10th BACSA INTERNATIONAL CONFERENCE

"Regeneration of sericultural industries in 21st century"

"REGESERI" 2023

PROCEEDINGS

Soufli, Greece

April 24th – 27th 2023

increases his income. Shell weight (cocoon after the pupa is removed) is related to the amount of silk that each cocoon has. Since shell weight did not differ significantly between the two varieties, this means that other factors also involve in silk production besides protein content in silkworm's food.

REFERENCES

Aruga, H. 1994. Principles of Sericulture. A. A. Balkema, Rotterdam. 376 pp.

Bongale, U. D., Chaluvachari, R. S. Mallikarjunappa, B. V. Narahari Rao, M. N. Anantharaman and S. B. Dandin 1997. Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus spp.*). Sericologia 37(1): 71-81.

Das P. K., P. C. Choudhury, Y. K. Gupta, A. Ghosh and R. K. Datta 1993. Effect of different levels of nitrogen, phosphorus and spacings on the growth, yield and nutritional quality of mulberry under rainfed conditions. Indian Journal of Sericulture 32(2):201-207.

Kumar, V., M.T. Himantharaj, R.K. Rajan, V.B. Mathur, C.K. Kamble and R.K. Datta 1994. Simple leaf preservation for young age silkworm rearing. Indian Silk 32(9): 20-21.

In, A., J. W. Latimer and W. Horwitz editors 2005. Official Methods of Analysis; AOAC International press: Washington DC.

Machii and Katagiri, 1990. Varietal differences in food value of mulberry leaves with special reference to production efficiency of cocoon shell. Journal of Sericultural Science. Japan 59(1): 34-42.

Minamizawa, K. 1997. Moriculture: Science of Moriculture Cultivation. A. A. Balkema, Rotterdam.431 pp.

Sarkar, A. and H. Fujita 1994. Better technique for nutritive evaluation of mulberry leaves for silkworm, *Bombyx mori* L. Indian Journal of Sericulture 33(1):19-22.

Shankar, M.A., K. Shivashankar and M.C. Devaiah 1994. Effect of feeding mulberry leaves deficient in secondary nutrients on larval growth, development, cocoon weight and silk quality. Sericologia 34(3): 511-518.

LABOR SAVING TECHNOLOGY FOR SILKWORM REARING IN BULGARIA

By

Panomir Tzenov[1]*, Krasimira Avramova[2], Dimitar Grekov[2]

Agricultural Academy, Scientific Center on Sericulture, Vratsa 3000, Bulgaria

[2]Agricultural University, Plovdiv 4000, Bulgaria

***e-mail: panomir@yahoo.com**

ABSTRACT

During the period 2019 – 2022, at the Scientific Center on Sericulture, Vratsa, Bulgaria a 4-year field testing, using 3 Bulgarian hybrids, tolerant to adverse rearing conditions in a volume of 9 silkworm egg boxes has been conducted. The silkworm rearing was performed during the spring season. During the 1st and 2nd instars the larvae were reared in cartoon boxes and covered by nylon. After the beginning of 3rd instar the silkworm larvae were moved to constructions with movable trays. The feeding was 1 time per day up to the 2nd day of 5th instar and two times per day after that. The bed was not cleaned during the larval feeding. It was detected that the labor saving

technology tested provided obtaining of comparatively high cocoon yield and percentage of cocoons with alive pupae, by the same time at 2 times less labor expenditures, compared with the standard technology.

Key words: sericulture, rearing technology, labor, cocoons

INTRODUCTION

The favourable climatic conditions in Bulgaria and the existing rich national traditions are fundamental prerequisites for sericulture development. It could be an economically effective sub-sector of agriculture, as it can supply incomes for silkworm farmers in a significantly short period of time, as well as new working places and raw material for textile industry. The following factors influence significantly the silkworm development and productivity: the breed /hybrid/, the used rearing technology and environmental conditions (temperature and air humidity; ventilation in the room; quantity and quality of mulberry leaves).

In recent years there have been developed improved technologies of silkworm rearing aiming at lowering the electricity expenses and using less labour force in the process. Vasta et.al (2023) have proposed to automatize the process of sorting out cocoons by quality as they have developed the first prototype of the machine.

