Effect of feeding mulberry silkworms with leaves of different cultivars and hybrids on silk gland activity and yield of cultivated cocoons

Chorshanbi Bekkamov[1*]

[1]Tashkent State Agrarian University, University str., 2, 100140, Tashkent, Uzbekistan

Abstract. During the agrotechnics of mulberry silkworm care by farms, clusters and specialized farms engaged in cocooning in our country, the nutritious feed given to the mulberry silkworm during its youth is used in the season of medicating agricultural crops. The purpose of the research was to investigate the causes of mulberry silkworm diseases resulting from poisoning in several districts of the Tashkent region, including Orta Chirchik, Lower Chirchik, Piskent, Yangiyol, Chinoz, Bostanliq, and Ohangaron. The results showed that the weight and volume of the silk gland were higher in the experimental variants, ranging from 1550-1650 mg and 1.55-1.63 cm3, respectively, compared to the comparative variant, where the weight and volume were 1470-1480 mg and 1.45-1.48 cm3, respectively. The difference in weight and volume was found to be 6.9-11.5% and 6.5-10.1%, respectively, lower than the experimental variants.

1 Introduction

Effective research and development efforts are being made to create new breeds and hybrids of silkworms and mulberry varieties that are adaptable to various climatic conditions and resistant to external environmental factors [1-4]. This is particularly important considering the geographic distribution of cocoon-growing countries worldwide. Countries such as Japan, the People's Republic of China, India, Uzbekistan, Vietnam, and South Korea have developed scientific centers dedicated to sericulture. These centers focus on utilizing various biologically active substances, studying the physiology of mulberry silkworms, and adopting modern methods of worm feeding to mitigate the negative effects of changing natural climate conditions [5-9]. To this end, several scientific and research studies have been conducted to establish special intensive nutrient-giving mulberry groves and grow nutritious mulberry leaves through the reproduction of fertile mulberry seedlings.

Currently, it is imperative to employ effective methods of genetics and selection processes to create mulberry varieties and hybrids that are suitable for the changing natural climatic conditions in order to grow nutritious mulberry leaves that meet the demand for seasonal worm feeding [6-9]. This will ultimately reduce the impact of external environmental factors on cocoon productivity and facilitate the creation of new advanced innovative agrotechnologies, which is an urgent scientific and practical problem. To address this issue, it is essential for all stakeholders involved in the cocoon industry,

[*]Corresponding author: bekkamovchorshanbi@gmail.com

including farmers, cluster workers, silk agronomists, mulberry specialists, homemakers, and agricultural experts, to have knowledge of ways to improve nutrition and to correctly identify mulberry diseases and mulberry leaf poisoning. By using modern methods of control, treatment, and inspection, mulberry productivity can be maintained, and mulberry leaves can be protected from mulberry silkworms [1-7, 9-11].

In response to this challenge, the President of the Republic of Uzbekistan issued PQ-4411 on July 31, 2019, which calls for additional measures to develop deep processing in the cocoon industry. Furthermore, the President's order on January 17, 2020, titled "On the development of the silkworm feed base in the cocoon industry," outlines measures to deepen the reforms implemented in the cocoon industry, create favorable conditions for its rapid development and diversification, introduce the cluster method of production organization, form special feeding farms based on family contracts, and increase investment in the deep processing of cocoons to establish the production of finished products with high added value by small enterprises [10-13]. It is noteworthy that over 30% of the food and products grown in the world's agriculture are lost during the growing season as a result of diseases, pests, poisoning by chemical substances, and negative effects of harmful alien weeds.

In order to mitigate the damage caused by diseases and pests in the cultivation of ecologically clean food products and feed for farm animals, it is crucial to have a comprehensive understanding of the types of microorganisms that cause these diseases, their biological properties, and effective measures to combat them. Furthermore, it is necessary to determine the safe and effective methods of treatment from both a scientific and practical perspective [1-7, 9]. The level of research on this problem is considerable. It is well-established that the amount and ratio of proteins, carbohydrates, vitamins, and other nutritional elements in mulberry leaves that are necessary for the growth, development, and productivity of mulberry silkworms depend not only on the mulberry variety but also on factors such as the growing season, agrotechnical care, and pruning methods. Moreover, the genus of the mulberry tree can also impact these factors [1-8]

Researchers have found that multivariety mulberry has positive effects on silkworm growth and development [5-7, 11-15]. In their experiment, the larvae grew evenly, released less gana, and produced a higher quality cocoon when fed with multi-variety mulberry leaves. Conversely, the use of unripe, low-nutritional, and poisoned mulberry leaves has been found to have a negative effect on these useful properties. In addition, Rajabov and Akhmedovlar (2002) have observed that inadequate feeding of silkworms leads to poor growth, deteriorated biological indicators, and decreased productivity. In their study, larvae that were fed only 50% of the required amount of food exhibited a 7-day extension of the larval period, a 36.0% decrease in viability, and a decrease in the amount of silk produced in the cocoons they spun.

