**Report for year 2006**
**on**
**BACSA mini regional project**
**"Comparative studies of silkworm hybrids performance for sericultural enterprise development in Black, Caspian seas and Central Asia region"**

**Abstract:** *A comparative testing of the best 15 commercial $F_1$ silkworm hybrids, produced in Azerbaijan, Bulgaria, Turkey, Romania, Ukraine and Uzbekistan as countries from the Black, Caspian seas and Central Asia (BACSA) region and their comparison with hybrids from China, Italy, Japan and Korea as world recognized standards has been carried out in three testing centers in Azerbaijan, Bulgaria and Uzbekistan. The hybrids were reared in the spring season under the standard technology and the data were obtained and calculated following the internationally recognized methods. The results obtained allow making the following more important conclusions:In all the three countries as the best silkworm hybrid performed the Japanese Shunrei x Shogetsu which scores in every point having both high cocoon yield by one box of eggs and high raw silk productivity. The silkworm hybrids, produced in BACSA member countries have comparatively high hatchability, pupation rate, cocoon weight, shell weight and fresh cocoon yield by one box of silkworm eggs. Compared with the Japanese hybrid the local hybrids, excluding the hybrid Turon 1, which has only male individuals, manifested lower cocoon shell ratio, filament length, raw silk percentage and consecutively much lower raw silk yield by one box of eggs. The local hybrids as well as those from China, Korea and Italy showed raw silk yield by one box of silkworm eggs values far below the Japanese hybrid Shunrei x Shogetsu. The breeding work in the BACSA member countries should be directed towards improvement the silk productivity of the hybrids, by the same time preserving their comparatively high pupation rate and cocoon yield. Considering the results obtained from this testing we may recommend as silkworm egg exporters among the BACSA member countries Azerbaijan, Bulgaria, Turkey and Ukraine.*

**Key words:** silkworm, Bombyx mori L., BACSA, hybrids, testing

## Introduction

It has to be stated with sufficient reason that now-a-day successes in the world silkworm science and practice are built just on the most rationalized utilization of heterosis and hybridization. The selection is applied, in principle, to the crosses, with the aim of finding pairs of lines that cross well, so that the lines may be perpetuated and provide cross – bred individuals for commercial use. (Lea 1993, 1996; Harada, 1952; Hirobe, 1956; Yokojama, 1956; Craiciu and Otarasanu, 1971; Tadjieva, 1973; Craiciu et al., 1975; Akimenko, Braslavskii, 1976, 1977, 1984, 1995, 1997; Gvinipadze, Jobashvili, 1975; Kanarev, 1980; Nacheva, 1980, 1981, 1990; Shurshikova, 1981; Shahbazov, 1982; Petkov et al., 1987; Compriranona et al., 1987; Datta and Pershad, 1988; Tayade, 1987; Kantaratanakul et al., 1987; Jeong et al., 1990; Brasla and Matei, 1992; Vijaya and Das, 1992; Gupta et al., 1992; Sreerama et al., 1992; Osawa and Harada, 1994; Das et al., 1994; Badalov et al., 1993; Ignatova, 1999; Petkov et al., 1999; Greiss et al., 2003).

The silkworm breeds may form simple (A x B), triple [(A x B)x C] and double (four-way) crosses [(A x B) x (C x B)]. It is considered that the simple cross hybrids display a stronger hybrid vigor. On the other hand if compare the main quantitative characters values in the four-way hybrids with those in the initial parental pure lines, but not with the direct parents, the heterosis manifested is not very different from those detected in the simple cross hybrids (Tzenov, 2005, 2006). On studying different types of crosses, it was found that double

and triple hybrids do not show bigger variation on account of the commercial traits of cocoons compared with simple ones. For triple hybrids it is difficult to choose between hybrids of the [(Japanese x Japanese) x Chinese] type and these of the [(Chinese x Chinese) x Japanese] type, though the quality of silk from the latter is considered better (Lea, 1993, 1996).

Double crosses of the [(Japanese x Chinese) x (Japanese x Chinese)] type produce cocoons not enough uniform in shape and in thread length compared with those from the [(Japanese x Japanese) x (Chinese x Chinese)] type, which is preferable. There are no significant differences between the simple, three and four-way hybrids, except for the fecundity characters in the parents which are higher in three and four-way crosses, compared with the simple hybrids.

In all the three types of commercial hybrids it was detected a comparatively high heterosis expression, both for the mid-parent value (MP) and the higher parent value (HP) as regards the main quantitative traits, such as cocoon weight, shell weight, shell percentage as well as the complex character fresh cocoon yield by one box of silkworm eggs. (Lea, 1993, 1996; Petkov, 1976, 1984, 1995; Hirata, 1985; Braslavskii, 1990, 1992; Nacheva, 1990; Gupta et al., 1992; Brasla and Matei, 1992; Osawa and Harada, 1994; Petkov et al., 1999)

However in crossing of silkworm breeds, having very big differences between their productivity the main quantitative characters inheritance in $F_1$ is intermediate with a high and positive heterosis expression for the MP and negative heterosis for the HP (Tzenov et al., 1999).

Most of the BACSA member countries have a well developed silkworm breeding science, resulted in creation series of highly productive commercial $F_1$ hybrids. However these hybrids require providing the optimal conditions for silkworm rearing, otherwise due to their sensitivity they suffer from diseases (mostly NPV and flachery) and the cocoon yield at farmer's level is poor. By the same time the practice in some of the region countries manifested that some hybrids imported from Japan, China, Korea, Italy and Thailand showed comparatively better results. The poor local hybrid silkworm egg quality is one of the reasons, forced some region countries (Tajikistan, Uzbekistan) to import, mostly from China every year more than 50 % of the necessary silkworm eggs.

