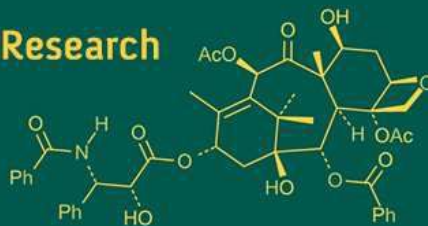
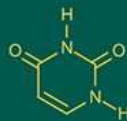
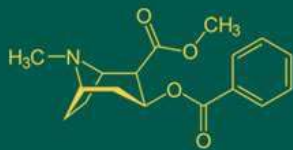


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Effect of different growth regulators on biology and economic traits of silkworm (*Bombyx mori* L.)

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Abstract

Investigations on Effect of growth regulators on growth and economic traits of bivoltine silkworm *Bombyx mori* L." The experiment was conducted at Department of Agricultural Entomology, College of Agriculture, Parbhani during the month July-August 2022. The disease free layings of FC1xFC2 bivoltine silkworm were used in the investigation. The laboratory experiment was conducted in completely randomized design with ten treatments and four replications. One hundred larvae were reared in each replication. Treatment of fifth instar bivoltine silkworm larvae with growth regulator Serimore at the rate 3.5 ml per liter of water during the onset of fifth instar, and administration of folic acid at 200 ppm has improved the growth and economic parameters of bivoltine silkworm. Treatment of Sampoorina at the rate of 7.5 ml/l has significantly reduced larval duration and ingesta, but has negative impact on economic parameters of silkworm at early treatments. Hence, it is suggested to use Serimore at the rate 3.5 ml per liter water and Folic acid 200 ppm at the onset of fifth instar larvae, and Sampoorina at the rate of 7.5 ml/l of water before spinning stage of bivoltine silkworm in order to improve the growth and economic traits of bivoltine silkworm (*Bombyx mori* L.).

Keywords: *Bombyx mori*, silkworm, bivoltine, Sampoorina, seriwaste

Introduction

Sericulture, an ancient industry in India and Asia, is a labour-intensive and commercially viable economic activity that falls under the cottage and small-scale sector. It involves the production of silk, which serves as the final product. This industry is particularly suitable for rural populations engaged in agriculture, as well as entrepreneurs and artisans, due to its low investment requirement and potential for relatively higher returns. It plays a crucial role in generating income and employment opportunities for the rural people, especially farmers with small land holdings and vulnerable sections of the society. Maharashtra, despite being a nontraditional sericulture state, produces Mulberry and Tasar silk. Notably, the state excels in bivoltine sericulture, accounting for 98% of its production, and ranks first among nontraditional states in India, making it a promising region for silk manufacturing (Hiware 2016) [7].

Sericulture plays a significant role in both the global and rural economies. China holds the distinction of being the largest producer of silk worldwide, while India follows closely as the second highest producer of raw silk and a prominent consumer of pure silk on the global stage. The southern state of Karnataka held the leading position as the producer of raw silk during that period (Anonymous, 2022) [2]. The *Bombyx mori* L., commonly known as the Mulberry silkworm, is a monophagous insect that exclusively feeds on the leaves of the Mulberry tree (*Morus* spp.) for its nutritional needs and produces natural protein-based silk. While the rate of food consumption increases with each larval stage, the conversion of food into body weight decreases (Bongale *et al.*, 1997) [4].

Silkworm growth regulators (SGRs) such as juvenile and moulting hormones and their analogs (juvenoids and ecdysoids) when it is used judiciously have been found to be useful in the sericulture industry. The silkworm, *Bombyx mori* L. is known to exhibit a stimulatory effect on the administration of exogenous JH analogs in minute quantities which leads to enhancement in commercial traits such as cocoon weight, shell weight, and silk filament length (Akai *et al.* 1985; Mamatha *et al.*; 2006) [1, 8] This principle has been exploited in the

sericulture industry in which the silkworm rearing and the production of cocoons can be managed effectively or manipulated positively depending on the requirement by administering bioactive compounds mimicking the circulating hormone regardless of the source. JH analogs or mimics have been a celebrated option for Sericulturists as these can control silk gland function and indirectly cause an increase in silk production. Earlier it was made clear that exogenous JH delays the silkworm larva maturation and the increase in silk yield was mainly because of this phenomenon (Akai *et al.* 1985) ^[1]. The non-uniform maturation is due to the fact that the hormone does not reach the optimum level required for spinning in all the worms simultaneously (Trivedy *et al.*, 2006) ^[16].