The studies showed that newly developed varieties of mulberry trees, such as SANISH-44, Topkros-1, Topkros-2, Jararik-1, Jararik-2, and Jararik-4, exhibit improved leaf productivity, nutritional quality, cold and disease resistance, and are highly palatable and digestible for silkworms, resulting in high silk production [4-8, 11]. These varieties have also shown 1.3-1.6% higher silkiness than previously created varieties. It is important to conduct further research on mulberry diseases, leaf poisoning, and effective measures to combat them. To increase the productivity of mulberry trees, it is recommended to develop productive varieties, employ appropriate agrotechnical measures, and implement scientifically-based disease control methods [5-9]. The yield and nutritional value of mulberry leaves are related to the quality of cocoon production. Previous studies have focused on mulberry diseases, seed germination, seedling growth, disease symptoms, and yield decrease caused by infectious and non-infectious diseases. Further research is needed to determine the relationship between the types and amounts of food given to silkworms

 https://doi.org/10.1051/e3sconf/202338903088

and their silk productivity. Studies have been conducted on the development, weight, changes in the silk gland, and physical and chemical properties of silk in different types of mulberry leaves fed to silkworms during their youth [11-13]. However, there have been no scientific studies to determine the relationship between the types and amounts of food given to silk gland activity of the mulberry silkworm and the relationship between silk productivity (biological parameters, productivity and productivity of the cocoon, and technological characteristics) [13-15].

The objective of this research is to determine the relationship between the composition and nutritional status of the food given to young mulberry silkworms and the variety and hybrid of the mulberry tree, as well as the impact of disease and poisoning on larval development, productivity, and the activity of the silk gland. The research aims to improve the quality and yield of cultivated cocoons through careful monitoring and control of the feed base of sericulture, as well as the viability, productivity, and growth dynamics of mulberry silkworms [7-9]. The novelty of this study lies in the need to increase the exportability of high-quality cocoon raw materials with high productivity, which can only be achieved through effective care and use of the feed base.

2 Materials and methods

The purpose of the research was to investigate the causes of mulberry silkworm diseases resulting from poisoning in several districts of the Tashkent region, including Orta Chirchik, Lower Chirchik, Piskent, Yangiyol, Chinoz, Bostanliq, and Ohangaron. Two experiments were conducted [3-5]:

The first experiment involved studying the effect of Bestseller 20% k.e., a chemical preparation approved for use against plant pests, diseases, and weeds in Uzbekistan. The preparation was applied at a rate of 0.05-0.075 as recommended, and solutions of 0.015 and 0.0075% (reduced by 5 and 10 times) and 0.01 and 0.005% were tested in laboratory conditions [4-7, 12-14].

The second experiment studied the mortality rates of spring worms when exposed to various concentrations of Bestseller 20% k.e. Mortality rates ranged from 87-95% when exposed to a 0.05-0.075% solution, 57-79% when exposed to 0.015 and 0.0075% solutions, and 0% when the amount of the drug was reduced by 10 times. A 50-53% mortality rate was observed when exposed to a 0.005% solution [5-9].

3 Results and discussion

The nutritional composition and quality of food given to mulberry silkworms during their early developmental stages, as well as exposure to poisoning and disease, have significant effects on the silk gland organ in the larva's body and the resulting quality of cultivated cocoons. Inadequate food and consumption of poisoned mulberry leaves lead to adverse changes in metabolic, physiological, and biochemical processes in the body, which ultimately affect the activity of silk glands. The reduction in the amount of silk fluid synthesized in the silk glands leads to thinner cocoons with less silk content, and some silkworms fail to cocoon. Consequently, this has a negative impact on the productivity of industrial cocoons. The findings of the study are summarized in Table 1.

 https://doi.org/10.1051/e3sconf/202338903088

Table 1. The amount of food given to mulberry silkworms affects the activity of the silk gland and the productivity of the cocoons impact on productivity.