On the other hand the region has a very high potential as producer of high quality silkworm eggs for self supply as well as export to the countries in Africa, Europe, Central Asia and the Near East. Therefore the problem of hybrid silkworm eggs quality has both economical and scientific importance. From the economical point of view the self-supply with eggs would provide a lot of incomes to the local egg production factories and contribute to a big extent to sericulture preservation and revival in the region countries. On the other hand if the locally produced silkworm hybrids considerably fall against the imported ones, that means the silkworm germplasm and the breeding practices in BACSA countries need of a serious improvement. Considering the above there is a necessity to make a comparative testing of the best commercial $F_1$ silkworm hybrids, produced in the Black, Caspian seas and Central Asia (BACSA) region countries and their comparison with hybrids from China, Italy, Japan and Korea as world recognized standards.

The expected outputs of this study are:

- Obtaining information about the quality of commercial silkworm hybrids, produced in the Black, Caspian Seas and Central Asia region, in comparison with the leading world standards from China, Italy, Japan and Korea.
- Making conclusions and recommendations regarding necessities and directions for improvement of silkworm germplasm and breeding work in the Black, Caspian Seas and Central Asia region countries.

- Giving recommendations about possible suppliers of high quality silkworm eggs from BACSA countries, China, Italy, Japan and Korea to the silkworm egg importers from Africa, Europe, Central Asia and the Near East.

**Materials and methods**

**Allocation of the participating countries:**

During the second BACSA executive meeting, held from 6 to 10 March at Bursa, Turkey the following countries have been allocated to participate in the international testing with their commercial silkworm hybrids:
1) From the BACSA region: Azerbaijan, Bulgaria, Romania, Turkey, Ukraine and Uzbekistan
2) Out of the region: China, Italy, Japan and Korea (South).

**Allocation of the three testing centers:**

During the 2nd BACSA meeting, held from 6 to 10 March 2006 at Bursa, Turkey the following three testing centers were chosen:
Sericulture Research Institute, Gandja, Azerbaijan
Sericulture Experiment Station, Vratza, Bulgaria
Uzbek Sericulture Research Institute, Tashkent, Uzbekistan

**Providing the silkworm egg samples:**

After making contacts with the participating countries/institutions the following silkworm hybrids have been provided to each one of the three testing centers:

| **Hybrids** | **Country** | **Provider** | **Silkworm egg producer** |
|---|---|---|---|
| Mayak 2 x Mayak 3 | Azerbaijan | Dr B. Abbasov, Sericulture Research Institute, Gandja | Sericulture Research Institute, Gandja |
| Gandja 6 x Yashar | Azerbaijan | Dr B. Abbasov, Sericulture Research Institute, Gandja | Sericulture Research Institute, Gandja |
| Super 1 x Hesa 2 | Bulgaria | Dr N. Petkov, Sericulture Experiment Station, Vratza | Sericulture Experiment Station, Vratza |
| Vratza 35 x Marfa 2 | Bulgaria | Dr N. Petkov, Sericulture Experiment Station, Vratza | Sericulture Experiment Station, Vratza |
| Bai Yun x Qin Feng | China | Dr Y. Miao, Zhejiang National University, Hangzhou | Zhejiang Haining Slkworm Egg Station, Haining city, Zhejiang Province, China. |
| 71 x 70 x 125 x 121* | Italy | Dr S. Cappellozza, Sericulture Experiment Station, Padua | Sericulture Experiment Station, Padua |
| Shunrei x Shogetsu | Japan | Dr E. Kosegawa, Laboratory of Insect Genetics, National Institute of Agrobiological Science, Kobuchisawa 6585, Kitakoma-gun, Yamanashi-ken | Laboratory of Insect Genetics, National Institute of Agrobiological Science, Kobuchisawa 6585, Kitakoma-gun, Yamanashi-ken, Japan |
| Baegokjam | Korea | Dr K. S. Ryu and Dr P. Kang, Department of Agricultural Biology, National Institute of Agricultural Science and | Department of Agricultural Biology, National Institute of Agricultural Science and Technology, Rural |

| | | | |
|---|---|---|---|
| | | Technology, Rural Development Administration, Suwon | Development Administration, Suwon |
| Record** | Romania | Dr A. Matei, Commercial society "Sericarom" – Research department | Commercial society "Sericarom" – Research department |
| Baneasa** super | Romania | Dr A. Matei, Commercial society "Sericarom" – Research department, Bucharest | Commercial society "Sericarom" – Research department, Bucharest |
| N x M | Turkey | Mr. A. Karagozoglu, Sericultural cooperative "Kozabirlik", Bursa | Sericultural cooperative "Kozabirlik", Bursa |
| Ukr. 26 x Ukr. 18 | Ukraine | Dr O. Galanova, Sericulture Research Institute, Merefa | Sericulture Research Institute, Merefa |
| Ukr. 27 x Ukr. 15 | Ukraine | Dr O. Galanova, Sericulture Research Institute, Merefa | Sericulture Research Institute, Merefa |
| Ipakchi 1 x Ipakchi 2 | Uzbekistan | Dr H. Homidy, Uzbek Sericulture Research Institute, Tashkent | Uzbek Sericulture Research Institute, Tashkent |
| Turon ♂♂ | Uzbekistan | Dr H. Homidy, Uzbek Sericulture Research Institute, Tashkent | Uzbek Sericulture Research Institute, Tashkent |

*** Tested only in Azerbaijan and Bulgaria; ** Tested only in Bulgaria;**

The following methodology was kept in conformity with:

**Methodology of the silkworm rearing:**

The eggs were hatched in the spring season (April – may) in the volume of 3 g per hybrid.
After the second molt from each hybrid are counted 4 replicates, consisting of 200 larvae each, grown until the cocooning.
The rearing technology followed was the standard one. (Grekov et al., 2005).