Materials and Methods

Investigation was carried out to know the "effect of growth regulators on growth and economic traits of bivoltine silkworm *Bombyx mori* L." The experiment was conducted at Sericulture Research Unit, VNMKV, Parbhani during the month July-August 2022. Methods involved and materials used are described below.

Materials

Disease free layings of bivoltine mulberry silkworm (*Bombyx mori* L.) race FC1xFC2 were fed the leaves of mulberry variety Victory-1 in the present investigation. The growth regulators were made available from different silk producing parts of the country. Details of material used and technique adopted are described under suitable heading.

Methods of recording observation

Observations were recorded on following parameters on ten randomly selected larvae / cocoons of silkworm hybrids from each replication of each treatment.

Hatching percentage (%)

The mean number of larvae hatched out of the total eggs laid by the female moth per hybrid was recorded and expressed in percentage.

$$\text{Hatching (\%)} = \frac{\text{No. of hatched eggs}}{\text{Total no. of eggs}} \times 100$$

Larval duration (days)

The total larval period measured by recording the period from hatching to the onset of spinning.

Larval weight (g)

The maximum larval weight was recorded by taking the weight of matured larvae just before the onset of spinning.

Single shell weight (g)

The cocoon was cut at one end and shell weight will be recorded after removing pupae.

$$\text{Single shell weight (g)} = \frac{\text{Weight of 10 shell}}{10}$$

Cocoon shell Ratio (%)

$$\text{Shell Ratio (\%)} = \frac{\text{Single shell weight}}{\text{Single cocoon weight}} \times 100$$

Pupal duration (days)

The total pupal period was measured by recording period from spinning to the emergence of moth.

Treatment details

Treatment 1	Application of serimore at the rate of 1.5 ml/l of water
Treatment 2	Application of serimore at the rate of 2.5 ml/l of water
Treatment 3	Application of serimore at the rate of 3.5 ml/l of water
Treatment 4	Application of sampoorina at the rate of 2.5 ml/l of water
Treatment 5	Application of sampoorina at the rate of 5 ml/l of water
Treatment 6	Application of sampoorina at the rate of 7.5 ml/l of water
Treatment 7	Application of folic acid at the rate of 100ppm
Treatment 8	Application of folic acid at the rate of 150ppm
Treatment 9	Application of folic acid at the rate of 200ppm
Treatment 10	Control

Results and Discussion

Effect of growth regulators on the fifth instar larval duration of bivoltine silkworm (*B. mori* L.) (days)

The data on effect of growth regulators on fifth instar larval duration (days) of bivoltine silkworm (*B. mori* L.) presented in Table 1 revealed that the shortest 5th instar larval duration (5.678 days, 6.595 days) was recorded by treatment of Sampoorina at the rate of 7.5 ml per litre at 72 and 96 hours treatment and at 48 and 120 hours treatment shortest larval duration recorded (7.113 days) by control.

The longest 5th instar larval duration (8.77, 7.837, 7.96, 8.795 days) was recorded by treatment of Serimore at the rate of 3.5 ml per litre of water. However at 96 hour treatment it was at par with the treatment of Serimore at 1.5 and 2.5 ml/l of water (7.92 and 7.933 days). The literature pertaining to the effect of Serimore on the larval duration of

bivoltine silkworm was scanty. However, several scientists reported the use of growth regulators enhanced the larval period of silkworm (Trivedy *et al.*, 1997) ^[15]. Chandrakal *et al.* (2001) ^[5] reported that the administration of phytoecdysteroids during the fifth instar of the silkworm, *Bombyx mori*, particularly at the sample spinning stage, yielded the most beneficial results. This treatment led to several advantages, including the induction of uniform spinning, reduction in larval and molting periods, and increased uniformity in the mounting process, Nair *et al.* (2005) ^[10] investigated the varying response of the silkworm, *Bombyx mori* L., to Phytoecdysteroid depending on the timing of administration. The researchers found that when the larvae were treated with Phytoecdysteroid at 72 hours, there were adverse effects on the economic traits of the silkworm. However, they observed a significant

reduction in larval duration as a result of the treatment. The above results are in agreement with the findings of the

above workers

Table 1: Effect of growth regulators on 5th instar mean larval duration (days) of bivoltine silkworm (*Bombyx mori* L.)