Variants	The amount of food given to the worms, %	The size of the silk cloth, cm^3	Cocoon yield from box 1 worm, kg X± Sx	Pd	The amount of seed cocoons, % X± Sx	Type - you cocoons, %	Pd
Silky 1 breed							
V1	100	1.47	72.0±0.57	-	91.0±0.58	9	-
V2	75	1.20	57.0±0.46	0.998	82.0±0.56	18	0.992
V3	50	1.10	42.0±0.42	0.994	77.0±0.54	23	0.993
Silky 2 breed							
V4	100	1.52	73.0±0.59	-	92.0±0.59	8	-
V5	75	1.25	58.0±0.48	0.998	83.0±0.57	17	0.994
V6	50	1.13	43.0±0.43	0.996	78.0±0.56	22	0.992

Based on the findings presented in Table 1, it is evident that the quality and quantity of food given to mulberry silkworms during their young age and the presence of toxic substances in the leaves have a significant impact on larval development, molting, larval duration, biological indicators, silk gland activity, cocoon yield, and fertility. Insufficient food and toxic substances in the leaves negatively affect the total number and yield of wrapped cocoons. For instance, providing enough food to the worms yielded 72-73 kilograms of cocoons per box, while a decrease in nutritional value and a lack of food resulted in a yield of 57-58 kilograms and 42-43 kilograms, respectively.

Furthermore, a 26.3% reduction in cocoon yield was observed in the case of a 15-kilogram nutrient deficiency or damaged leaves, indicating a significant impact on productivity. When different types of mulberry leaves with insufficient nutritional content were given instead of a box of worms, only 77-78% of the cocoons were productive, with the remaining 20-22% being non-productive. This is 9% and 14% higher than the cases of insufficient nutrition according to their age. The data presented in Fig. 1 and 2 confirm these findings.

https://doi.org/10.1051/e3sconf/202338903088

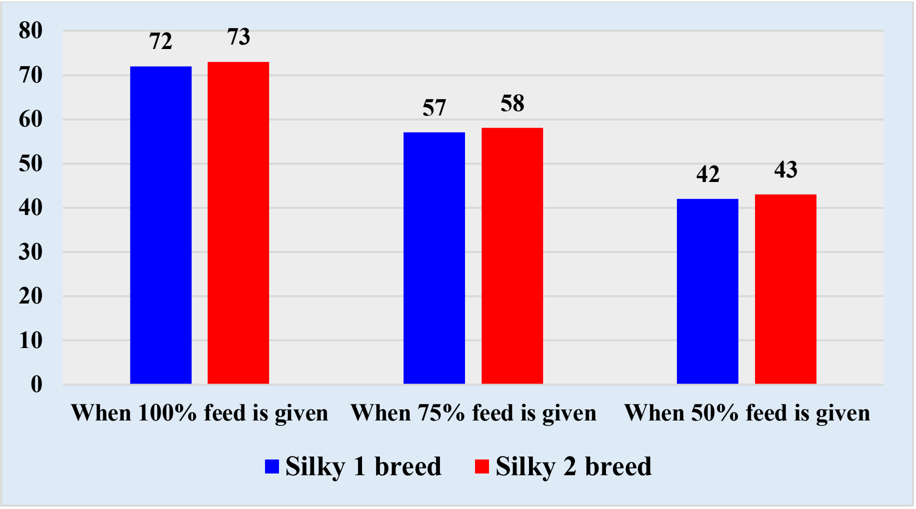

Fig. 1. Effect of mulberry silkworm feeding amount on cocoon productivity.

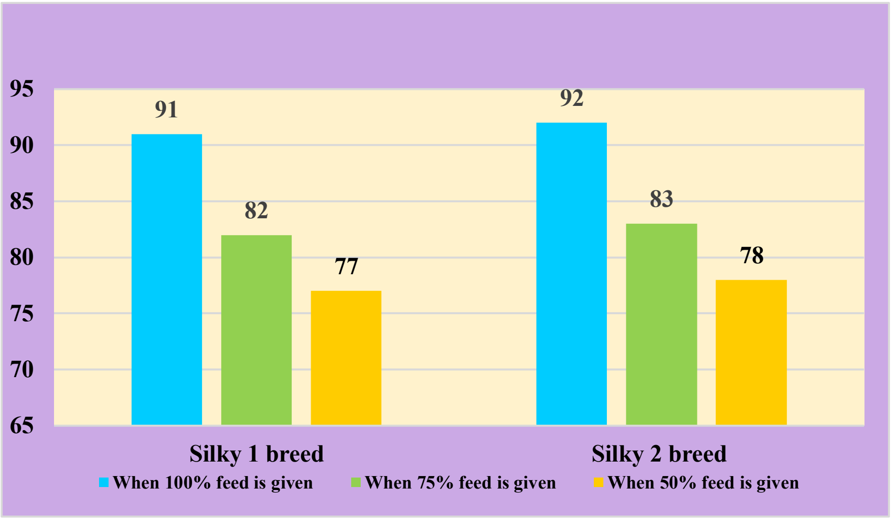

Fig. 2. Effect of feeding amount to mulberry silkworms on the productivity of reared cocoons.

