

TƏBİƏT ELMLƏRİ
NATURAL SCIENCES

Technological Results Obtained Using Domestic Silkworm Genotypes in Various Seasons

Lala Abdullayeva¹ , Arzu Mirzayeva^{2*} , Gulabatin Humbatova¹ ,
Arzu Mammadov³ , Seyfali Kahramanov⁴ 

Abstract. Since one of the primary objectives of sericulture is the production of high yields of high-quality raw silk output, any domestic silkworm line (*Bombyx mori*) demonstrating enhanced silk productivity is considered of significant value. Just as biological indicators reflect overall agricultural performance, technological indicators must correspond to the requirements of industrial processing. It is well established that certain biological and technological traits in silkworms are interrelated, and improvement in one group of traits often leads to corresponding enhancement in the other. For example, an increase in the cocoon shell ratio (silk content of fresh cocoons) is associated with a higher conversion efficiency from fresh to dry cocoon weight. This, in turn, results in an increased cocoon shell ratio of dry cocoons and a higher raw silk yield. In this context, the technological characteristics of the silkworm lines were evaluated. The results presented here are based on a three-year experimental study conducted under suboptimal rearing conditions across three seasonal cycles (spring, summer, and autumn). Raw silk yield from cocoons—considered the principal technological indicator of productivity—was 44.2% for the Atlas 1 line and 44.3% for the Atlas 2 line. Cocoon reelability rate (moth emergence) was relatively high in both lines, reaching 88.8% in Atlas 1 and 90.3% in Atlas 2. The filament length reeled from a single cocoon averaged 1,693 m in Atlas 1 and 1,309 m in Atlas 2. Atlas 1 line is characterized by a longer and finer filament, whereas Atlas 2 produces a thicker filament. This difference suggests that Atlas 2 may provide silk with higher mechanical strength and higher quality, while Atlas 1 yields finer and longer fibers. The metric number—an indicator of filament fineness and length—was 4,422 m/g for Atlas 1 and 3,700 m/g for Atlas 2, with higher values corresponding to finer and longer filaments. Overall, the Atlas 1 line is distinguished by a fine, long filament, a satisfactory reelability rate, and high raw silk yield. In contrast, the Atlas 2 line exhibits a thicker filament of moderate length, a high reelability rate, and similarly high silk productivity. The results of the selection experiment further indicate that maintaining both genotypes under suboptimal feeding conditions is effective.

¹Ganja State University, Doctor of Philosophy in Agricultural Sciences, Ganja, Azerbaijan

²Ministry of Science and Education of the Republic of Azerbaijan Institute of Genetic Resources, Baku, Azerbaijan

³Institute of Bioresources of Nakhchivan State University, Doctor of Sciences Biology, Nakhchivan, Azerbaijan

⁴Institute of Bioresources of Nakhchivan State University, Nakhchivan, Azerbaijan

*Corresponding author. E-mail: mirzyevaa@bk.ru

Received: 20 February 2026; Accepted: 6 April 2026; Published online: 22 June 2026

© The Author(s) 2026. This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0).

Such selective pressure enhances technological traits while improving environmental adaptability and resilience.

Keywords: selection, line, domestic silkworm, cocoon, silk, technological indicators

Ev ipəkqurdundan istifadə etməklə əldə edilən texnoloji nəticələr müxtəlif fəsilərdə genotiplər

Lalə Abdullayeva¹ , Arzu Mirzəyeva^{2*} , Güləbatın Hübətova¹ ,
Arzu Məmmədov³ , Seyfəli Qəhrəmanov⁴ 