Treatment No.	Treatment details	Treatment timing in 5 th instar			
		48 hrs	72 hrs	96 hrs	120 hrs
T ₁	Serimore 1.5 ml/l of water	8.162	7.249	7.92	8.162
T ₂	Serimore 2.5 ml/l of water	8.147	7.264	7.933	8.147
T ₃	Serimore 3.5 ml/l of water	8.77	7.837	7.96	8.795
T ₄	Sampoorna 2.5 ml/l of water	7.143	7.12	6.427	7.19
T ₅	Sampoorna 5.0 ml/l of water	7.354	7.16	5.937	7.156
T ₆	Sampoorna 7.5 ml/l of water	7.12	6.595	5.678	7.118
T ₇	Folic acid 100 ppm	7.705	7.632	7.632	7.632
T ₈	Folic acid 150 ppm	7.322	7.322	7.311	7.322
T ₉	Folic acid 200 ppm	7.331	7.356	7.356	7.356
T ₁₀	Control	7.113	7.113	7.113	7.113
SE±		0.062	0.075	0.11	0.11
CD at5%		0.127	0.154	0.225	0.225
CV		1.149	1.466	2.178	2.041

Table 2: Effect of growth regulators on the mean larval weight of bivoltine silkworm (*B. mori* L.) (g).

Treatment No.	Treatment details	Treatment timing in 5 th instar			
		48 hrs	72 hrs	96 hrs	120 hrs
T ₁	Serimore 1.5 ml/l of water	51.475	51.64	50.585	48.95
T ₂	Serimore 2.5 ml/l of water	53.365	52.8825	52.065	50.25
T ₃	Serimore 3.5 ml/l of water	54.4175	54.6375	54.175	51.75
T ₄	Sampoorna 2.5 ml/l of water	47.3975	47.4825	47.72	48.1075
T ₅	Sampoorna 5.0 ml/l of water	47.245	47.275	47.69	48.22
T ₆	Sampoorna 7.5 ml/l of water	45.135	44.47	47.5225	48
T ₇	Folic acid 100 ppm	48.02	47.855	48.1025	48.0625
T ₈	Folic acid 150 ppm	51.44	51.22	49.8875	49.8875
T ₉	Folic acid 200 ppm	52.9375	52.9375	51.8	48.4925
T ₁₀	Control	47.9925	47.9925	47.9925	47.9925
SE±		0.629356	0.665079	0.49437	0.483242
CD at5%		1.817712	1.920887	1.42784	1.395705
CV		2.520323	2.668896	1.98725	1.973576

The lowest 5th instar larval weight (g) recorded (45.13 g, 44.47 g and 47.52 g) in Sampoorna 7.5 ml/l of water at 48h, 72 h and 96 h. However, at 48h it was at par with Sampoorna 5 ml/l of water (47.25 g) and at 96 h it was at par with all other sampoorna treatments and control (47.99 g). At 120 h lowest 5th instar larval weight (g) recorded by control which was at par with all other treatments except Serimore at the rate 2.5 ml and 3.5 ml per litre of water (50.25 and 51.75 g).

Nair *et al.*, (2004) ^[11] reported that there is significant increase in larval weight of silkworm with the use of juvenoids. Plantevin *et al.*, (1991) ^[12] also reported that growth regulator treated larvae were heavier than untreated silkworm larvae. Rai *et al.* (2002) ^[13] investigated the effects of folic acid administration to fifth instar silkworm larvae. They found that larval weight increased and duration decreased in all treatment groups compared to the control. The result in the present investigation are in agreement with above scientists.

Effect of growth regulators on the pupal duration of bivoltine silkworm (*Bombyx mori* L.) (days)

The data on the effect of growth regulators on the pupal duration (days) of bivoltine silkworm (*Bombyx mori* L.) are presented in Table 02 revealed that shorter pupal duration (11 and 10.75 days) in Sampoorna 7.5 ml/l of water at 96 h and 120 h treatment which was at par with control (11.25

days) and at 48h and 72 h shortest pupal duration (11.25 and 11.25 days) was observed in control.

The significantly longer pupal duration (15.25, 15.5, 15.75 and 15.75 days) was recorded at 48h, 72 h, 96 h and 120 h treatment timings in 5th instar with Serimore at the rate 3.5 ml per litre water. However, at 120 h treatment in 5th instar significantly longer pupal duration (15.75) was observed with treatment of Serimore at the rate of 1.5 ml/l of water and 25 ml/l of water. The literature on the effect of growth regulators on the pupal duration of silkworm is scanty so results could not be discussed.

