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Chaitra S. and T. S. Jagadeesh Kumar

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Photoperiodic Regimes and Rhythmic Response of Embryonic Developmental Stages and Manifestation of Economic Parameters of Different Strains of Mulberry Silkworm

Chaitra S[1]. and T. S. Jagadeesh Kumar*[2]

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ABSTRACT

The silkworms are important domesticated monophagous sericigenous insects used in the production of economically important silk. Being domesticated from several years, the silkworms face many challenges during their rearing practices that further affects the quality of silk derived from them. There are several biotic and abiotic factors that affects the growth and development of the silkworm. Among which the photoperiodic cycle plays a significant role. So far, the photoperiodic treatment on the larval stages were investigated. but limited information was available but the impact of photoperiodic treatment given during egg stage will alter the economic parameters of mulberry silkworm. In the present study we have been analyzed the consequences of photoperiodic treatment of LD 12:12, 14:10 and 16:08 on the economic traits of three different strains of the silkworm viz. APM1, MU303 and PM for about 8 generations. Our results revealed that, the photoperiodic treatment can drastically alter the expression of economic traits in these three different strains of the silkworm. However, the cognate photoperiodic treatment of 16L:08D is ideal regimes in the enhancement of most of the economic characters in the silkworm. Further, APM1 was observed to be most responsive strain for varied photoperiodic treatment at different generation.

***Key words*:** Photoperiodic regimes, Egg stage, Economic parameters, Silkworm strains

Sericulture is the science of rearing the silkworm *Bombyx mori* L. (Bombycidae: Lepidoptera) for the production of economically valuable silk [7]. The production of silk from the silkworm was practiced since 2700 BC [11], and is considered as one of the profitable cottage industries responsible for the economic development in various countries across the globe. India is the one of the largest producers and consumers of the pure silk [13], which is mostly been used by the textile industries. In addition, there are several valuable by-products derived from the sericulture have its own market value. The silkworm is a domesticated monophagous sericigenous insect that feeds on the foliage of Mulberry plant and convert leaf protein in to silk protein [1]. Generally, the production of raw silk from the silkworm is a polygenic trait [6], [12], which is further influenced by several biotic and abiotic factors [5], [10]. Apart from this, the optimum growth and development of the silk worm is essential in the production of best quality silk which is mainly depending on the rearing practice. Among several aspects considered in the rearing of the mulberry silkworm, the photoperiodic cycle is physical stimuli in regulating the manifestation of economic characters.

So far, several studies have been carried out to understand relationship of the silkworm with varied photoperiodic cycle. Generally, silkworms are highly photosensitive, shows positive phototactic behaviour and have tendency of crawling towards dim light [11]. It is observed that, the prolonged exposure to the light during rearing practices retards growth in the silkworm and hence affects the cocoon characters [11]. On the other hand, limited information is available on the consequences of photoperiodic treatment during the egg stage. It is essential to understand how the light and dark treatment given in the egg stage can influences expression of economic characters associated with the silkworm. we have documented the variation in the expression of economic traits in three different strains of the silkworm viz. APM_1, MU_{303} and PM when the silkworm eggs were subjected to photoperiodic regimes.

MATERIALS AND METHODS

Collection and rearing of mulberry silkworm

APM1, MU303 and PM are the three different strains of silkworms utilized in the present investigation. A total of 5 DFL's (in which only 3 DFLs were used for the study) of APM1

* **T. S. Jagadeesh Kumar**
tsj.bio@gmail.com

[1-2] Silkworm Physiology and Biochemistry Laboratory, Department of Studies in Sericulture Science, University of Mysore, Manasagangothri, Mysuru - 570 006, Karnataka, India

were bought from APSSRDI, Kirikere, Hindupur, Andhra Pradesh and three diseases free layings of MU303 were collected from the germplasm of the DOS in sericulture University of Mysore. Mysuru further, three DFL's of Pure Mysore were collected from CSR&TI, cold storage, Mysuru.