**Methodology for obtaining the data and calculation of the main breeding characters values.**

**Qualitative characters**

-**egg serosa color:** It is determined visually on all the silkworm eggs of each hybrid before the start of incubation. The color could be gray-green, green-gray, brown, yellow, and yellow and gray in the sex-limited for egg color hybrids.

-**egg chorion color:** It is determined visually on all the silkworm eggs from each hybrid, immediately after the hatching. The color is white or yellow.

**-body color of the last instar larva:** It is determined visually on the $5^{th}$-$7^{th}$ day of the fifth instar on all silkworm larvae of the hybrid. It could be bluish white, yellowish white, reddish white, translucent, black and yellowish orange.

**-body shape of the last instar larva:** It is determined visually on the $5^{th}$-$7^{th}$ day of the fifth instar on all silkworm larvae of the hybrid. The body shape could be thinner and longer, normal, thicker and shorter, bigger and smaller.

**-larval markings:** It is determined visually on the $5^{th}$-$7^{th}$ day of the $5^{th}$ instar on the all larvae reared per each hybrid. The larval markings could be:
-plain;
-normal marked, having eye spot on the second thoracic segment, crescents on the second abdominal segment, and star spot on the fifth abdominal segment;
-pale marked;
-zebra;
-zebra with crescents and star spot;
-striped;

**-cocoon shape:** It is determined visually after harvesting and floss removal, on the whole amount of good quality cocoons produced per each hybrid. Cocoon shape is oval, elongated oval, elongated, elongated with constriction, spindle.

**-cocoon color:** It is determined visually after harvesting and floss removal on the whole amount of good quality cocoons produced per each hybrid. Cocoon color may be white and colored.

**-cocoon size:** It is determined on random sample of 100 good quality cocoons. The cocoon size is big, medium, small.

**-cocoon nature of grains:** It is determined on random sample of 100 good quality cocoons. It is fine, medium, coarse and flossy.

**Quantitative characters**

**-hatchability in %:** It is determined on 4 replicates, consisted of 200 normal eggs per each hybrid. It is calculated on the $3^{rd}$ day after hatching by the following formula:

$$Eggs\ \ hatchability\ \ =\ \ \frac{Number\ \ of\ \ normal\ \ eggs - number\ \ of\ \ non\ \ hatched\ \ eggs}{Number\ \ of\ \ normal\ \ eggs}\ \ x\ \ 100$$

**-larval duration in h:** The beginning is day and hour of larval brushing, the end is day and hour when the feeding is stopped and larvae mounted.

**-$5^{th}$ instar duration in h:** The beginning is day and hour of the first feeding after the $4^{th}$ molt, the end is day and hour when the feeding is stopped and larvae mounted.

**-pupation rate in %:** It is calculated by the formula:

$$Pupation\ \ rate\ \ =\frac{Number\ \ of\ \ cocoons\ \ with\ \ alive\ \ pupa}{Number\ \ of\ \ larvae\ \ counted\ \ after\ \ \sec ond\ \ moult}\ \ x\ \ 100$$

**-fresh cocoon grades in %:** It is determined after the cocoon harvesting and floss removal. The cocoons are assorted in good quality (having alive pupae and without any big defects on the shell), double cocoons and unreelable cocoons. After the assorting all the three categories are weighed and the percentage of each category towards the total cocoon yield is calculated.

**-fresh cocoon weight, and shell weight in g:** There are used the following two methods:
1. All good quality cocoons per replicate are weighed and after that divided by their number;
2.A random sample consisted of 30 female and 30 male good quality cocoons/shells is taken and after weighting their weight is divided by the number.

**-shell percentage:** It is calculated by the formula:

$$Shell\ \ percentage\ \ =\ \ \frac{Weight\ \ of\ \ cocoon\ \ shell}{Weight\ \ of\ \ fresh\ \ cocoon}\ \ x\ \ 100$$

**-fresh cocoon yield by replicate in kg:** It is determined by weighting all good quality cocoons obtained.

**-fresh cocoon yield by one box of eggs (20000 eggs) in kg:** It is calculated by the following formula:

$$Fresh\ \ cocoon\ \ yield\ \ =\ \ \frac{Cocoon\ \ yield\ \ per\ \ repetiiton}{Number\ \ of\ \ larvae\ \ in\ \ repetition}\ \ x\ \ eggs\ \ hatchabiliity\ \ x\ \ 20000$$

**-filament length in m:** It is determined on a random sample of 30 good quality cocoons after single cocoon reeling test.

