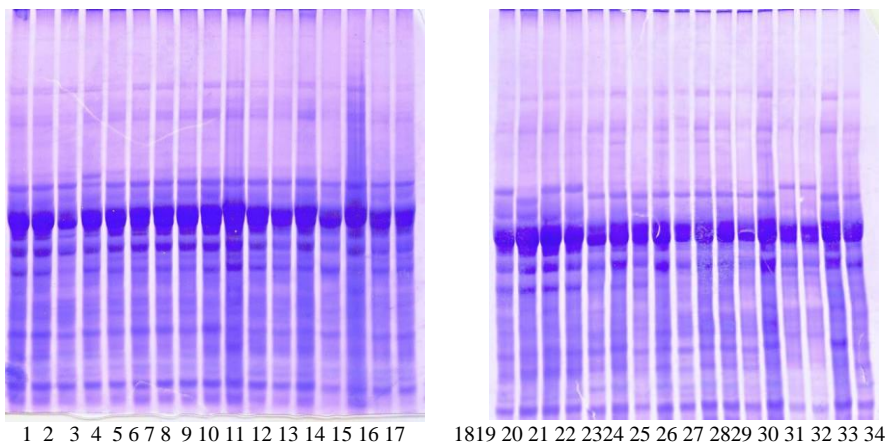


Figure 4. Electrophoretic analysis of lentil samples

Note:1-2. Zafar; 3-. Jasmin (st);4 № 9; 5-6 №3; 7. Jasmin ; 8-9№4; 10-11 №5; 12-13 №6; 14-15 №7;16-17 №8; 18-19 №9; 20-21 №10; 22-23 №11; 24 Jasmin; 25-26№12; 27-28 №13; 29-30 №14; 31-32 №15; 33-34 №16.

As can be seen from the figure, the spectra of the samples were not very diverse and complex. This may be primarily due to the lack of selection material to date. In addition, it can be observed that the 4th spectrum (belonging to the LIEN-MN-17(28) sample) was selected from other samples. Spectra 18-19 also belong to the same sample, but they do not differ from the other spectra. If you look closely, you can see that spectra 31-32 (X2011S 63-18 hybrid sample) are similar to the spectrum of LIEN-LS-17(34) sample. The X2011S 63-18 hybrid sample is a small-grain (microsperma) lentil sample (average value of 50 cm across years and regions), but the LIEN-MN-17(34) sample is a sample with small grains (average value of 71 cm across years and regions). However, their spectra were more similar.

When looking at the distribution table based on the Nei index, it can be seen that they show similar and different numbers in different zones.

Table 3
Distribution of electrophoretic analysis results according to
Nei index

Sequence number	Genotypes	Zones			
		ω 6	Υ 2	β 4	α 5
1	Zafar	1	1	1	1
2	Jasmin	2	1	2	2
3	LIEN-LS-17(1)	2	2	3	2
4	LIEN-LS-17(8)	2	2	4	2
5	LIEN-LS-17(9)	1	2	2	2
6	LICTN-17(16)	1	2	2	2
7	LIEN-LS-17 (18)	1	1	4	2
8	LIEN-MH-17(19)	1	2	5	3
9	LIEN-MH-17(28)	3	1	4	4
10	LIEN-LS-17(34)	4	1	6	4
11	6002/LRIL18-50 9-6	1	1	7	5
12	6002/LRIL18-50 34-2	1	2	8	5
13	6002/LRIL18-50 33	1	1	9	2
14	6002/LRIL18-50 11-7	1	1	1	2
15	X2011 S 63-18	5	2	3	6
16	X2013 -119 - 14	5	1	9	2

In lentil samples, the genetic diversity indices of the electrophoregrams of globulin reserve proteins for polymorphism zones were (Nei : H_{ω} =0.560; H_{γ} =0.495; H_{β} =0.735; H_{α} =0.541). The highest genetic diversity in the zones was observed in the zone (H_{β} =0.735). The highest genetic diversity in the zones was observed in the zone (H_{β} =0.735).

As can be seen from the dendrogram constructed based on the results of the cluster analysis, the distribution of 16 samples placed in the three main clusters corresponded to different distances (Figure 5).