Rearing and maintenance

The silkworm eggs were maintained under standard laboratory conditions/method described by [5], [9], respectively. Plastic trays of 90 X 70 X 10cm size disinfected with 2% formalin solution and covered with paraffin paper of the same size were used for maintaining the eggs. The eggs were black boxed at blue egg stage in order to obtain uniform hatching and the hatched larvae on the 10th day were brushed into labeled plastic trays. The Chawki and late age silkworms were fed with Mulberry leaves of S36 and V1 varieties respectively derived from the mulberry garden of Department of Sericulture, University of Mysore. The leaves were chopped into suitable size according to the larval stage to be fed. The rearing bed was cleaned after 2nd moult and thereafter every day. The ripened healthy silkworms were allowed to spin the cocoons on bamboo montages.

Photoperiodic treatment regimes

The photoperiodic treatment of experiments was carried out in the Department of Sericulture, University of Mysore. The eggs were incubated at 25±1°C temperature and 80-85% relative humidity and Photoperiods of LD 12:12, 14:10 and 16:08 was maintained in BOD incubator. A total of three replications were maintained from the first day until hatching in BOD incubator (normal tube lights – two). Separate plates covered with paraffin paper were maintained for different experimental DFL's (Directly kept on paraffin paper) in the bod. The hatched eggs were then taken out from the BOD and reared under regular conditions in the rearing house.

Evaluating the economic characters

A total of 11 essential economic characters were evaluated in the silkworm strains used in the present study.

Larval weight (g): The average weights of ten silkworm Larvae will be recorded.

Single cocoon weight (g): The average weights of ten cocoons will be taken after removing the floss from the cocoons.

Single pupal weight (g): The average weights of ten pupals will be taken from after cutting the cocoons.

Single shell weight (g): The average weights of ten cocoon shell will be taken separately after removing the pupa.

Shell ratio (%): The shell percentage was calculated by using the formula:

$$\text{Shell ratio} = \frac{\text{Weight of cocoon shell (g)}}{\text{Weight of cocoon}} \times 100$$

Fecundity: Reproductive potential of a normal, healthy female moth as represented by the number of eggs laid during its fertility period.

Hatching percentage (%):

$$\text{Hatching percentage} = \frac{\text{Number of eggs hatched}}{\text{Number of eggs laid}} \times 100$$

Filament length (m): The total length of the silk filament from ten good cocoons will be used for reeling by epprouvette.

$$L = R \times 1.125$$

Where;
L = Total filament length (m/cocoon)
R = number of revolutions recorded by epprouvette
1.125 = Circumference of epprouvette in meters.

Filament weight (g): The total weight in grams of the silk filament of a single cocoon will be estimated (The mean value of 10 observations was considered).

Denier (d): This denotes the thickness of the filament, 9000 meters in a gram being considered as one denier. It is calculated using the formula:

$$\text{Denier} = \frac{\text{Weight of filament}}{\text{Length of the filament}} \times 9000$$

Renditta (kg): This is a measure of actual silk available from the cocoons. The Renditta was expressed as the quantity of cocoons required to get a kg of raw silk.

$$\text{Renditta} = \frac{\text{Cocoon weight (g)}}{\text{Raw silk weight (g)}}$$

Statistical analysis

The data collected from the experiments were first converted into mean value and then standard deviation was calculated. Further, the data was subjected to ANOVA by using SPSS.

RESULTS AND DISCUSSION

The results gathered from the present study represents the impact of light and dark treatment (L:D) on the eggs of three different strains of the silkworms and how it regulates the efficiency of their economic parameters up to eight generations.

The highest fecundity of 647.33±2.25 was reported in the APM1 treated with 16L:08D in seventh generation which was higher than the respective control, whereas lowest fecundity of 433.33±29.08 was observed in PM treated with 14L:10D which was much more lesser than the respective control in sixth generation. Further, the highest hatchability of 95.02±2.56 was reported in the PM treated with 16L:08D in G2 which is higher than the respective control. Similarly, the lowest hatchability of 74.77±5.74 was observed in the APM1 treated with 12L:12D in G0.