**-filament weight in g:** After the cocoon reeling the filament is dried to constant weight and weighed.

**-filament size in denier:**It is calculated by the formula:

$$Filament\ \ size\ \ =\ \ \frac{Weight\ \ of\ \ filament}{Filament\ \ length}\ \ x\ \ 9$$

**-reelability in %:** It is calculated by the formula:

$$Cocoon\ \ reelability\ \ =\ \ \frac{Filament\ \ weight}{Filament\ \ weight+\ \ weight\ \ of\ \ other\ \ products}\ \ x\ \ 100$$

**-raw silk percentage:** The formula used is:

$$Raw\ \ silk\ \ percentage\ \ =\ \ \frac{Filament\ \ weight}{Weight\ \ of\ \ dry\ \ cocoon}\ \ x\ \ 100$$

**-raw silk yield by one box of silkworm eggs:** .The following formula is used:

$$Raw\ silk\ yield\ \ =\ \ Yield\ of\ \ fresh\ cocoons\ \ \ x\ \ \ dry\ cocoons\ percentage\ \ \ x\ \ \ raw\ silk\ \ percentage$$

Since the Italian and Romanian hybrids have not been tested in all the three centers in the discussion they are not considered for comparison with the other 12 hybrids.

**Results and discussion**

The results obtained are presented in Tables 1 - 9. It's evident from Table 1 that most of the hybrids tested had gray egg serosa color and white and yellow egg chorion color. The prevailing body color is bluish white, the body shape – normal and most of the hybrids had marked larvae.

The data, presented in Table 2 manifest that most of the silkworm hybrids have elongated oval cocoon shape, white cocoon color and medium cocoon size and nature of grains. It could be concluded that most of the silkworm hybrids tested manifested the normal for uni-bivoltine race qualitative characters.

Considering the way of delivery in this year the egg hatchability (Table 3) of the most hybrids was comparatively high in all the three testing centers. Since the eggs of Italian hybrid arrived already hatched and most of the larvae dead in Uzbekistan this hybrid was reared only in Azerbaijan and Bulgaria. The lower hatchability of the Uzbek hybrid Turon 1 is due to hatching only male individuals and dieing of the females what is a genetical peculiarity of this hybrid. In Azerbaijan and Bulgaria the hybrid Ipakchi 1 x Ipakchi 2 manifested too low hatchability.

In nearly all the hybrids the pupation rate in Azerbaijan was normal. In Bulgaria the pupation rate was lower in the hybrid Ukr. 26 x Ukr. 18 (72.86 %). In Uzbekistan the pupation rate was lower in the hybrids Majak 2 x Majak 3 (76.70 %), N x M (76.00 %) and Ukr. 26 x Ukr. 18 (73.50 %).

It may be concluded that in all the three countries the optimal rearing conditions provided led to a comparatively normal values of the pupation rate character.

The data presented in Table 4 show that in all the hybrids the highest values of cocoon weight and shell weight characters were obtained in Azerbaijan, followed by Bulgaria and they were the lowest in Uzbekistan. Among the hybrids with the highest fresh cocoon weight are characterized the Japanese Shunrei x Shogetsu (2.139 g in average) and Bulgarian Vratza 35 x Merefa 2 (2.110 g). The hybrids having the highest cocoon shell weight are Turon 1 (0.499 g), Shunrei x Shogetsu (0.499 g), Ukr. 27 x Ukr. 15 (0.452 g) and Vratza 35 x Merefa 2 (0.451 g). The hybrids which are characterized with comparatively higher cocoon shell ratio (Table 5) are Turon 1 (23.92 %), Shunrei x Shogetsu (23.33 %) and Baegokjam (22.34 %). As regards the complex character fresh cocoon yield by one box of eggs which is presented in Table 5 the three hybrids having the highest values may be ranged as follows: Shunrei x Shogetsu (39.227 kg), Ukr. 27 x Ukr. 15 (36.586 kg) and Vratzsa 35 x Merefa 2 (36.320 kg).

In table 6 are presented the data about cocoon filament length and reelability. The hybrids, having the longest cocoon filament are Shunrei x Shogetsu (1284 m), Baegokjam (1153 m) and Turon 1 (1138 m).

The reelability percentage is the highest in hybrids Bay Yun x Qin Feng (88.78 %), Super 1 x Hesa 2 (88.75), Shunrei x Shogetsu (88.61 %) and and Baegokjam (88.56 %).

The hybrids, having the highest raw silk percentage value (Table 7) are Turon 1 (44.10 %), Shunrei x Shogetsu (42.92 %) and Baegokjam (42.65 %).

The values of the most important both for the sericulture farmers and the silk reelers complex trait raw silk yield by one box of silkworm eggs are presented in Table 7 and manifest that the best hybrids are Shunrei x Shogetsu (7.09 kg), Vratza 35 x Merefa 2 (5.80 kg), Ukr. 27 x Ukr. 15 (5.77 kg) and Turon 1 (5.71 kg). It is evident that all the local hybrids as well as those from China, Korea and Italy showed raw silk yield by one box of silkworm eggs values far below the Japanese hybrid Shunrei x Shogetsu. That means the Japanese hybrid scores in every point: it has both high cocoon yield by one box of eggs and high raw silk productivity.

The average data representing the performance of the silkworm hybrids tested in the three countries are presented in Table 8.