Mulberry leaves are the main food source for silkworms, but their nutritional requirements are difficult to meet due to variations in agrotechnical care and usage methods of mulberry trees. Although some studies have been conducted in this area, little is known about the impact of feeding silkworms with infected mulberry leaves on the productivity and quality of the cocoons. In order to investigate this further, we conducted experiments using several varieties of mulberries, including Tajik seedless, Oktyabr, Uzbekistan, and Jararik, which were developed by the Silk Research Institute. A group of silkworms were fed with freely pollinated mixed hybrid mulberry leaves for comparison purposes. The results of the experiments, including the effects of fertile mulberry leaves on larval viability and silk gland performance, are presented in Table 2.

Table 2. Effects of feeding caterpillars with fertile mulberry leaves on larval biological parameters, silk gland activity and cocoon productivity.

Name of mulberry varieties	**Silk cloth indicators**		**Worms are viable - league, % X± Sx**	**Extension of the worm period , days**	**Total cocoon %**	**Cocoon yield from 1 box of worms, kg**	**Pd**
	Weight, mg	**Volume cm^3**					
In breed Silky-1							
Tajikistan seedless	1600	1.58	93.0±0.70	22	95.5	76	0.990
October	1550	1.55	93.5±0.71	22	95.0	75	0.992
Jararik	1650	1.63	94.0±0.72	22	96.5	80	0.999
Uzbekistan	1630	1.60	93.5±0.72	22	96.0	78	0.996
A mixture of hybrids (comparative)	1450	1.45	92.0±0.70	22.5	92.0	72	-
Silk-2 breed							
Tajikistan seedless	1620	1.60	93.0±0.72	22	96.0	77	0.998
October	1580	1.57	93.5±0.73	22	95.5	76	0.994
Jararik	1670	1.65	94.5±0.74	22	96.5	82	0.996
Uzbekistan	1640	1.62	93.5±0.71	22	96.0	79	0.996
A mixture of hybrids (comparative)	1480	1.48	92.0±0.69	22.5	92.0	74	-

Based on the findings presented in Table 2, it can be inferred that the use of seeded mulberry leaves in feeding silkworms resulted in a slightly better performance compared to unseeded leaves. The weight and volume of the silk gland were higher in the experimental variants, ranging from 1550-1650 mg and 1.55-1.63 cm3, respectively, compared to the comparative variant, where the weight and volume were 1470-1480 mg and 1.45-1.48 cm3, respectively. The difference in weight and volume was found to be 6.9-11.5% and 6.5-10.1%, respectively, lower than the experimental variants. This suggests that feeding silkworms with non-poisonous fertile mulberry leaves promotes their growth and development, enabling the silk gland to produce sufficient silk material. The data also revealed that silkworms fed with cultivar mulberry leaves showed slightly higher viability (1.5-2.5%) compared to those fed with a mixture of hybrid mulberry leaves. The highest viability rate was observed in silkworms fed with Jararik and Uzbek varieties. Furthermore, feeding silkworms with fertile mulberry leaves resulted in a cocoon rate of 95.0-96.5% in the experimental variants, which was 3.0-4.5% higher compared to the comparative variant (92.0%). Subsequently, our research delved into the causes of mulberry diseases, which have been identified as bacteria, viruses, fungi, mycoplasmas, and actinomycetes. These diseases significantly impact the nutritional value of mulberry leaves, leading to a decrease in their quality over time.

Mulberry trees are often planted in areas with high levels of pollution, such as along roadsides and ditches. This exposure to harmful microorganisms can lead to the development of diseases that negatively impact the nutritional value and productivity of cultivated leaves. A 2009 study conducted by A. Sheraliev et al. found that temperature fluctuations, sunlight, dehydration, and lack of light can contribute to the development of various diseases in mulberry trees and leaves. While it is known that mulberry leaf diseases can reduce the nutritional properties of the leaves, the effects of feeding silkworms with diseased mulberry leaves on their growth, development, and cocoon quality have not been extensively studied. To address this gap in knowledge, we conducted experiments to assess the viability of Silky-1 and Silky-2 silkworms when fed leaves infected with leaf blight, cylindrosporiosis, powdery mildew, and chlorosis, as well as the impact on their productivity. The results of these experiments are presented in Table 3.