The highest larval weight of 3.50±0.49 was observed in APM1 of G6 treated with 16L:08D, which was higher than the respective control. The lowest larval weigh of 1.35±0.06 was observed in PM of G5 treated with 12L:12D. Further, the highest cocoon weight of 1.50±0.06 was observed APM1 of G0 treated with 14L:10D. Whereas lowest cocoon weight of 1.11±0.01 has been reported in the PM of G1 treated with 14L:10D. Similarly, the highest shell weight of 0.29±0.03 was observed in APM1 of G7 treated with 16L:08D which was higher than the respective control. The lowest shell weight of 0.1±0.01 was reported in the PM of G2 treated with 12L:12D. Apart from this, the treatment of 14L:10D has been reported in the increase of pupal weight up to 1.26±0.05 in APM1 of G0 which was more than that of the respective control. Whereas the treatment of 16L:08D in MU303 of G1 has been resulted in the decrease of pupal weight to 0.76±0.45 which was lesser than the respective control. Further, the highest shell ratio of 18.80±0.38 has been reported in the APM 1 of G6 treated with

16L:08D which is higher than that of respective control. Whereas the lowest shell ratio of 8.06±1.30 was reported in the PM of G2 treated with 12L:12D, which was lesser than the respective control.

Table 1 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at zero generation

Generation-G0 (1)												
Strains	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	508.33±12.94	79.43±3.10	3.08±0.50	1.28±0.05	0.20±0.03	1.10±0.08	15.83±2.46	780.35±1.69	0.20±0.01	2.38±0.14	6.54±0.32
	14L:10D	514.66±16.23	80.62±1.19	2.90±0.15	1.50±0.06	0.24±0.01	1.26±0.05	16.02±0.09	800.47±14.66	0.16±0.01	3.07±0.20	7.81±2.19
	12L:12D	494.33±15.90	74.77±5.74	2.59±0.16	1.39±0.09	0.16±0.04	1.12±0.07	11.20±2.54	796.18±25.48	0.17±0.02	2.65±0.43	8.08±1.65
	Control	540±24.93	95.71±3.77	3.012±0.14	1.43±0.04	0.23±0.01	1.20±0.03	16.26±0.86	853.46±56.41	0.17±0.01	2.64±0.35	7.98±0.71
MU303	16L:08D	654.66±20.67	88.77±1.43	2.93±0.15	1.36±0.03	0.16±0.01	1.19±0.01	12.00±1.05	552.25±44.68	0.13±0.02	2.10±0.24	10.68±1.69
	14L:10D	602.33±63.39	92.59±4.66	2.813±0.13	1.37±0.08	0.15±0.03	1.22±0.08	11.41±2.30	388.5±27.84	0.13±0.01	3.08±0.14	10.46±1.62
	12L:12D	558.33±11.25	90.45±1.25	2.30±0.26	1.35±0.03	0.14±0.01	1.22±0.02	10.59±1.17	479.66±31.95	0.13±0.01	2.52±0.14	9.99±1.26
	Control	606±68.04	95.27±3.66	2.83±0.11	1.16±0.06	0.17±0.01	0.98±0.06	9.70±7.48	435.62±36.06	0.15±0.03	3.08±0.50	8.08±1.99
PM	16L:08D	473.33±39.11	92.97±3.47	1.72±0.07	1.18±0.06	0.15±0.03	1.03±0.02	12.63±3.57	491.32±66.97	0.14±0.01	2.69±0.14	8.15±1.22
	14L:10D	488.33±36.14	92.69±3.97	1.78±0.06	1.2±0.03	0.16±0.01	1.03±0.02	13.34±1.21	471.37±34.25	0.13±0.01	2.47±0.16	9.37±1.55
	12L:12D	475±27.20	86.15±5.37	1.75±0.08	1.20±0.03	0.15±0.01	1.05±0.03	12.70±0.80	481±40.22	0.13±0.01	2.47±0.14	9.10±0.67
	Control	497.66±13.45	94.08±4.29	1.69±0.06	1.14±0.01	0.12±0.004	1.02±0.008	10.77±0.33	447.7±21.62	0.13±0.01	2.66±0.25	8.72±1.31