Ohura (2003) has developed a system for automatized insect breeding aiming at industrial production. The technology has a control program. After evaluation of the machine functionality, it has been established that its vibration and noise do not affect the silkworm growth and productivity. Henceforth, the process of larvae rearing in the fifth age can be completely automatized.

One of the main problems in sericulture is the maintenance of a relevant temperature-humidity regime during the period of silkworm feeding and cocoon spinning (Rahmathulla 2012). The success in sericulture depends on the environmental conditions, especially the biotic and abiotic factors. With relation to abiotic factors, temperature plays a main role for larval growth and productivity (Ueda 1975, Benchamin 1986). According to some research studies, high-quality cocoons are obtained at temperatures between 22–27°C. The presence of higher temperature values leads to lower-quality cocoons (Krishanswami 1973). The optimum temperature for silkworm rearing is between 20°C and 28°C, depending on the larval age. On the other hand, humidity is a factor influencing larval physiological functions and mulberry leaf drying rate.

According to Sodiqov (2023), the use of cloth and polyethylene foil for humidity preservation shortens the larval period with 2.7-4.0 days and leads to considerable growth of larva weight.

The silkworm rearing at the farmer's level in Bulgaria is mostly based on the traditional technology, namely feeding 3 – 4 times per day in the young ages and 2 – 3 times daily in the 4^{th} and 5^{th} instars by leaves and/or shoots, which requires higher labour expenses.

The present study purpose was to develop a labour saving technology in order to reduce the cocoon production costs and make the sericulture more profitable for the farmers.

MATERIALS AND METHODS

The study has been carried out during the period 2019 – 2022 at the Scientific Center of Sericulture – Vratsa. The experiment included 3 silkworm hybrids, which were tolerant to unfavourable rearing conditions, in 9 boxes of silkworm eggs each year. The silkworm rearing was performed in the spring season. During the first and second instars the silkworms were reared in cardboard boxes sizing 100 cm/60 cm/20 cm, arranged on a cross one over another. During both instars the silkworms were covered with polyethylene. During the young ages the mulberry leaves were cut by a cutting machine. The machine was designed and made at the Ukrainian Sericulture

Research Institute, Merefa, Kharkov district in early 90's. The machine capacity is 65 kg of fresh mulberry leaves per 1 hour.

After the beginning of 3rd instar the silkworm larvae were moved to constructions with movable trays. The rearing was performed at one level, on the floor. The pipes are installed on the floor by putting them into bigger pipes, welded on the floor. There's a wheel tray for feeding by mulberry branches/shoots and nylon net around the rearing bed in order to prevent larvae, leaf, remnants of excrement's dropping. The feeding was 1 time per day up to the 2nd day of 5th instar and two times per day after that.

From the third instar the silkworm rearing was done with whole mulberry branches, on deep unchangeable bedding, the mountages used for cocoon spinning were laid directly on the bedding, which was cleaned after the cocoons were harvested. The cocoons were deflossed by a deflossing machine, designed and made in Uzbekistan in 80's. The machine capacity is 60 kg of fresh cocoon per hour.

In the period from the beginning of fifth instar age to the cocoon harvesting the rearing room was not heated or cooled because the natural air temperature varied from 17 – 30 º C and the silkworm hybrids reared were tolerant to adverse rearing conditions.

The following character values were detected: yield of cocoons from one box of silkworm eggs, % of cocoons with live pupa, average cocoon weight, silk shell weight and silk shell %. The data obtained were mathematically processed (Lidanski, 1988).

RESULTS AND DISCUSSION

The results obtained are presented in Tables 1, 2, 3 and 4.