The complex evaluation of the hybrids, based on the all 10 characters studied allows us to make the following gradation of the best hybrids:

The best hybrids from testing in Azerbaijan:

1. Shunrei x Shogetsu
2. Mayak 2 x Mayak 3
3. N x M
4. Ukr.26 x Ukr. 18

The best hybrids from testing in Bulgaria:

1. Shunrei x Shogetsu
2. Vratza 35 x Merefa 2
3. Ukr. 27 x Ukr. 15
4. Super 1 x Hesa 2
5. Turon 1

The best hybrids from testing in Uzbekistan:

1. Shunrei x Shogetsu
2. Turon 1
3. Ipakchi 1 x Ipakchi 2
4. Ukr. 27 x Ukr. 15

The best hybrids in average from the testing in Azerbaijan, Bulgaria and Uzbekistan:

1. Shunrei x Shogetsu
2. Vratza 35 x Merefa 2
3. Ukr. 27 x Ukr. 15
4. N x M

The results obtained allow making the following more important conclusions:

1. In all the three countries as the best silkworm hybrid performed the Japanese Shunrei x Shogetsu which scores in every point having both high cocoon yield by one box of eggs and high raw silk productivity.
2. The silkworm hybrids, produced in BACSA member countries have comparatively high hatchability, pupation rate, cocoon weight, shell weight and fresh cocoon yield by one box of silkworm eggs.
3. Compared with the Japanese hybrid the local hybrids, excluding the hybrid Turon 1, which has only male individuals, manifested lower cocoon shell ratio, filament length, raw silk percentage and consecutively much lower raw silk yield by one box of eggs.
4. The local hybrids as well as those from China, Korea and Italy showed raw silk yield by one box of silkworm eggs values far below the Japanese hybrid Shunrei x Shogetsu.
5. The breeding work in the BACSA member countries should be directed towards improvement the silk productivity of the hybrids, by the same time preserving their comparatively high pupation rate and cocoon yield.
6. Considering the results obtained from this testing we may recommend as silkworm egg exporters among the BACSA member countries Azerbaijan, Bulgaria, Turkey and Ukraine.

**Table 1. Qualitative characters in different silkworm hybrids**

| Hybrids | Country | Egg serosa color | Egg chorion color | Body color of the last instar larva | Body shape of the last instar larva | Larval markings |
|---|---|---|---|---|---|---|
| Mayak 2 x Mayak 3 | Azerbaijan | Gray | White, yellow | Bluish – white | Smaller | Plain and marked |
| Gandja 6 x Yashar | Azerbaijan | Gray | White, yellow | Bluish – white | Normal | Marked |
| Super 1 x Hesa 2 | Bulgaria | Gray | White | Bluish - white | Normal | Marked |
| Vratza 35 x Marfa 2 | Bulgaria | Gray | White | Bluish - white | Bigger | Marked and plain |
| Bai Yun x Qin Feng | China | Gray | White | Yellowish – white | Smaller | Plain |
| 71 x 70 x 125 x 121 | Italy | Gray | White | Bluish – white | Normal | Marked |
| Shunrei x Shogetsu | Japan | Gray | White, yellow | Bluish – white | Normal | Marked |
| Baegokjam | Korea | Gray | White, yellow | Bluish – white | Smaller | Marked |
| Record | Romania | Gray | White | Bluish – white | Normal | Marked |
| Baneasa super | Romania | Gray - green | White, yellow | Bluish – white | Normal | Marked |
| N x M | Turkey | Gray | White, yellow | Bluish - white | Normal | Marked |
| Ukr. 26 x Ukr. 18 | Ukraine | Gray | White, yellow | Bluish – white | Bigger | Plain and marked |
| Ukr. 27 x Ukr. 15 | Ukraine | Gray-green | yellow | Bluish – white | Normal | Plain and marked |
| Ipakchi 1 x Ipakchi 2 | Uzbekistan | Gray | White, yellow | Bluish – white | Normal | Plain and marked |
| Turon ♂♂ | Uzbekistan | Gray | White, yellow | Bluish – white | Normal | Marked |

**Table 2. Qualitative characters in different silkworm hybrids**

| Hybrids | Country | Cocoon shape | Cocoon color | Cocoon size | Cocoon natu |
|---|---|---|---|---|---|
| Mayak 2 x Mayak 3 | Azerbaijan | Oval elongated | White | Big | Coarse |
| Gandja 6 x Yashar | Azerbaijan | Elongated oval | White | Small | Medium |
| Super 1 x Hesa 2 | Bulgaria | Elongated oval | White | Medium | Fine |
| Vratza 35 x Marfa 2 | Bulgaria | Elongated oval | White | Medium | Medium |
| Bai Yun x Qin Feng | China | Elongated oval | White | Small | Medium |
| 71 x 70 x 125 x 121 | Italy | Elongated oval | White | Medium | Medium |
| Shunrei x Shogetsu | Japan | Elongated oval | White | Medium | Fine |
| Baegokjam | Korea | Elongated oval | White | Small | Medium |
| Record | Romania | Elongated oval | White | Medium | Medium |
| Baneasa super | Romania | Elongated oval | White | Medium | Coarse |
| N x M | Turkey | Elongated oval | White | Big | Coarse |
| Ukr. 26 x Ukr. 18 | Ukraine | Elongated oval | White | Big | Coarse |
| Ukr. 27 x Ukr. 15 | Ukraine | Elongated oval | White | Medium | Medium |
| Ipakchi 1 x Ipakchi 2 | Uzbekistan | Elongated oval | White | Medium | Medium |
| Turon ♂♂ | Uzbekistan | Elongated oval | White | Medium | Medium |