Xülasə. *İpəkçiliyin əsas məqsədlərindən biri bol və yüksək keyfiyyətli xam ipək istehsalı olduğuna görə, sınaqdan keçirilən yerli tut ipəkqurdu xətləri (cinsləri) yüksək ipək məhsuldarlığı nümayiş etdirdikdə dəyərli hesab olunur. Bioloji göstəricilər kənd təsərrüfatı məhsuldarlığını əks etdirdiyi kimi, texnoloji göstəricilər də sənaye istehsalının tələblərinə uyğun olmalıdır. Bu məqsədlə ipəkqurdularının texnoloji xüsusiyyətləri qiymətləndirilmişdir. Qeyd etmək vacibdir ki, təqdim olunan nəticələr üç il müddətində yaz, yay və payız mövsümlərini əhatə edən və pessimal (əlvərişsiz) şəraitdə aparılmış eksperimental tədqiqatlara əsaslanır. İpəkçilikdə texnoloji göstəricilər əsasında əsas məhsuldarlıq meyarı hesab olunan baramalardan alınan xam ipək çıxımı Atlas 1 cinsi üçün 44,2%, Atlas 2 cinsi üçün isə 44,3% təşkil etmişdir. Baramaların açılma (çıxma) qabiliyyəti üzrə Atlas 1 cinsi 88,8% göstərici ilə nisbətən yüksək nəticə göstərmiş, Atlas 2 cinsi isə 90,3% kimi daha yüksək qiymət nümayiş etdirmişdir. Bir baramadan açılan ipək lifinin uzunluğu Atlas 1 cinsində 1693 metr, Atlas 2 cinsində isə 1309 metr olmuşdur. Atlas 1 cinsi daha nazik və uzun lifə malik olması ilə Atlas 2 cinsindən fərqlənir, Atlas 2 cinsinin lifləri isə daha qalındır. Bu xüsusiyyət Atlas 2 cinsindən alınan ipək sapının keyfiyyət baxımından üstün olduğunu göstərir. Metrik nömrə—sapın naziklik və uzunluq göstəricisi—Atlas 1 üçün 4422 m/q, Atlas 2 üçün isə 3700 m/q olmuşdur; bu göstəricinin yüksək olması ipək sapının daha uzun və nazik olduğunu ifadə edir. Atlas 1 cinsinin lifləri nazik və uzundur, baramaların açılma qabiliyyəti normaldır və xam ipək çıxımı yüksəkdir. Atlas 2 cinsi isə standart uzunluğa malik daha qalın liflər, yüksək barama açılma göstəricisi və eyni dərəcədə yüksək xam ipək məhsuldarlığı ilə xarakterizə olunur. Seçmə eksperimenti nəticələri göstərir ki, hər iki genotipin pessimal (əlvərişsiz) bəslənmə şəraitində saxlanması daha səmərəlidir. Belə selektiv təzyiq tək cə ipəkqurdularının texnoloji xüsusiyyətlərini yaxşılaşdırmır, həm də onların ekoloji uyğunlaşma qabiliyyətini və dözümlülüyünü əhəmiyyətli dərəcədə artırır.*

Açar sözlər: seleksiya, cins, yerli tut ipəkqurdu, barama, ipək, texnoloji göstəricilər

¹Gəncə Dövlət Universiteti, kənd təsərrüfatı elmləri üzrə fəlsəfə doktoru, Gəncə, Azərbaycan

²Azərbaycan Respublikası Elm və Təhsil Nazirliyi Genetik Ehtiyatlar İnstitutu, Bakı, Azərbaycan

³Naxçıvan Dövlət Universitetinin Bioresurslar İnstitutu, biologiya elmləri doktoru, Naxçıvan, Azərbaycan

⁴Naxçıvan Dövlət Universitetinin Bioresurslar İnstitutu, Naxçıvan, Azərbaycan

*Məsul müəllif. E-poçt: mirzyevaa@bk.ru

Daxil oldu: 20 Fevral 2026; Qəbul edildi: 6 Aprel 2026; Onlayn dərc edildi: 22 İyun 2026

© Müəllif(lər) 2026. Bu, Creative Commons Attribution-NonCommercial 4.0 Beynəlxalq Lisenziyası (CC BYNC 4.0) şərtləri altında paylanan açıq girişli məqalədir.

Introduction

Given the diverse topography and climatic variability of Azerbaijan, newly developed silkworm (*Bombyx mori*) breeds must possess high adaptive potential to ensure stable expression of their genetic traits under fluctuating environmental conditions (Tzenov & Grekov, 2008; Vasileva et al., 2005). Although this presents a significant challenge, it is a solvable one. In recent years, research in Azerbaijan has focused on elucidating the genetic mechanisms underlying silkworm responses to

environmental variation (Abbasov, 2000). For the first time in sericulture, the scientific and theoretical foundations of adaptive selection have been established, along with practical approaches for their implementation. These advances have enabled the development of silkworm breeds with enhanced resilience to diverse environmental stressors (Abdullayeva, 2025).