When considering the division of the lentil samples' reserve proteins and globulins foregrams by zones, it is noticeable that there is more difference in the β zone. The Jasmin and Zafar cultivars are located in the same cluster.

Electrophoretic analysis of globulins revealed that the microsperm hybrid sample X2011S 63-18 had a distinct spectrum. Statistical analysis confirmed that X2011 S 63-18 was located separately in cluster 3.

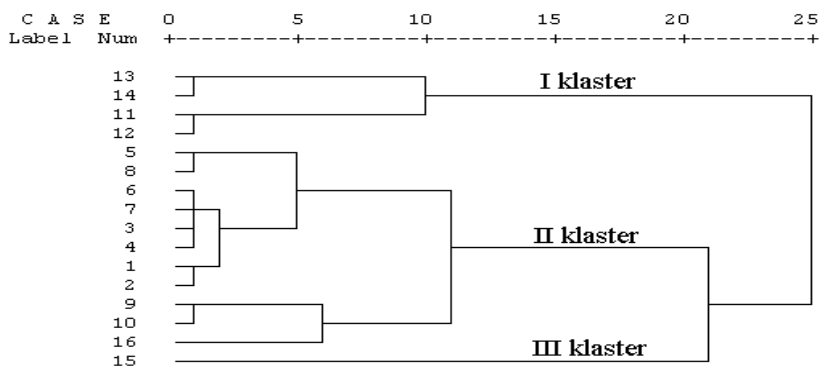


Figure 5. Dendrogram based on electrophoresis analysis results

Results

1. Cultivar samples and hybrids showed similar results in terms of flowering and full maturity in both regions (Absheron and Jalilabad). LIEN-MH-17(19) is the only sample that showed flowering and full maturity at the same dates in both conditions and in all three years (2019, 2020 and 2021) with very slight differences.

2. The LICTN-17(16) sample had the highest plant height over the three years (44,539 cm). The height of this sample was relatively high regardless of the year and region. Along with this genotype, the plant height of the 6002/LRIL18-50/33 (44,428 cm), 6002/LRIL18-50/34-2 (42,939 cm) and LIEN-MH-17(19) (42,978 cm) samples was also high across the years and regions.

3. The genotype factor is the factor that most affects the height of the first bean from the ground. The LIEN-LS-17(18) and 6002/LRIL18-50/34-2 samples had stable indicators for the height of the first bean from the ground across years and regions.

4. According to the number of beans, which is one of the structural elements of productivity, samples LIEN-LS-17(1) (average 40,8 pcs.), LIEN-LS-17(18) (average 40,0 pcs.) and 6002/LRIL-18-50/ 33 (average 41,4 pcs.) were selected in both regions over three years.

5. LIEN-LS-17 (18), LIEN-MH-17(19), 6002/LRIL18-50|33, 6002/LRIL18-50|11-7 samples have demonstrated high yield in both regions and are resistant to diseases.

6. It has been found that the genotype factor has the greatest effect on the structural elements of productivity. Thus, it was found that this factor had a 98.1% effect on the height of the first bean from the ground and a 99.8% effect on the number of beans.

7. The high quality sample 6002/LRIL18-50|11-7 was selected by showing above average results for starch, fat and protein content in both regions for three years.

8. Electrophoretic analysis of globulins revealed that the microsperm hybrid sample X2011 S 63-18 had a distinct spectrum. Statistical analysis confirmed that X2011 S 63-18 was located separately in cluster 3.

Recommendations

1. In the breeding of lentil plants, LIEN-MH-17(19), LIEN-LS-17(18) samples are recommended to be widely used in breeding since they have relatively high adaptability and high indicators.

2. Considering that the genotype factor has the greatest influence in the selection of lentil plants in order to obtain high productivity and relatively high quality products, it is recommended to use the genotypes with optimal color, height of the first bean from the ground, number of beans, high productivity and resistance to diseases: LIEN-LS-17(1), 6002/LRIL18-50/34-2 and 6002/LRIL18-50|11-7.

3. In order to obtain high quality products from the small-grain X2011 S 63-18 sample, it is recommended to provide special agrotechnical care specific to small-grain lentil plants and cultivate them in more fertile conditions.

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