**Table 3. Hatchability and pupation rate**

| Hybrids | Hatchability (%) | | | | Pupation rate (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Azerbaijan | Bulgaria | Uzbekistan | average | Azerbaijan | Bulgaria | Uzbekistan | average |
| Mayak 2 x Mayak 3 | 95.00 | 96.50 | 96.50 | **96.00** | 91.50 | 87.62 | 76.70 | **85.27** |
| Gandja 6 x Yashar | 94.10 | 92.60 | 93.00 | **93.23** | 90.50 | 94.64 | 80.50 | **88.55** |
| Super 1 x Hesa 2 | 91.50 | 95.75 | 92.40 | **93.22** | 88.80 | 96.91 | 91.00 | **92.24** |
| Vratza 35 x Marfa 2 | 91.80 | 94.50 | 94.50 | **93.60** | 90.60 | 94.72 | 79.30 | **88.21** |
| Bai Yun x Qin Feng | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 99.00 | 98.25 | 93.50 | **96.92** | 93.00 | 94.64 | 89.50 | **92.38** |
| 71 x 70 x 125 x 121 | 83.60 | 97.50 | - | **90.55*** | 95.60 | 94.98 | - | **95.29*** |
| Shunrei x Shogetsu | 98.40 | 98.50 | 96.50 | **97.80** | 86.00 | 96.07 | 91.30 | **91.12** |
| Backokjam | 90.50 | 91.75 | 96.50 | **92.92** | 92.20 | 95.52 | 81.00 | **89.57** |
| Record | - | 90.00 | - | **90.00**** | - | 87.74 | - | **87.74**** |
| Baneasa super | - | 96.50 | - | **96.50**** | - | 92.50 | - | **92.50**** |
| N x M | 95.80 | 98.50 | 94.00 | **96.10** | 89.80 | 85.48 | 76.00 | **83.76** |
| Ukr. 26 x Ukr. 18 | 97.40 | 96.50 | 92.80 | **95.57** | 85.50 | 72.86 | 73.50 | **77.29** |
| Ukr. 27 x Ukr. 15 | 95.00 | 98.25 | 94.80 | **96.02** | 86.20 | 94.76 | 85.60 | **88.85** |
| Ipakchi 1 x Ipakchi 2 | 88.10 | 77.50 | 94.00 | **84.53** | 87.50 | 95.11 | 85.00 | **89.20** |
| Turon ♂♂ | 80.90 | 81.00 | 62.50 | **74.80***** | 89.20 | 88.10 | 80.50 | **85.93***** |

*** Tested only in Azerbaijan and Bulgaria; ** Tested only in Bulgaria; *** Having only male individuals**

**Table 4. Cocoon weight and cocoon shell weight**

| **Hybrids** | **Cocoon weight (g)** | | | | **Cocoon shell weight (g)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** |
| Mayak 2 x Mayak 3 | 2.320 | 1.952 | 1.550 | **1.941** | 0.514 | 0.412 | 0.322 | **0.416** |
| Gandja 6 x Yashar | 2.360 | 1.893 | 1.550 | **1.934** | 0.498 | 0.394 | 0.335 | **0.409** |
| Super 1 x Hesa 2 | 2.520 | 2.107 | 1.320 | **1.982** | 0.523 | 0.435 | 0.265 | **0.408** |
| Vratza 35 x Marfa 2 | 2.550 | 2.220 | 1.560 | **2.110** | 0.528 | 0.510 | 0.316 | **0.451** |
| Bai Yun x Qin Feng | 2.170 | 1.745 | 1.220 | **1.712** | 0.465 | 0.393 | 0.254 | **0.371** |
| 71 x 70 x 125 x 121 | 2.310 | 1.982 | - | **2.146*** | 0.449 | 0.387 | - | **0.418*** |
| Shunrei x Shogetsu | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2.560 | 2.187 | 1.870 | **2.139** | 0.622 | 0.518 | 0.356 | **0.499** |
| Baegokjam | 2.200 | 1.864 | 1.320 | **1.795** | 0.491 | 0.421 | 0.292 | **0.401** |
| Record | - | 2.307 | - | **2.307**** | - | 0.467 | - | **0.467**** |
| Baneasa super | - | 2.194 | - | **2.194**** | - | 0.445 | - | **0.445**** |
| N x M | 2.360 | 2.184 | 1.550 | **2.031** | 0.529 | 0.461 | 0.342 | **0.444** |
| Ukr. 26 x Ukr. 18 | 2.480 | 2.319 | 1.300 | **2.033** | 0.542 | 0.521 | 0.263 | **0.442** |
| Ukr. 27 x Ukr. 15 | 2.460 | 2.201 | 1.570 | **2.077** | 0.528 | 0.493 | 0.338 | **0.452** |
| Ipakchi 1 x Ipakchi 2 | 2.210 | 2.198 | 1.600 | **2.003** | 0.479 | 0.460 | 0.336 | **0.425** |
| Turon ♂♂ | 2.480 | 2.258 | 1.520 | **2.086***** | 0.585 | 0.540 | 0.372 | **0.499***** |