Table 3. Effects of feeding mulberry silkworms on infected mulberry leaves on larval productivity and cocoon productivity.

Disease name	Survival rate of worms, %	Prolongation of the worm period, day	Totally wrapped cocoons, %	Weight of one cocoon, g X± Sx	Taken from 1 box of worms yield, kg	Pd
Leaf wilting	72	32	65.0 _	1.38 ± 0.06	42.2	0.996
Chlorosis	74	30	71.0	1.45±0.04	47.5	0.994
Flour-dew	78	28	76.0	1.53±0.05	52.3	0.991
Non-diseased mulberry leaf (comparative)	93	23	88.0	1.92±0.03	72.0	-

Table 3 showed that silkworms' survival rate is adversely affected by the ingestion of infected mulberry leaves, particularly those affected by powdery mildew, chlorosis, and leaf blight diseases. The larvae's ability to consume infected leaves is hampered, and their development slows down, leading to a longer larval period, with reduced age-to-age transition and a 15-19% decline in viability compared to the control group. The extended larval period results in the fifth age remaining longer on the leaves, which become coarse, and the number of cocooned worms drops by 12-17% compared to the control group's 88.0%. The weight of one cocoon was also found to decrease by 20.5-24.5%, resulting in a yield reduction of 20-24 kilograms from one box of worms. The overall cocoon biological performance is reduced, indicating that silkworms' ingestion of infected mulberry leaves has a significant negative impact on their growth and productivity. Based on the analysis of the above-mentioned data and pictures, one of the main problems is the decrease in nutritional value of mulberry leaves due to infection with infectious and non-infectious diseases in the care of mulberry silkworms during different worm feeding seasons. due to poisoning of silkworms, it causes a large number of larvae to die in relation to the number of boxes and a sharp decrease in viability. We present the results obtained on the basis of our scientific research in this regard in the next table (Table 4).

Table 4. Influence of the level of mulberry leaf damage on the viability of larvae caused by the use of a chemical drug against the wheat pest khasva planted in different regions of Uzbekistan.

Experience options	Bestseller spray against wheat pest from agricultural crops 20% k.s. drug			
	Duration of spraying the drug	Drug consumption , l/ha	The amount of water consumption in the preparation of the working solution, l	Death of larvae with poisoned mulberry leaves,%
Option-1	In the southern regions March-April	0.05-0.075	300	50-53
Option-2	In the central regions	0.015-0.075	300	57-79

	April-May			
Option-3	In the northern regions May-June	0.015-0.005	300	87-95
Option-4 (comparative)	In areas where the drug has not been sprayed	-	-	5-7

According to the table provided, during the spring worm feeding period, the worms that consumed poisoned mulberry leaves began vomiting from the second day of the experiment. Furthermore, the larvae in the worm house started dying. The study showed that exposure to a drug solution with concentrations of 0.05-0.075% resulted in the death of 87-95% of the larvae. When the concentration was reduced by five times (0.015-0.0075%), 57-79% of the larvae died. Similarly, a ten-fold reduction in the concentration (0.01-0.005%) resulted in the death of 50-53% of the larvae.

4 Conclusions

The study showed that the nutritional value of mulberry leaves significantly affects the growth dynamics, biological indicators, and silk gland activity of mulberry silkworms. Feeding the silkworms with mulberry leaves of varieties with high nutritional value, such as Tajikistan seedless mulberry, Oktyabr, Uzbekistan, Jararik, resulted in a 10.1% increase in viability and a 1.5-2.5% increase in the productivity index of total wrapped cocoons. Additionally, productivity increased by 8-10 kg per box.

The study also found that feeding the silkworms with diseased mulberry leaves led to reduced larval survival rates, delayed shedding, and a decrease in the number of cocooned worms by 71-76% compared to the control variant. Moreover, the weight of one cocoon was 20.5-24.5% lighter compared to the control variant, which also affected the yield of cocoons obtained from one box of worms, decreasing it to 24-30 kg.

Finally, the study observed cases of vomiting in worms that consumed poisoned mulberry leaves during the spring worm feeding period. When exposed to a 0.05-0.075% solution of the drug, larvae in the worm house began to die. The study found that 57-79% of the larvae died when exposed to 0.075% solution, while 50-53% died when exposed to 0.01 and 0.005% solution with a 10-fold reduction in the amount of the drug.

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