During the four experimental years for the hybrid Nova 2 x HB2 it was observed that cocoon yield from one box of silkworm eggs gradually grew, as in 2019 the values were from 31.23 kg, and in 2022 the values were 33.15 kg. The highest value of yield was reported in 2021 – 34.95 kg. In the three-year period – from 2019 to 2021 there was an increase with 3.72 kg, and after that in 2022 there was a slight decrease in yields up to 33.15 kg. Taking into account the same hybrid, the % of cocoons with alive pupa had preserved its comparatively high values - over 90% during the four experimental years. Cocoon weight gradually decreased during the years of silkworm rearing. In 2019 it had values from 1972 mg and in the last experimental year it reached 1596 mg, which was 376 mg less. The same tendency was observed regarding the silk shell weight – in 2019 it was 390 mg, and in 2022 – 307 mg, which was 83 mg less. In the four years the cocoon silkiness was within the bounds of 19-20%. Only in 2020 it was 20.58%.

The other hybrid - SN1xIva1 was reported with lowest values of cocoon yield already in the first year of study compared to the three tested hybrids. These values were preserved in the period 2019-2022, when the yield was within the bounds between 26-28 kg, and in 2021 there were reported extremely low values – 23.95 kg. In the same year there were reported low values of the other characters – cocoon weight, silk shell weight, silkiness. In the year 2021 all hybrids were established with lower values of the characters in comparison to the rest three experimental years. It could be due to a worse mulberry leaf quality. The hybrid SN1xIva1 showed high values of cocoon weight in 2019 – from 2038 mg, as this value was the highest among the three hybrids for the whole experimental period. After that this value started steadily decreasing, as in 2021 it reached the critical low value of 1623 mg, which was 415 mg less than in 2019. The next year these values were slightly increased up to 1752 mg, or 129 mg more than in 2021 and 286 mg less than in 2019. The same tendency was observed regarding the silk shell weight, where at the beginning of the experiment the values were 405 mg, in 2021 they went down to 286 mg, followed by a slight growth in 2022. The difference in silk shell weight values from 2019 to 2022 was 119 mg for the hybrid SN1xIva1. At the same time, in 2019 when the experiment started, the hybrid SN1xIva1 was reported with the highest values of cocoon weight and silk shell weight compared

to all hybrids tested. With relation to the silkiness character, the same tendency was observed – in 2019 it started with the highest value of silkiness compared to all hybrids – 19.87%, after that there was a decrease to 17.62% in 2021 followed by an increase up to 19.52 % in the last experimental year, which was the highest value compared to all tested hybrids. The percent of cocoons with alive pupa varied – from 85% in 2020, which was the lowest value for all years of study, to 96% in 2022.

The last tested hybrid Iva1 x VB1 was established with similar values of cocoon yield from one box of silkworm eggs in the first and fourth years of study – at the beginning of 2019 the yield was 34.27 kg, and in the last year – 34.80 kg. It made an impression that in 2021 there were reported extremely low values of 30 kg compared to the rest years of rearing. The hybrid Iva1 x VB1 showed the highest values of the cocoon yield from one box of silkworm eggs trait, as these values were comparatively high during the whole experimental period – 30 kg or above 30 kg. With relation to the percent of cocoons with alive pupa, in 2020 and 2022 there were equal values of 98%, and in the other two years, 2019 and 2021, the values were 90% for both years. The cocoon weight character showed a stable increase in values, as at the beginning of the experimental period the hybrid started with values of 1480 mg and in the last year there were values of 1972 mg. It was the highest value for this trait compared to all hybrids tested.

The silk shell weight trait for the hybrid Iva1 x VB1 showed a significant increase in values during the period – in 2019 the hybrid had values of 253 mg, which was the lowest value regarding this experimental year and this trait. The following year these values grew up to 344 mg, and in 2022 they reached 343 mg. The value in 2022 was the highest one taking into account the three hybrids, only the hybrid SN1xIva1 had similar values of 342 mg. Cocoon silkiness for the hybrid Iva1 x VB1 varied from 17.09% in 2019 to 18.49 % in 2021, as there was a slight decrease in 2022 – 17.39%.