*** Tested only in Azerbaijan and Bulgaria; ** Tested only in Bulgaria; *** Having only male individuals**

**Table 5. Cocoon shell ratio and fresh cocoon yield by one box of eggs**

| **Hybrids** | **Cocoon shell ratio (%)** | | | | **Fresh cocoon yield by one box of eggs (kg)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** |
| Mayak 2 x Mayak 3 | 22.16 | 21.35 | 20.78 | **21.43** | 38.216 | 33.010 | 27.500 | **32.910** |
| Gandja 6 x Yashar | 21.10 | 21.00 | 21.16 | **21.15** | 37.567 | 33.179 | 28.900 | **33.220** |
| Super 1 x Hesa 2 | 20.75 | 20.69 | 20.00 | **20.59** | 38.837 | 38.218 | 27.800 | **34.950** |
| Vratza 35 x Marfa 2 | 21.02 | 23.38 | 20.20 | **21.37** | 39.586 | 40.661 | 28.700 | **36.320** |
| Bai Yun x Qin Feng | 21.43 | 22.59 | 20.80 | **21.67** | 35.650 | 32.152 | 20.800 | **29.530** |
| 71 x 70 x 125 x 121 | 19.41 | 19.75 | - | **19.48*** | 35.135 | 36.716 | - | **35.930*** |
| Shunrei x Shogetsu | 24.30 | 23.09 | 21.20 | **23.33** | 41.278 | 41.103 | 35.300 | **39.227** |
| Baegokjam | 22.32 | 23.20 | 22.08 | **22.34** | 33.558 | 32.734 | 24.800 | **30.364** |
| Record | - | 20.36 | - | **20.36**** | - | 36.135 | - | **26.135**** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Baneasa super | - | 20.51 | - | **20.51**** | - | 39.168 | - | **39.168**** |
| N x M | 22.42 | 21.03 | 22.00 | **21.86** | 38.296 | 36.497 | 27.300 | **34.030** |
| Ukr. 26 x Ukr. 18 | 21.85 | 22.70 | 20.10 | **21.74** | 39.023 | 32.610 | 22.100 | **31.244** |
| Ukr. 27 x Ukr. 15 | 21.46 | 22.59 | 21.50 | **21.81** | 37.577 | 40.982 | 31.200 | **36.586** |
| Ipakchi 1 x Ipakchi 2 | 21.67 | 21.09 | 21.00 | **21.22** | 31.795 | 29.894 | 31.500 | **31.063** |
| Turon ♂♂ | 23.59 | 23.91 | 24.50 | **23.92***** | 32.133 | 32.227 | 28.700 | **31.020** |

*** Tested only in Azerbaijan and Bulgaria; ** Tested only in Bulgaria; *** Having only male individuals**

**Table 6. Cocoon filament length and reelability**

| **Hybrids** | **Cocoon filament length (m)** | | | | **Reelability (%)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** |
| Mayak 2 x Mayak 3 | 1191 | 1008 | 689 | **963** | 87.80 | 89.03 | 83.20 | **86.68** |
| Gandja 6 x Yashar | 1153 | 1004 | 650 | **936** | 87.30 | 86.52 | 83.50 | **85.77** |
| Super 1 x Hesa 2 | 1131 | 1182 | 897 | **1070** | 85.100 | 95.64 | 85.50 | **88.75** |
| Vratza 35 x Marfa 2 | 1096 | 1208 | 986 | **1097** | 78.40 | 89.82 | 84.50 | **84.24** |
| Bai Yun x Qin Feng | 1140 | 995 | 1050 | **1062** | 87.70 | 91.45 | 87.20 | **88.78** |
| 71 x 70 x 125 x 121 | 1252 | 1020 | - | **1136*** | 89.10 | 90.14 | - | **89.62*** |
| Shunrei x Shogetsu | 1405 | 1331 | 1115 | **1284** | 85.10 | 92.14 | 88.60 | **88.61** |
| Baegokjam | 1162 | 1041 | 1256 | **1153** | 88.20 | 90.18 | 87.30 | **88.56** |
| Record | - | 1108 | - | **1108**** | - | 87.12 | - | **87.12**** |
| Baneasa super | - | 1097 | - | **1097**** | - | 84.06 | - | **84.06**** |
| N x M | 1310 | 1222 | 987 | **1173** | 80.60 | 90.87 | 85.70 | **85.72** |
| Ukr. 26 x Ukr. 18 | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1210 | 1076 | 972 | **1086** | 82.00 | 82.96 | 83.50 | **82.82** |
| Ukr. 27 x Ukr. 15 | 1120 | 1154 | 968 | **1081** | 81.30 | 87.37 | 82.50 | **83.72** |
| Ipakchi 1 x Ipakchi 2 | 1069 | 967 | 967 | **1001** | 80.00 | 87.97 | 87.50 | **85.16** |
| Turon ♂♂ | 1212 | 1185 | 1017 | **1138*** ** | 84.30 | 91.05 | 88.00 | **87.78*** ** |

*** Tested only in Azerbaijan and Bulgaria; ** Tested only in Bulgaria; *** Having only male individuals**

**Table 7. Raw silk percentage and raw silk yield by one box of eggs**

| **Hybrids** | **Raw silk percentage (%)** | | | | **Raw silk yield by one box of eggs (kg)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** | **Azerbaijan** | **Bulgaria** | **Uzbekistan** | **average** |
| Mayak 2 x Mayak 3 | 44.00 | 40.02 | 38.15 | **40.78** | 7.09 | 5.24 | 4.30 | **5.54** |
| Gandja 6 x Yashar | 42.10 | 37.65 | 35.69 | **38.48** | 6.43 | 4.99 | 4.23 | **5.22** |
| Super 1 x Hesa 2 | 41.10 | 37.78 | 36.40 | **38.43** | 6.42 | 5.83 | 4.15 | **5.47** |
| Vratza 35 x Marfa 2 | 39.60 | 40.68 | 37.80 | **39.36** | 6.34 | 6.61 | 4.45 | **5.80** |
| Bai Yun x Qin Feng | 42.10 | 39.83 | 39.86 | **40.60** | 6.27 | 5.07 | 3.40 | **4.91** |
| 71 x 70 x 125 x 121 | 42.50 | 39.70 | - | **41.10*** | 5.80 | 5.66 | - | **5.73*** |
| Shunrei x Shogetsu | 45.00 | 42.35 | 41.42 | **42.92** | 8.24 | 7.05 | 5.99 | **7.09** |
| Baegokjam | 44.30 | 42.82 | 40.84 | **42.65** | 6.28 | 5.57 | 4.15 | **5.33** |
| Record | - | 30.44 | - | **30.44**** | - | 4.33 | - | **4.33**** |
| Baneasa super | - | 39.52 | - | **39.52**** | - | 4.80 | - | **4.80**** |
| N x M | 40.90 | 38.50 | 37.46 | **38.95** | 6.72 | 5.62 | 4.19 | **5.51** |
| Ukr. 26 x Ukr. 18 | 40.60 | 37.11 | 39.10 | **38.94** | 6.64 | 4.68 | 3.54 | **4.95** |
| Ukr. 27 x Ukr. 15 | 39.0 | 39.80 | 35.28 | **38.33** | 6.28 | 6.51 | 4.51 | **5.77** |
| Ipakchi 1 x Ipakchi 2 | 40.90 | 38.05 | 37.16 | **38.70** | 5.43 | 4.61 | 4.80 | **4.95** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Turon ♂♂ | 44.20 | 45.55 | 42.55 | **44.10** | 6.15 | 5.96 | 5.01 | **5.71** |

