HSR London International Conference on Multidisciplinary Academic Research
(HSR-ICMAR) 2026
https://houghtonstreetreview.com/index.php/conference

UDK 638.27:575.22

DEVELOPMENT AND EVALUATION OF HIGH-PRODUCTIVITY COMMERCIAL SILKWORM HYBRIDS USING THE 5140PK PARTHENOGENETIC CLONE *(BOMBYX MORI L.)*

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Abstract. The aim of this study was to evaluate the reproductive, biological, technological, and economic characteristics of complex commercial silkworm hybrids developed using the 5140PK parthenogenetic clone and to determine its breeding value in hybrid development. In the experiments, the 5140PK parthenogenetic clone was used as the maternal component, while the commercial hybrids Mayin tola-1, Mayin tola-2, Navro'z-3, and Navro'z-4 served as paternal breeding components. The newly developed complex hybrids were comparatively evaluated with the commercial hybrid Ipakchi-2 × Ipakchi-1 for reproductive performance, larval viability, cocoon and shell weight, silk ratio, technological characteristics, and economic efficiency under production conditions. Among the studied combinations, 5140PK × Mayin tola-1 demonstrated the best overall performance, producing an average of 641.3 eggs, 94.3% larval viability, 22.5% silk ratio, 45.76% raw silk yield, and 50.33% silk productivity. Under field production conditions, this hybrid yielded 60.5 kg of fresh cocoons per box, generating a net profit of 757.3 thousand UZS with a profitability of 22.3%. The obtained results indicate that the 5140PK parthenogenetic clone possesses high combining ability and can be effectively utilized as a valuable breeding component for developing high-yielding commercial silkworm hybrids (Bombyx mori L.).

These findings provide a scientific basis for the utilization of parthenogenetic clones in commercial silkworm breeding programs.

Keywords: Bombyx mori L., parthenogenetic clone, heterosis, silkworm breeding, commercial cocoon production, breeding, combining ability, reproductive performance, biological productivity, technological traits, economic efficiency.

Introduction. Sericulture is one of the important branches of agriculture, providing high-quality natural silk as a valuable raw material for the textile industry. Therefore, improving the biological and economically important traits of the mulberry silkworm (*Bombyx mori* L.) and developing high-yielding commercial hybrids remain among the primary objectives of modern silkworm breeding programs [1].

In recent years, advances in molecular genetics and genomics have significantly improved our understanding of the genetic mechanisms controlling economically important traits in *Bombyx mori*, thereby enhancing the efficiency of breeding programs [1, 13, 14]. The integration of genomic information with conventional breeding methods has provided a scientific basis for the development of superior commercial silkworm hybrids.

One of the most promising approaches in silkworm breeding is the use of parthenogenetic clones. Parthenogenesis enables the preservation of valuable genotypes, the establishment of genetically stable maternal lines, and the improvement of hybridization efficiency [2]. Previous studies have demonstrated that parthenogenetic clones possess high genetic stability and can serve as effective maternal breeding components in the development of commercial silkworm hybrids [5, 12].

Recent investigations into the molecular mechanisms of parthenogenesis have identified proteins and cell-cycle regulatory factors involved in embryonic development [3, 7]. Moreover, the development of genetic transformation techniques for parthenogenetic embryos has further expanded the opportunities for silkworm breeding and genome engineering [6].

The development of high-yielding commercial hybrids largely depends on the combining ability of the parental breeding components. Therefore, comprehensive evaluation of reproductive performance, biological productivity, technological characteristics, heterosis, and genetic diversity is an essential part of modern silkworm breeding programs [9–11].

Studies conducted in Uzbekistan have also demonstrated the effectiveness of using parthenogenetic clones in silkworm breeding. In particular, crosses between parthenogenetic clones and locally developed breeding materials have produced promising hybrids with improved biological and technological characteristics [4, 8].