From both economic and agricultural perspectives, the properties of the cocoon shell—the principal structural component of the cocoon—are highly variable and of critical importance. One of the most effective strategies for increasing natural silk and cocoon production is the development of high-yielding, technologically superior silkworm breeds and hybrids through selective breeding (Huo et al., 2023; Zhang et al., 2021). The technological characteristics of cocoons are primarily determined by the biological traits of the silkworm strain, the level of agro-zootechnical management during rearing, and the methods applied in primary cocoon processing, as well as other associated factors (Kumar & Prasad, 2018; Ganie et al., 2020). At the same time, it should be noted that although considerable research has been devoted to improving the biological productivity of silkworm breeds, significantly less attention has been paid to the stability and consistency of technological indicators under suboptimal and seasonally variable environmental conditions (Umarov, 2005). In particular, there is a lack of comprehensive studies addressing how adaptive selection influences key technological traits such as filament length, reelability, raw silk yield, and metric number across different rearing seasons (Hemmatbadi et al., 2016).

This gap is especially important for regions with unstable climatic conditions, where environmental stress factors such as high temperature, low humidity, and fluctuations in mulberry leaf quality can significantly affect both the productivity and technological performance of silkworms. Traditional breeding approaches, which are typically conducted under optimal conditions, may not adequately reflect the real production environment, thereby limiting the practical applicability of newly developed breeds (Tzenov & Grekov, 2008). In this context, the present study contributes to the field by applying adaptive selection under pessimal (suboptimal) rearing conditions and by evaluating the technological characteristics of silkworm genotypes across multiple seasons. The scientific novelty of this research lies in the integrated assessment of technological indicators under environmental stress conditions, as well as in identifying genotypes that combine high productivity with enhanced adaptability and stability (Hemmatbadi R., 2016; Huo, 2023).

Therefore, the aim of this study is to evaluate the technological characteristics of newly developed silkworm genotypes and to determine their suitability for seasonal rearing under unfavorable environmental conditions, with particular emphasis on their performance stability and industrial relevance (Chen et al., 2022; Zhang et al., 2021). Mulberry silkworm breeds and hybrids produce a single commercial product—raw silk. However, numerous economically important quantitative traits influence both the quantity and quality of this product. The yield of raw silk is largely determined by cocoon productivity, larval viability, cocoon shell ratio (silk content), reelability of dry cocoons, and overall raw silk recovery. In addition, resistance to infectious diseases and efficient feed utilization (feed conversion efficiency) play a significant role. In contrast, the quality of raw silk is mainly affected by the total and continuous filament length reeled from a single cocoon, filament fineness (metric number), and uniformity. Genetic improvement of these traits ultimately leads to enhanced productivity and quality of raw silk (Abbasov, 2001; Navruzov, 2020; Alimova, 2023).

Methods

The aim of this selection program was to evaluate silkworm families and individual cocoons by genotype, using cocoon shell ratio (silk content of live cocoons) as the primary selection criterion, and to develop two new mulberry silkworm (*Bombyx mori*) breeds. These breeds were intended to surpass the best regionally adapted strains in key technological and productivity indicators.

Synthetic populations Hesa 2/1 × Khayal and Mziuri 5 × Mayak 6 were used as the initial breeding material. From each population, 40–45 egg batches (nests) were incubated, and the 50 best-performing and surviving families were selected for rearing. During rearing, particular attention was given to larval development, viability, and the morphological characteristics of both larvae and cocoons. Families and individuals that did not meet the selection criteria were eliminated. Selection was initiated in the second generation and continued through the eighth generation.

Experimental Material

Adaptive selection methodology was applied using the newly developed hybrids Hesa 2/1 × Khayal (Atlas 1) and Mziuri 5 × Mayak 6 (Atlas 2). The study aimed to develop strains suitable for rearing under different seasonal conditions.

Experimental Design and Conditions

Experiments were conducted over a three-year period under unfavorable environmental conditions, including elevated temperatures, low relative humidity, and suboptimal feeding regimes. Rearing trials were performed during three seasonal cycles: spring, summer, and autumn. Such experimental conditions were intentionally selected to simulate real production environments and to evaluate the adaptability and stability of technological traits under environmental stress. Throughout the first three years, larvae of both sexes were reared under standard agro-zootechnical conditions without replication. Beginning in the fourth year, experimental groups were established, consisting of three replicates of 250–300 larvae per sex. These groups were reared under suboptimal (pessimal) conditions until the completion of larval development. To simulate stress conditions, the temperature was maintained at 27–28°C and relative humidity below 55–60% throughout the feeding period. Feeding frequency was six times per day in the fourth year and four times per day in the fifth year.

During the fourth and fifth years, continuous visual assessment of larval morphology was carried out during selection rearing. Individuals and entire families that deviated from the established phenotypic standard, as well as those exhibiting low survival rates due to disease or other factors, were systematically excluded. Technological parameters were determined using samples of cocoons obtained from each replicate. For each experimental variant, 25 male and 25 female cocoons were subjected to standard processing procedures, including stifling (thermal treatment), drying, and reeling. Based on these procedures, key technological indicators were evaluated.