Effect of growth regulators on the single shell weight of bivoltine silkworm (*Bombyx mori* L.) (g)

The data on effect of growth regulators on the single shell weight (g) of bivoltine silkworm (*B. mori* L.) are presented in Table 3, The data revealed the following details. At 48 hour treatment the significantly highest Shell weight recorded (0.514 g) by the treatment of Serimore at 3.5 ml per litre and lowest shell weight recorded (0.337 g) by treatment of Sampoorna at the rate of 7.5 ml per litre.

At 72 h treatment, the significantly highest shell weight was recorded (0.474 g) by treatment of Serimore at 3.5 ml per litre which was at par with treatment of Folic acid 200ppm and lowest shell weight recorded (0.349 g) by treatment of Sampoorna at 5 ml/l of water.

Table 3: Effect of growth regulators on mean pupal duration (days) of bivoltine silkworm (*Bombyx mori* L.)

Treatment No.	Treatment details	Treatment timing in 5 th instar			
		48 hrs	72 hrs	96 hrs	120 hrs
T ₁	Serimore 1.5 ml/l of water	13.5	13.75	12.75	15.75
T ₂	Serimore 2.5 ml/l of water	13.75	14.75	14.5	14
T ₃	Serimore 3.5 ml/l of water	15.25	15.5	15.75	15.75
T ₄	Sampoorna 2.5 ml/l of water	12.25	12	12.25	11.25
T ₅	Sampoorna 5.0 ml/l of water	12.25	13	13	11.25
T ₆	Sampoorna 7.5 ml/l of water	12.25	12	11	10.75
T ₇	Folic acid 100 ppm	12.25	12.75	12.5	13
T ₈	Folic acid 150 ppm	13.5	12.75	13.75	12.75
T ₉	Folic acid 200 ppm	12.75	13.75	13.75	13.5
T ₁₀	Control	11.25	11.25	11.25	11.25
SE±		0.316228	0.25	0.29580	0.262202
CD at5%		0.913332	0.722052	0.85434	0.757295
CV		4.902756	3.802281	4.53339	4.057288

Table 4: Effect of growth regulators on mean single shell weight (g) of bivoltine silkworm (*Bombyx mori* L.)

Treatment No.	Treatment details	Treatment timing in 5 th instar			
		48 hrs	72 hrs	96 hrs	120 hrs
T ₁	Serimore 1.5 ml/l of water	0.376	0.376	0.396	0.39
T ₂	Serimore 2.5 ml/l of water	0.463	0.434	0.428	0.437
T ₃	Serimore 3.5 ml/l of water	0.514	0.474	0.478	0.426
T ₄	Sampoorna 2.5 ml/l of water	0.377	0.364	0.387	0.387
T ₅	Sampoorna 5.0 ml/l of water	0.343	0.349	0.393	0.475
T ₆	Sampoorna 7.5 ml/l of water	0.337	0.388	0.475	0.477
T ₇	Folic acid 100 ppm	0.377	0.385	0.384	0.385
T ₈	Folic acid 150 ppm	0.379	0.385	0.387	0.385
T ₉	Folic acid 200 ppm	0.492	0.473	0.435	0.387
T ₁₀	Control	0.377	0.377	0.377	0.377
SE±		0.002	0.002	0.003	0.002
CD at5%		0.007	0.006	0.01	0.007
CV		1.129	1.085	1.587	1.206

At 96 h treatment, the significantly highest shell weight was recorded (0.478 g) by treatment of Serimore at 3.5 ml per litre which was at par with treatment of Sampoorna 7.5 ml/l of water and lowest shell weight recorded (0.377 g) by control.

At 120 h treatment, the significantly highest shell weight was recorded (0.477 g) by treatment of Sampoorna 7.5 ml/l of water which was at par with treatment of Sampoorna 5 ml/l of water and lowest shell weight recorded (0.377 g) by control.

Dutta *et al.*, (2013) ^[6] and Nair *et al.* (2011) ^[14] reported increase in the shell weight with the application of juvenile hormones. Rai *et al.* (2002) ^[13] found the effects of folic acid administration to fifth instar silkworm larvae, it increased shell weight by 21.9%. The researchers suggested that folic acid facilitated nucleic acid synthesis in silk gland cells, increasing the silk content in the shell. Nair *et al.* (2005) ^[10] investigated the varying response of the silkworm, *Bombyx mori* L., to Phytoecdysteroid depending on the timing of administration. The researchers found that when the larvae were treated with Phytoecdysteroid at 72 hours, there were adverse effects on the economic traits of the silkworm. The result in the present investigation are in agreement with the research findings of the above workers.

Effect of growth regulators on the cocoon shell ratio of bivoltine silkworm (*B. mori* L.) (Percent).