Table 2 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at first generation

Generation-G1 (2)												
Strains	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	447.33±39.52	92.17±1.72	3.17±0.26	1.31±0.06	0.14±0.02	1.17±0.04	10.88±1.43	574.31±33.03	0.14±0.02	2.18±0.25	9.68±2.21
	14L:10D	449±46.12	88.92±1.24	2.66±0.33	1.05±0.03	0.13±0.009	0.92±0.023	12.71±0.52	518.49±67.28	0.12±0.02	2.16±0.15	8.65±1.75
	12L:12D	471.66±14.81	89.77±0.47	2.54±0.05	1.30±0.02	0.16±0.005	1.13±0.03	12.79±0.66	585.33±5.75	0.14±0.01	2.20±0.17	8.93±0.76
	Control	507.66±7.81	91.16±1.93	3.24±0.69	1.141±0.05	0.177±0.007	0.964±0.049	15.52±0.58	474.61±21.43	0.13±0.01	2.54±0.18	8.01±1.38
MU303	16L:08D	460.66±27.57	85.54±5.60	2.35±0.05	1.2±0.04	0.16±0.01	0.76±0.45	13.85±1.31	477.73±11.78	0.15±0.01	2.88±0.27	7.78±0.69
	14L:10D	481±20.80	92.41±2.09	2.3±0.05	1.16±0.03	0.18±0.01	0.98±0.04	15.35±1.573	466.22±25.68	0.13±0.02	2.61±0.44	8.91±2.42
	12L:12D	469±16.56	90.23±1.81	2.36±0.13	1.28±0.01	0.15±0.02	1.13±0.03	11.65±1.91	466.66±13.66	0.12±0.01	2.4±0.17	10.22±1.01
	Control	486±20.95	95.54±3.02	2.16±0.05	1.24±0.29	0.17±0.01	1.07±0.28	14.66±2.58	463.97±23.42	0.15±0.01	2.93±0.21	8.58±3.05
PM	16L:08D	458±45.85	89.60±1.88	1.45±0.03	1.12±0.03	0.18±0.008	0.93±0.02	16.7±0.62	465.19±17.61	0.14±0.01	2.77±0.28	7.96±1.34
	14L:10D	459.33±28.93	91.45±1.54	1.46±0.05	1.11±0.01	0.17±0.01	0.93±0.01	15.97±1.21	448.05±26.57	0.13±0.01	2.74±0.20	7.72±1.06
	12L:12D	483.66±24.66	90.88±5.69	1.43±0.06	1.22±0.03	0.18±0.005	1.03±0.03	15.03±0.63	460.33±11.67	0.12±0.01	2.36±0.18	9.98±1.27
	Control	444.33±41.63	88.70±1.19	1.41±0.01	1.17±0.046	0.16±0.02	1.01±0.051	14.06±2.216	443.62±9.71	0.12±0.01	2.56±0.31	8.87±0.63

Table 3 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at second generation

Generation-G2 (3)												
Races	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	542.33±24.43	79.48±1.23	3.09±0.45	1.42±0.10	0.21±0.06	1.21±0.04	14.47±3.68	726.91±32.80	0.20±0.01	2.55±0.13	8.70±2.29
	14L:10D	503±5.44	78.58±2.16	3.13±0.25	1.49±0.02	0.27±0.07	1.22±0.06	16.94±3.30	653.55±113.19	0.19±0.04	2.68±0.38	7.89±1.80
	12L:12D	568.33±14.37	76.41±4.85	2.55±0.09	1.39±0.04	0.16±0.05	1.23±0.01	11.81±3.66	700.33±17.02	0.21±0.02	2.76±0.33	6.51±0.65
	Control	608±21.48	92.92±1.87	2.89±0.44	1.43±0.06	0.19±0.05	1.24±0.04	13.16±3.31	830.26±40.02	0.25±0.008	2.69±0.07	5.73±0.09
MU303	16L:08D	608.66±4.58	86.85±2.15	2.43±0.08	1.39±0.04	0.18±0.02	1.22±0.02	13.35±1.74	516.97±36.04	0.13±0.01	2.36±0.17	10.32±1.15
	14L:10D	596±5.44	82.02±2.65	2.48±0.39	1.29±0.02	0.19±0.03	1.18±0.04	14.96±2.33	499.50±17.99	0.12±0.01	2.27±0.17	10.27±1.12
	12L:12D	574.66±12.56	81.44±3.005	2.41±0.09	1.3±0.04	0.15±0.04	1.14±0.03	11.69±3.01	545±27.92	0.12±0.01	1.97±0.19	10.74±1.82
	Control	622.33±8.95	87.38±1.89	2.80±0.38	1.38±0.07	0.20±0.03	1.18±0.05	14.92±1.87	529.23±28.70	0.12±0.01	2.15±0.32	10.21±1.18
PM	16L:08D	496.33±5.95	95.02±2.56	1.53±0.16	1.20±0.03	0.16±0.04	1.09±0.06	14±3.98	484.26±16.90	0.11±0.008	2.01±0.13	11.01±0.70
	14L:10D	490±8.53	92.78±4.92	1.45±0.29	1.173±0.02	0.12±0.018	1.133±0.013	10.79±1.58	448.18±28.17	0.11±0.008	2.20±0.17	10.71±0.67
	12L:12D	469.33±15.002	86.15±4.85	1.54±0.05	1.23±0.03	0.1±0.01	1.13±0.02	8.06±1.30	472±13.17	0.12±0.01	2.36±0.31	9.81±1.34
	Control	484±17.27	90.55±1.40	1.66±0.15	1.306±0.09	0.15±0.05	1.08±0.07	11.89±3.42	474.87±17.58	0.11±0.01	2.15±0.34	11.73±2.09