*** Tested only in Azerbaijan and Bulgaria; ** Tested only in Bulgaria; *** Having only male individuals**

**Table 8. Average performance of the silkworm hybrids tested**

| **Hybrids** | **Country** | **Hatchability (%)** | **Pupation rate (%)** | **Fresh cocoon weight (g)** | **Cocoon shell weight (g)** | **Cocoon shell percentage (%)** |
|---|---|---|---|---|---|---|
| Mayak 2 x Mayak 3 | Azerbaijan | 96.00 | 85.27 | 1.941 | 0.416 | 21.43 |
| Gandja 6 x Yashar | Azerbaijan | 93.23 | 88.55 | 1.934 | 0.409 | 21.15 |
| Super 1 x Hesa 2 | Bulgaria | 93.22 | 92.24 | 1.982 | 0.408 | 20.59 |
| Vratza 35 x Marfa 2 | Bulgaria | 93.60 | 88.21 | 2.110 | 0.457 | 21.37 |
| Bai Yun x Qin Feng | China | 96.92 | 92.38 | 1.112 | 0.371 | 21.67 |
| 71 x 70 x 125 x 121 | Italy | 90.55* | 95.29* | 2.146* | 0.418* | 19.48* |
| Shunrei x Shogetsu | Japan | 97.80 | 91.12 | 2.139 | 0.499 | 23.33 |
| Baegokjam | Korea | 92.92 | 89.57 | 1.795 | 0.401 | 22.34 |
| Record | Romania | 90.00** | 87.74** | 2.307** | 0.467** | 20.36** |
| Baneasa super | Romania | 96.50** | 92.50** | 2.194** | 0.445 | 20.57** |
| N x M | Turkey | 96.10 | 83.76 | 2.031 | 0.444 | 21.86 |
| Ukr. 26 x Ukr. 18 | Ukraine | 95.57 | 77.29 | 2.033 | 0.442 | 21.74 |
| Ukr. 27 x Ukr. 15 | Ukraine | 96.02 | 88.85 | 2.077 | 0.453 | 21.81 |
| Ipakchi 1 x Ipakchi 2 | Uzbekistan | 84.53 | 89.20 | 1.003 | 0.425 | 21.22 |
| Turon ♂♂ | Uzbekistan | 74.80*** | 85.93*** | 2.086*** | 0.499*** | 23.99*** |

**Table 9. Average performance of the silkworm hybrids tested**

| **Hybrids** | **Country** | **Fresh cocoon yield by one box of eggs (kg)** | **Cocoon filament length (m)** | **Reelabiliti (%)** | **Raw silk percentage (%)** | **Raw silk yield by one box of eggs (kg)** |
|---|---|---|---|---|---|---|
| Mayak 2 x Mayak 3 | Azerbaijan | 32.910 | 963 | 86.68 | 40.78 | 5.54 |
| Gandja 6 x Yashar | Azerbaijan | 33.220 | 936 | 85.77 | 38.48 | 5.22 |
| Super 1 x Hesa 2 | Bulgaria | 34.950 | 1070 | 88.75 | 38.43 | 5.47 |
| Vratza 35 x Marfa 2 | Bulgaria | 36.320 | 1097 | 84.24 | 39.36 | 5.80 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Bai Yun x Qin Feng | China | 29.530 | 1062 | 88.78 | 40.60 | 4.91 |
| 71 x 70 x 125 x 121 | Italy | 35.930* | 1136* | 89.62* | 47.10* | 5.73* |
| Shunrei x Shogetsu | Japan | 39.227 | 1284 | 88.61 | 42.92 | 7.09 |
| Baegokjam | Korea | 30.364 | 1153 | 88.56 | 42.65 | 5.33 |
| Record | Romania | 36.135** | 1108** | 87.12** | 30.44** | 4.33** |
| Baneasa super | Romania | 39.168** | 1097** | 84.06** | 39.52** | 4.80** |
| N x M | Turkey | 34.030 | 1173 | 85.72 | 38.95 | 5.51 |
| Ukr. 26 x Ukr. 18 | Ukraine | 37.244 | 1086 | 82.82 | 38.94 | 4.95 |
| Ukr. 27 x Ukr. 15 | Ukraine | 36.586 | 1081 | 83.72 | 38.33 | 5.77 |
| Ipakchi 1 x Ipakchi 2 | Uzbekistan | 31.063 | 1001 | 85.16 | 38.70 | 4.95 |
| Turon ♂♂ | Uzbekistan | 31.020 | 1138*** | 87.78*** | 44.10*** | 5.71*** |