The data on effect of growth regulators on the single shell ratio (%) of bivoltine silkworm (*B. mori* L.) are presented in Table-5. revealed that at 48h treatment timing in 5th instar of Serimore at the rate 2.5 ml per litre water recorded highest

shell ratio (25.188 percent). The lowest shell ratio (19.365 percent) at 48h treatment timing was observed with Folic acid 150 ppm. However, it was at par with Sampoorna at the rate 7.5 ml/l of water and 5 ml/l of water. (20 and 19.73 percent).

At 72 h treatment timing in 5th instar, the significantly highest cocoon shell ratio recorded (23.973) in treatment of Folic acid 200 ppm, which was at par with treatment of Serimore at the rate 2.5 ml per litre (23.575) and lowest cocoon shell ratio recorded (19.83) in treatment of Sampoorna at the rate 7.5 ml/l of water and 5 ml/l of water.

At 96 h treatment timing in 5th instar, the significantly highest cocoon shell ratio recorded (24.098) in treatment of Sampoorna at the rate 7.5 ml/l of water, which was at par with treatment of Serimore at the rate 2.5 ml per litre (23.515) and lowest cocoon shell ratio recorded (20.583) in treatment of Serimore at the rate 1.5 ml per litre.

At 120 h treatment timing in 5th instar, the significantly highest cocoon shell ratio recorded (23.55) in treatment of Sampoorna at the rate 7.5 ml/l of water, which was at par with treatment of Sampoorna at the rate 5 ml/l of water (22.903) and Folic acid 200 ppm (22.478), lowest cocoon shell ratio recorded (20.118) in treatment of Serimore at the rate 1.5 ml per litre which was at par with other Serimore treatments (21.005 and 20.663).

Bharathi and Miao (1999) ^[3] and Sashindran *et al.*, (2011) ^[14] observed that there is improvement in cocoon shell ratio with the treatment of growth regulators. Nair *et al.* (2005) ^[10] investigated the varying response of the silkworm, *Bombyx mori* L., to Phytoecdysteroid depending on the timing of administration. The researchers found that when

the larvae were treated with Phytoecdysteroid at 72 hours, there were adverse effects on the economic traits of the

silkworm. The findings of present investigation are in line with the results obtained by above worker.

Table 5: Effect of growth regulators on mean cocoon shell ratio (%) of bivoltine silkworm (*Bombyx mori* L.)

Treatment No.	Treatment details	Treatment timing in 5 th instar			
		48 hrs	72 hrs	96 hrs	120 hrs
T ₁	Serimore 1.5 ml/l of water	21.29 (4.721)	20.993 (4.69)	20.583 (4.645)	20.118 (4.595)
T ₂	Serimore 2.5 ml/l of water	25.188 (5.117)	21.325 (4.724)	23.515 (4.951)	21.005 (4.689)
T ₃	Serimore 3.5 ml/l of water	23.875 (4.984)	23.575 (4.957)	23.288 (4.928)	20.663 (4.652)
T ₄	Sampoorna 2.5 ml/l of water	21.96 (4.792)	20.73 (4.661)	22.08 4.804	21.315 4.724
T ₅	Sampoorna 5.0 ml/l of water	19.73 (4.553)	19.83 (4.564)	22.703 (4.868)	22.903 (4.889)
T ₆	Sampoorna 7.5 ml/l of water	20 (4.582)	21.713 (4.766)	24.098 (5.01)	23.55 (4.953)
T ₇	Folic acid 100 ppm	20.44 (4.63)	21.475 (4.741)	20.9 (4.68)	21.475 (4.741)
T ₈	Folic acid 150 ppm	19.365 (4.513)	21.055 (4.696)	21.283 (4.72)	21.495 (4.743)
T ₉	Folic acid 200 ppm	23.56 (4.956)	23.973 (4.997)	21.875 (4.782)	22.478 (4.845)
T ₁₀	Control	21.343 (4.727)	21.32 (4.724)	21.32 (4.724)	21.32 (4.724)
SE±		0.041	0.025	0.022	0.043
CD at 5%		0.118	0.072	0.063	0.124
CV		1.707	1.037	0.899	1.803

Summary and Conclusion

To use Serimore at the rate 3.5 ml per liter water and Folic acid 200 ppm at the onset of fifth instar larvae, and Sampoorna at the rate of 7.5 ml/l of water before spinning stage of bivoltine silkworm in order to improve the growth and economic traits of bivoltine silkworm (*Bombyx mori* L.).

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