The highest filament length of 903.33±60.05 was reported in the APM1 of G5 treated with 16L:08D which was higher than the respective control. Whereas, lowest of 388.5±27.84 has been reported in the MU303 of G0 treated with 14L:10D which was lesser than the respective control. Similarly, the highest filament weight of 0.21±0.02 has been reported in APM1 of G2 treated with 12L:12D which was lesser than the control. Whereas the lowest of 0.11±0.01 has been reported in the PM of G3, MU303 of G5 and G7 treated with 14L:10D16L:08D and 12L:12D respectively which were lesser than the respective control.

The highest denier value of 3.07±0.20 has been reported in the APM1 of G0 treated with 14L:10D which was higher than the control. Whereas the lowest of 1.36±0.18 has been reported in APM1 of G6 treated with 14L:10D which was lesser than the respective control. Similarly, the highest renditta of 12.36±0.70 has been reported in the APM1 of G3 treated with 14L:10D which was which was higher than the control. Whereas, the lowest of 6.51±0.65 was reported in the APM1 of G2 treated with 12L:12D. which was higher than the respective control.

Photoperiodic cycle plays a significant role in the evolution of life on this earth [2]. Silkworms being ectothermic Lepidopterans insects, have drastically influenced by the light/dark cycle. The success of sericulture industry is directly depending on the quality silk produced by the silkworm. However, the growth and development of silkworm is influenced by several environmental factors that further alter the production of quality silk [11]. Generally, the photoperiodic cycle influences all the developmental stages in the silkworm but in the present study we have been considered the active egg stage of APM1, MU 303 and PM strains of the silkworm and investigated an approach the impact of light dark treatment on the egg stage and regulates the various economic parameters of each strain in all the seven generations.

Table 4 Variation in the economic parameters observed in the APM1, MU303 and PM when their eggs were subjected to the photoperiodic treatment of 16L:08D, 14L:10D and 12L:12D at their generation-G3

Generation-G3 (4)												
Races	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	592.33±28.51	86.55±4.92	3.12±0.31	1.28±0.05	0.22±0.02	1.05±0.03	17.30±1.24	752.33±39.92	0.15±0.02	1.82±0.26	8.52±2.03
	14L:10D	543±18.84	76.59±2.11	2.64±0.12	1.48±0.05	0.25±0.03	0.89±0.54	16.88±1.99	671.33±37.05	0.12±0.008	1.55±0.08	12.36±0.70
	12L:12D	581.66±26.95	86.03±3.69	3.18±0.55	1.44±0.03	0.22±0.06	1.18±0.07	15.61±4.03	753±49.69	0.15±0.01	1.75±0.06	9.70±0.92
	Control	614.66±12.20	89.8±0.37	3.006±0.14	1.43±0.04	0.23±0.01	1.19±0.03	16.03±0.97	857.33±102.80	0.18±0.03	1.88±0.20	8.19±1.60
MU303	16L:08D	549.33±40.96	82.74±5.81	2.78±0.06	1.35±0.03	0.16±0.01	1.19±0.01	12.006±1.05	475.66±39.33	0.14±0.01	2.68±0.11	9.53±1.08
	14L:10D	562±26.39	82.10±10.89	2.8±0.14	1.37±0.08	0.16±0.01	1.21±0.07	12.11±1.23	472±21.70	0.15±0.008	2.8±0.08	9.20±1.06
	12L:12D	574.66±21.91	84.58±11.54	3.03±0.17	1.41±0.02	0.19±0.01	1.22±0.01	13.59±0.76	496±22.41	0.13±0.01	2.40±0.23	10.78±1.40
	Control	558.33±47.66	85.42±5.15	2.77±0.04	1.19±0.01	0.17±0.01	1.02±0.02	14.97±1.36	485.66±14.34	0.15±0.009	2.71±0.18	7.97±0.38
PM	16L:08D	469.66±16.59	87.95±8.07	1.72±0.07	1.16±0.04	0.16±0.02	1.003±0.03	13.73±1.78	476.33±39.41	0.13±0.01	2.53±0.18	8.56±0.90
	14L:10D	460.66±22.38	76.69±2.18	1.78±0.06	1.19±0.03	0.15±0.02	1.043±0.01	12.77±1.34	445.66±19.84	0.11±0.01	2.23±0.20	10.70±1.52
	12L:12D	467.33±18.35	31.31±5.27	1.76±0.07	1.20±0.02	0.13±0.01	1.06±0.02	11.32±0.79	474.33±5.39	0.14±0.01	2.63±0.31	8.69±0.92
	Control	488±9.42	93.56±2.45	1.68±0.06	1.14±0.013	0.12±0.005	1.02±0.008	10.77±0.33	468.33±28.57	0.12±0.01	2.34±0.12	9.35±0.89