Despite these advances, information regarding the combining ability of newly developed parthenogenetic clones with commercial breeding components, as well as their reproductive, biological, technological, and economic performance, remains limited. Therefore, the present study aimed to evaluate the reproductive, biological, technological, and economic characteristics of complex commercial silkworm hybrids developed using the 5140PK parthenogenetic clone and to determine its breeding value as a maternal component for the development of high-productivity commercial hybrids of *Bombyx mori* L.

Materials and Methods. The study was conducted during 2023–2025 at the Scientific Research Institute of Sericulture, Uzbekistan.

The 5140PK parthenogenetic clone, developed at the Scientific Research Institute of Sericulture, was used as the maternal breeding component. Commercial silkworm hybrids Mayin tola-1 (♀ Ipakchi-1 × ♂ Ya-120), Mayin tola-2 (♀ Ya-120 × ♂ Ipakchi-1), Navro‘z-3 (♀ L-51 × ♂ K-108), and Navro‘z-4 (♀ K-108 × ♂ L-51) were used as paternal breeding components to evaluate the combining ability of the parthenogenetic clone in the development of complex commercial hybrids.

Hybridization resulted in the development of the following hybrid combinations: 5140PK × Mayin tola-1, 5140PK × Mayin tola-2, 5140PK × Navro‘z-3, and 5140PK × Navro‘z-4. The widely cultivated commercial hybrid Ipakchi-2 × Ipakchi-1 was used as the control.

The reproductive performance (fecundity, egg weight, and individual egg weight), biological characteristics (larval viability, cocoon weight, cocoon shell weight, and shell ratio), technological traits (raw silk yield, reelability, silk productivity, metric number, and filament length), and economic efficiency of the developed hybrids were evaluated using the standard methods adopted in silkworm breeding.

The experimental data were statistically analyzed using Microsoft Excel 2021. Results are presented as mean ± standard error ($\bar{X} \pm Sx$).

All hybrid combinations were evaluated under identical rearing conditions following the standard silkworm rearing technology adopted by the Scientific Research Institute of Sericulture.

Results and Discussion. Reproductive performance is one of the primary criteria for evaluating the breeding value of parental components and newly developed silkworm hybrids. Traits such as fecundity, egg weight, and individual egg weight directly influence egg production efficiency, larval emergence, and the biological potential of subsequent generations. Therefore, comparative evaluation of these parameters provides reliable information on the combining ability of parental components and the breeding value of newly developed hybrids.

In the present study, the reproductive characteristics of complex commercial hybrids developed using the 5140PK parthenogenetic clone and commercial hybrid components were evaluated over three consecutive years (2023–2025). The obtained results are presented in Table 1.

Table 1

Reproductive characteristics of complex commercial silkworm hybrids developed using the 5140PK parthenogenetic clone and commercial hybrids (2023–2025)

No.	Hybrid combinations	Year	Average number of eggs, pcs	Average egg mass, mg	Weight of one egg, mg
1	5140PK x Mayin tola-1	2023	612	350	0.572
		2024	645	345	0.535
		2025	667	361	0.541
		X̄±Sx	**641.3 ± 16.0**	**352.0 ± 4.7**	**0.549 ± 0.011**
2	5140PK x Mayin tola-2	2023	608	312	0.529
		2024	634	321	0.525
		2025	660	365	0.521
		X̄±Sx	**634.0 ± 15.0**	**332.7 ± 16.4**	**0.525 ± 0.002**
3	5140PK x Navro‘z-3	2023	571	302	0.529
		2024	612	324	0.529
		2025	640	321	0.502
		X̄±Sx	**607.7 ± 20.0**	**315.7 ± 6.9**	**0.520 ± 0.009**
4	5140PK x Navro‘z-4	2023	595	310	0.521
		2024	631	321	0.509
		2025	634	319	0.503
		X̄±Sx	**620.0 ± 12.5**	**316.7 ± 3.4**	**0.511 ± 0.005**
Ipakchi-2 x Ipakchi-1 (Control)		2023	574	285	0.497
		2024	588	285	0.485
		2025	657	340	0.518
		X̄±Sx	**606.3 ± 25.7**	**303.3 ± 18.3**	**0.500 ± 0.010**