Table 1. Industrial testing of the labour-saving technology for silkworm rearing in 2019

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**
Nova2 xHB2	31.23	93.00	1972	390	19.78
SN1xIva1	26.46***	92.00	2038**	405*	19.87
Iva1x VB1	34.27**	90.00*	1480	253***	17.09**

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

Table 2. Industrial testing of the labour-saving technology for silkworm rearing in 2020

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**

Nova2 xHB2	32.25	90.00	1764	363	20.58
SN1xIva1	26.55***	85.00***	1940***	376	19.38*
Iva1x VB1	32.45	98.00**	1863**	344*	18.46**

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

Table 3. Industrial testing of the labour-saving technology for silkworm rearing in 2021

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**
Nova2 xHB2	34.95	98.00	1875	338	18.03
SN1x Iva1	23.95***	90.00***	1623***	286***	17.62*
Iva1x VB1	30.00	90.00***	1693***	313	18.49

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

Table 4. Industrial testing of the labour-saving technology for silkworm rearing in 2022

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**
Nova2 xHB2	33.15	93.00	1596	307	19.24
SN1x Iva1	28.00***	96.00*	1752***	342*	19.52
Iva1x VB1	34.80*	98.00**	1972***	343*	17.39***

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

The developed labour-saving technology allowed that the premises were not heated during silkworm feeding. It reduced the energy costs, preserved the freshness of mulberry leaf for longer time, which led to longer period of leaf consumption and to higher yields of cocoons from one box of silkworm eggs.

On the other hand, the labor expenditures estimated were 1.8 hours per 1 kg of fresh cocoons produced while the labor expenditure at the standard rearing technology were 3.7 hours/kg of fresh cocoons. Until the beginning of 5th instar 9 boxes of silkworm eggs were fed by only one worker and after that 3 workers fed the larvae until mounting.

CONCLUSIONS:

From the results obtained we may conclude that the labor saving technology tested provides obtaining of comparatively high cocoon yield and percentage of cocoons with alive pupae, by the same time at 2 times less labor expenditures, compared with the standard technology.

REFERENCES:

1. Vasta, S.; Figorilli, S.; Ortenzi, L.; Violino, S.; Costa, C.; Moscovini, L.; Tocci, F.; Pallottino, F.; Assirelli, A.; Saviane, A.; Cappellozza, S. Automated Prototype for *Bombyx mori* Cocoon Sorting Attempts to Improve Silk Quality and Production Efficiency through Multi-Step Approach and Machine Learning Algorithms. *Sensors* **2023**, *23*, 868. https://doi.org/10.3390/s23020868
2. Ohura M. Development of an Automated Warehouse Type Silkworm Rearing System for the Production of Useful Materials},Journal of Insect Biotechnology and Sericology},72,163-169, 2003
3. Ueda S., R. Kimura, and K. Suzuki, "Studies on the growth of the silkworm Bombyx mori. IV mutual relationship between the growth in the fifth instar larvae and productivity of silk substance and eggs," *Bulletin of the Sericultural Experiment Station*, vol. 26, no. 3, pp. 233–247, 1975.
4. Benchamin K. V. and M. S. Jolly, "Principles of silkworm rearing," in *Proceedings of Seminar on Problems and Prospects of Sericulture*, S. Mahalingam, Ed., pp. 63–106, Vellore, India, 1986.
5. Krishanswami S., M. N. Narasimhanna, S. K. Suryanarayana, and S. Kumararaj, *Silkworm rearing Bulletin " 15/2 FAO Agricultural Services*, United Nations Organizations, Rome, Italy, 1973.
6. Sodiqov Davron Sodiq Ogli. (2023). INFLUENCE OF FEEDING IN DIFFERENT WAYS ON THE MASS OF SILKWORM AND COCOONS. *Open Access Repository*, *9*(2), 46–52.
7. Rahmathulla V. K., "Management of Climatic Factors for Successful Silkworm (Bombyx mori L.) Crop and Higher Silk Production: A Review", Psyche: A Journal of Entomology, vol. 2012, Article ID 121234, 12 pages, 2012

State-of-the-art in mulberry propagation at the Global Center of Excellence for Advanced Research in Sericulture and Promotion of Silk Production

By

Ecaterina-Daniela BACIU and Daniel Severus DEZMIREAN

University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Calea Mănăştur 3-5, 400372, Cluj-Napoca

(Abstract)