Data Collection and Evaluation

Quantitative data obtained during the study was analyzed using appropriate statistical methods to assess variation and performance across the experimental groups. Mean values were calculated based on repeated observations over three years.

The following technological indicators of cocoons were evaluated:

- cocoon weight (mg),
- cocoon shell weight (mg),
- shell ratio (%),
- raw silk yield (%),
- cocoon reelability (%),
- filament length (m),
- metric number (m/g).

Calculation of Technological Indicators

The calculation of cocoon technological indicators was performed using the following formulas.

a) Shell ratio;

$$I = \frac{X + S + K}{N} \cdot 100 ;$$

where: X – the weight of pure silk; S – the weight of silk floss; K – the weight of the shell; N – the weight of sample cocoon.

b) Silk yield, in%:

$$I = \frac{1}{N} \cdot 100 ;$$

where: I – the weight of pure silk, N – the weight of sample cocoon;

c) Cocoon reelability:

$$A = \frac{1}{I + S + K} \cdot 100 ;$$

where: I – the weight of pure silk, grams; S – the weight of silk floss, grams; K – the weight of shell - grams.

d) The length of silk filament, meter;

$$U = \frac{U}{B} ;$$

where: U – general reeled silk filament; B – number of cocoons.

e) Metric number of silk filament

$$M_n = \frac{U}{X} ;$$

where: U – general reeled silk, meter; X – the weight of pure silk, gram.

Results and discussion

As a result of experiments conducted across three different seasons (spring, summer, and autumn) using the adaptive selection method, two new silkworm breeds—Atlas 1 and Atlas 2—were developed. These breeds are technologically advanced and meet modern sericultural requirements. The hybrids of silkworm such as Hesa 2/1 × Khayal (Atlas 1) and Mizuri 5 × Mayak 6 (Atlas 2) were used as the breeding material for this study. Based on the average results obtained over a three-year experimental period, the findings demonstrated that, despite fluctuations in environmental conditions, the technological indicators remained consistent, and the quality of silk was preserved. Consequently, these results formed the basis for the assessment of the silkworms' technological traits. Given that the primary objective is to obtain abundant and high-quality raw silk, the silkworm breeds under evaluation must exhibit high adaptability. Just as biological indicators reflect agricultural productivity, technological indicators should correspond to industrial demands and are, in this context, of even greater significance. As presented in the table, the selected genotypes demonstrated robust performance, with high results observed under seasonal feeding conditions. Of particular industrial relevance is the weight of a single dry cocoon, as it determines the ratio between wet and

dry cocoon yields. In this regard, the wet cocoon weight was notably high in both breeds: in Atlas 1, the average weight reached 870 mg, while in Atlas 2, it was 793 mg.

Table 1
Average technological indicators of the newly developed silkworm breeds

№	Name of the breeds	Dry cocoon		Raw silk		Cocoon reeling, %	Silk filament	
		Average mass, mg	Shell ratio, %	Average mass, mg	Shell ratio, %		Total length, m	Metric number, m/g
1	Atlas 1	870	49,95	384	44,2	88,8	1693	4422
2	Atlas 2	793	49,05	349	44,3	90,3	1309	3700

The cocoon shell ratio of dry cocoons showed very similar values in both breeds, amounting to 49.95% in Atlas 1 and 49.05% in Atlas 2. This parameter is a key technological indicator, as it directly influences the potential yield of raw silk. Cocoon reelability represents another critical technological characteristic, as it has a direct impact on processing efficiency and overall productivity. Poor reelability leads to interruptions during reeling and, consequently, reduced production efficiency. In the present study, both breeds exhibited high reelability, reaching 88.8% in Atlas 1 and 90.3% in Atlas 2. Among the technological traits, filament thickness and length are of particular importance for silk processing and textile applications. Deviations from standard filament thickness, either excessively coarse or overly fine—are generally undesirable for weaving, although such variations may be inherent to specific breeds.

The average filament length reeled from a single cocoon was 1,693 m in Atlas 1 and 1,309 m in Atlas 2. Atlas 1 produced a longer and finer filament, whereas Atlas 2 yielded a comparatively thicker filament. This suggests that Atlas 1 is more suitable for applications requiring finer and longer fibers, while Atlas 2 may offer advantages in terms of filament strength and durability. Overall, both breeds fall within the acceptable limits for key technological indicators. In terms of raw silk quality, Atlas 2 may be considered superior due to its lower metric number and shorter filament length, which indicate a thicker filament better suited for certain industrial applications.