The data presented in Table 1 indicate that the reproductive performance of the complex commercial hybrids varied depending on the paternal breeding component used in the crosses. Among the studied combinations, 5140PK × Mayin tola-1 exhibited the highest reproductive potential, with an average fecundity of 641.3 eggs, an average egg mass of 352.0 mg, and an individual egg weight of 0.549 mg. Compared with the control hybrid (Ipakchi-2 × Ipakchi-1), fecundity increased by 35.0 eggs (5.8%), average egg mass by 48.7 mg (16.1%), and individual egg weight by 9.8%, indicating a positive effect of the 5140PK parthenogenetic clone on reproductive performance.

The 5140PK × Mayin tola-2 combination also demonstrated high reproductive ability, producing 634.0 eggs with an average egg mass of 332.7 mg. Although these values were slightly lower than those of 5140PK × Mayin tola-1, they remained considerably higher than the control, confirming the favorable combining ability of the parthenogenetic clone when crossed with commercial hybrids.

The hybrid combinations involving Navro'z-3 and Navro'z-4 produced intermediate results. Their average fecundity ranged from 607.7 to 620.0 eggs, while the average egg mass varied between 315.7 and 316.7 mg. These values were comparable to or slightly higher than the control but remained lower than those observed in the Mayin tola hybrid combinations. Such differences may be associated with the genetic characteristics and combining ability of the paternal breeding components.

The relatively low standard errors obtained for most reproductive traits indicate good stability of the investigated hybrid combinations during the three-year study period. Overall, the results demonstrate that the 5140PK parthenogenetic clone possesses high breeding value and can be effectively utilized as a maternal breeding component for developing high-productivity commercial

silkworm hybrids. In particular, the 5140PK × Mayin tola-1 combination showed the greatest reproductive advantage and may be recommended for further breeding and production evaluation.

The biological productivity of silkworm hybrids is one of the principal indicators determining their breeding value and commercial importance. Traits such as larval viability, cocoon weight, cocoon shell weight, and shell ratio directly influence cocoon yield, raw silk production, and the overall economic efficiency of sericulture. Therefore, comparative evaluation of these biological characteristics provides reliable information on the productivity and adaptive potential of newly developed commercial hybrids. The biological productivity of the complex hybrids developed using the 5140PK parthenogenetic clone was evaluated over a three-year period (2023–2025), and the obtained results are presented in Table 2.

Table 2.

Biological productivity of complex commercial silkworm hybrids developed using the 5140PK parthenogenetic clone (2023–2025)

No.	Hybrid combinations	Year	Larval viability, %	Average		Cocoon shell ratio, %
				cocoon weight, g	cocoon shell weight, mg	
1	5140PK x Mayin tola-1	2023	93.1	1.71	377	22.0
		2024	94.7	1.65	372	22.5
		2025	95.2	1.75	400	22.9
		X̄±Sx	**94.3 ± 0.6**	**1.70 ± 0.03**	**383 ± 8.6**	**22.5 ± 0.3**
2	5140PK x Mayin tola-2	2023	93.5	1.58	351	22.2
		2024	93.2	1.78	386	21.7
		2025	94.7	1.79	407	22.7
		X̄±Sx	**93.8 ± 0.5**	**1.72 ± 0.07**	**381 ± 16.2**	**22.2 ± 0.3**
3	5140PK x Navro‘z-3	2023	91.6	1.51	321	21.3
		2024	93.2	1.74	368	21.1
		2025	95.2	1.64	388	23.7
		X̄±Sx	**93.3 ± 1.0**	**1.63 ± 0.07**	**359 ± 19.6**	**22.0 ± 0.8**
4	5140PK x Navro‘z-4	2023	93.1	1.64	358	21.8
		2024	92.1	1.59	321	20.2
		2025	91.2	1.76	400	22.7
		X̄±Sx	**92.1 ± 0.6**	**1.66 ± 0.05**	**360 ± 22.9**	**21.6 ± 0.7**
Ipakchi-2 x Ipakchi-1 (Control)		2023	88.9	1.62	355	21.9
		2024	91.2	1.54	311	20.2
		2025	93.6	1.69	380	22.5
		X̄±Sx	**91.2 ± 1.4**	**1.62 ± 0.04**	**349 ± 20.2**	**21.5 ± 0.7**

The results presented in Table 2 demonstrated that the biological productivity of the developed complex commercial hybrids differed depending on the paternal breeding component. Among all hybrid combinations, 5140PK × Mayin tola-1 exhibited the highest biological performance, with an average larval viability of 94.3%, cocoon weight of 1.70 g, cocoon shell weight of 383 mg, and cocoon shell ratio of 22.5%. Compared with the control (Ipakchi-2 × Ipakchi-1), larval viability increased by 3.1 percentage points, cocoon shell weight by 34 mg (9.7%), and cocoon shell ratio by

1.0 percentage point (4.7%), indicating the positive influence of the 5140PK parthenogenetic clone on the biological productivity of the hybrids.

The 5140PK × Mayin tola-2 hybrid also demonstrated high biological productivity, recording the highest average cocoon weight (1.72 g) among all experimental combinations, while maintaining high larval viability (93.8%) and a cocoon shell ratio of 22.2%. These results indicate that this combination possesses a high production potential and favorable biological characteristics.

The hybrids 5140PK × Navro'z-3 and 5140PK × Navro'z-4 showed intermediate biological performance. Their larval viability ranged from 92.1% to 93.3%, while cocoon shell ratio varied between 21.6% and 22.0%. Although these values were generally higher than or comparable to those of the control, they remained lower than those recorded for the Mayin tola hybrid combinations. These differences may be attributed to the genetic characteristics and combining ability of the paternal breeding components.

The relatively small standard errors obtained for most biological traits indicate good stability of the evaluated hybrids over the three-year experimental period. Overall, the results confirmed that the 5140PK parthenogenetic clone possesses high breeding value and combining ability. In particular, the 5140PK × Mayin tola-1 and 5140PK × Mayin tola-2 combinations exhibited superior biological productivity and can be considered promising breeding materials for the development of high-yield commercial silkworm hybrids.

Technological characteristics are among the most important criteria for evaluating the commercial value of silkworm hybrids, as they directly determine raw silk yield and reeling performance. Parameters such as dry cocoon weight, raw silk yield, silk productivity, metric number of filament, non-breakable filament length, and total filament length are widely used to assess the technological efficiency and industrial suitability of newly developed hybrids. Therefore, comparative analysis of these traits provides a reliable basis for identifying promising hybrid combinations for commercial silk production. The technological characteristics of the complex commercial hybrids developed using the 5140PK parthenogenetic clone were evaluated during 2023–2025, and the obtained results are presented in Table 3.

Table 3.

Technological characteristics of complex commercial silkworm hybrids developed using the 5140PK parthenogenetic clone (2023–2025)

No.	Hybrid combinations	Year	Dry cocoon weight, g	Yield, %		Metric number of silk filament, m/g	Non-breakable filament length, m	Total filament length, m
				Raw silk	Silk productivity			
1	5140PK x Mayin tola-1	2023	0.702	44.21	48.99	3511	1000	1178
		2024	0.689	45.96	51.12	3800	1021	1165
		2025	0.777	47.12	50.89	3711	1025	1221
		X̄±Sx	**0.723±0.03**	**45.76±0.85**	**50.33 ± 0.68**	**3674 ± 85.45**	**1015 ± 7.75**	**1188 ± 16.92**
2	5140PK x Mayin tola-2	2023	0.681	43.87	49.54	3475	1030	1057
		2024	0.719	44.02	51.07	3601	1021	1181
		2025	0.751	46.32	51.99	3750	1089	1211
		X̄±Sx	**0.717±0.02**	**44.74±0.79**	**50.87 ± 0.72**	**3609 ± 79.48**	**1047 ± 21.33**	**1150 ± 47.14**
3	5140PK x	2023	0.605	41.71	48.12	3212	970	1100