The metric number of the reeled silk, defined as the ratio of filament length (m) to weight (g), also differed between the breeds. It reached 4,422 m/g in Atlas 1 and 3,700 m/g in Atlas 2, indicating that Atlas 1 produces finer and longer filaments, as higher values correspond to greater fineness. Raw silk yield, a principal indicator of technological efficiency in sericulture, was nearly identical in both breeds, amounting to 44.2% in Atlas 1 and 44.3% in Atlas 2. Overall, the results indicate that Atlas 1 is characterized by a fine and long filament, satisfactory reelability, and high raw silk yield. In contrast, Atlas 2 exhibits a thicker filament of moderate length, superior reelability, and similarly high productivity. Importantly, according to all evaluated technological parameters, the silk produced by these newly developed breeds meets the advanced standards established for modern silkworm breeds and hybrids in the Republic of Azerbaijan.

Conclusion

The results of the selection experiment indicate that maintaining breeding material under suboptimal (pessimal) feeding conditions is more effective for evaluating and enhancing genotype performance. Under these conditions, both newly developed breeds, Atlas 1 and Atlas 2, exhibited consistent patterns across key technological indicators. Specifically, selection led to a stable improvement in technological traits rather than merely altering them, ultimately contributing to increased raw silk productivity. Moreover, the genetic gains in technological traits were more pronounced under

suboptimal feeding conditions. Despite exposure to unfavorable environmental factors, both breeds maintained high cocoon shell ratio (silk content), demonstrating their stability and resilience. These findings suggest that, over the course of three years and across three seasonal cycles (spring, summer, and autumn), the studied lines have become well-established breeds characterized by high ecological adaptability and strong technological performance.

References

1. Abbasov, B. Kh. (2000). Study of ecological stability of silkworm breeds and hybrids by total cocoon yield. *Scientific Works of the Azerbaijan Scientific Research Institute of Sericulture*, 15, 49–55.
2. Abdullayeva, L. R. (2025). The effect of mulberry leaf maturity on silkworm rearing outcomes in Azerbaijan's ecological conditions. *Agricultural & Veterinary Sciences*, 9(1), 23–28.
3. Bedieva, G. Sh., & Djumaeva, N. I. (2015). Unwinding operations are performed in special cocoon packing machines for manual opening of cocoons. *Education and Upbringing*, 3, 1–2.
4. Chen, F., Liu, Z., & Chen, S. (2022). Comparative analysis of cocoon and filament traits in silkworm hybrids. *Insect Science*, 29, 1120–1132.
5. Ganie, N. A., et al. (2020). Performance evaluation of bivoltine silkworm hybrids under different rearing conditions. *Journal of Asia-Pacific Entomology*, 23, 456–463.
6. Hemmatabadi, R. N., Seidavi, A. R., & Gharahveysi, S. (2016). A review on correlation, heritability, and selection in silkworm breeding. *Journal of Applied Animal Research*, 44, 9–23.
7. Huo, Y., et al. (2023). Improvement of silk yield traits through hybrid silkworm breeding strategies. *Scientific Reports*, 13, Article 14567.
8. Kumar, P., & Prasad, B. (2018). Impact of environmental conditions on cocoon characteristics of silkworm hybrids. *Entomological Research*, 48, 250–258.
9. Singh, R., & Saha, S. (2019). Evaluation of hybrid silkworm breeds for cocoon productivity and silk yield. *International Journal of Industrial Entomology*, 38, 45–52.
10. Tzenov, P., & Grekov, D. (2008). Development of methods for breeding new silkworm (*Bombyx mori* L.) commercial hybrids tolerant to adverse rearing conditions. *Annals of Agrarian Science*, 6(2), 71–76.
11. Umarov, Sh. R. (2005). Changes in the leading productivity traits of silkworm hybrids during spring and summer feeding of caterpillars. *Problems of Agrarian Science*, 31, 140–143.
12. Vasileva, Y., Petkov, N., Greiss, H., & Nacheva, Y. (2005). Complex assessment of Egyptian breeds of silkworm (*Bombyx mori* L.) in relation to their utilization in breeding programs. *Journal of Agricultural Science*, 42(1), 81–85.
13. Zhang, Y., Wang, H., & Li, X. (2021). Genetic improvement of *Bombyx mori* for enhanced silk production. *Sericologia*, 61, 15–26.