	Navro‘z-3	2024	0.712	42.34	47.67	3451	870	1000
		2025	0.745	44.16	51.25	3406	1072	1215
		X̄±Sx	**42.74 ± 0.7**	**49.01±1.13**	**3356 ±73.33**	**971 ± 58.31**	**1105 ± 62.12**	**42.74 ± 0.74**
4	5140PK x Navro‘z-4	2023	0.695	42.87	46.41	3433	1002	1167
		2024	0.621	45.12	49.32	3345	921	1097
		2025	0.721	41.77	47.41	3595	1084	1170
		X̄±Sx	**0.679±0.03**	**3.25 ±0.99**	**47.71 ± 0.85**	**3458 ± 73.22**	**1002 ± 47.05**	**1145 ± 23.85**
Ipakchi-2 x Ipakchi-1 (Control)		2023	0.657	40.87	44.35	3120	891	1012
		2024	0.601	41.12	47.39	3352	1025	1200
		2025	0.772	44.89	49.25	3406	961	1100
		X̄±Sx	**0.677 ±0.05**	**42.29±1.30**	**47.00 ± 1.43**	**3293 ± 87.73**	**959 ± 38.70**	**1104 ± 54.31**

The technological characteristics of the developed complex commercial hybrids are presented in Table 3. The results demonstrated considerable differences among the hybrid combinations, indicating that the choice of paternal breeding component significantly influenced cocoon technological performance.

Among the evaluated hybrids, 5140PK × Mayin tola-1 exhibited the best overall technological performance. This hybrid produced the highest average dry cocoon weight (0.723 g), raw silk yield (45.76%), and total silk productivity (50.33%), exceeding the control (Ipakchi-2 × Ipakchi-1) by 6.1%, 3.47 percentage points, and 3.33 percentage points, respectively. In addition, the hybrid showed a high metric number of silk filament (3674 m/g) and a total filament length of 1188 m, indicating superior spinning quality and silk yield potential.

The 5140PK × Mayin tola-2 hybrid also demonstrated excellent technological characteristics. Although its average dry cocoon weight (0.717 g) was slightly lower than that of 5140PK × Mayin tola-1, it exhibited the highest silk productivity (50.87%) and the longest non-breakable filament length (1047 m) among the experimental hybrids. These characteristics indicate favorable technological performance and high industrial value.

The 5140PK × Navro'z-3 and 5140PK × Navro'z-4 combinations showed intermediate technological characteristics. Their average raw silk yield ranged from 42.74% to 43.25%, while silk productivity varied between 47.71% and 49.01%. Although these values were generally higher than or comparable to those of the control, they remained lower than those recorded for the Mayin tola hybrid combinations, suggesting relatively lower combining ability of these paternal components.

Overall, the results indicate that the 5140PK parthenogenetic clone effectively transferred favorable technological traits to its progeny when crossed with commercial breeding components. In particular, the combinations 5140PK × Mayin tola-1 and 5140PK × Mayin tola-2 consistently exhibited superior technological performance, confirming their high breeding value and potential for commercial silk production. These findings demonstrate that the use of the 5140PK parthenogenetic clone can contribute to the development of high-yielding commercial silkworm hybrids with improved technological characteristics.

Conclusion

The 5140PK parthenogenetic clone exhibited high combining ability when crossed with commercial breeding components. Among the studied hybrids, 5140PK × Mayin tola-1 showed the highest reproductive, biological and technological performance. The hybrid also demonstrated

superior economic efficiency under field conditions, indicating that the 5140PK clone is a valuable maternal breeding component for developing high-yield commercial silkworm hybrids.

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