Table 5 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at fourth generation

Generation-G4 (5)												
Races	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	605.66±39.15	80.56±0.53	3.45±0.22	1.31±0.07	0.16±0.008	1.15±0.06	12.23±0.86	692±63.17	0.17±0.01	2.23±0.33	7.46±0.86
	14L:10D	562±33.62	77.58±1.73	2.38±0.10	1.36±0.01	0.13±0.01	1.22±0.02	9.72±0.92	709.33±46.06	0.17±0.01	2.1±0.30	8.76±1.92
	12L:12D	592.33±14.26	80.63±1.79	2.82±0.33	1.39±0.008	0.19±0.02	1.19±0.01	13.89±1.53	759±46.48	0.14±0.01	1.60±0.16	10.06±1.32
	Control	606.66±10.36	81.05±4.61	3.32±0.31	1.31±0.04	0.14±0.013	1.17±0.05	11.14±1.39	711±127.11	0.14±0.01	1.88±0.55	9.26±1.10
MU303	16L:08D	520.33±23.93	79.37±3.11	2.35±0.05	1.23±0.02	0.12±0.01	1.14±0.01	10.25±1.09	552±39.80	0.14±0.005	2.31±0.19	8.64±0.49
	14L:10D	529±15.82	77.28±9.99	2.3±0.05	1.21±0.02	0.14±0.02	1.07±0.04	12.06±1.88	541.66±63.81	0.13±0.01	2.26±0.49	9.01±1.04
	12L:12D	541±41.59	25.63±4.35	2.74±0.23	1.29±0.01	0.19±0.02	1.1±0.04	15.15±2.17	690.33±30.54	0.13±0.01	1.63±0.13	10.75±1.72
	Control	574±28.39	77.42±2.45	2.16±0.05	1.22±0.03	0.16±0.03	1.04±0.03	13.56±2.90	581.66±20.98	0.13±0.02	2.09±0.35	9.22±1.70
PM	16L:08D	467.66±17.11	82.22±3.17	1.45±0.04	1.19±0.01	0.16±0.005	1.03±0.01	13.68±0.56	477.33±10.74	0.14±0.008	2.6±0.08	8.53±0.51
	14L:10D	464.33±23.34	82.38±6.12	1.45±0.05	1.17±0.03	0.13±0.008	1.04±0.02	11.09±0.47	476.66±20.10	0.14±0.008	2.6±0.15	8.36±0.77
	12L:12D	477±17.59	90.69±8.10	1.53±0.06	1.21±0.05	0.15±0.03	1.06±0.05	12.83±2.65	483.33±22.34	0.12±0.01	2.3±0.23	9.71±1.46
	Control	485.33±22.73	90.98±3.55	1.41±0.02	1.19±0.05	0.14±0.03	1.05±0.03	11.92±2.18	487.33±17.44	0.14±0.02	2.53±0.36	8.78±2.08

Table 6 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at fifth generation

Generation-G5 (6)												
Races	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	609.66±32.37	87.16±6.53	3.26±0.40	1.37±0.03	0.22±0.008	1.12±0.01	16.36±0.39	903.33±60.05	0.14±0.008	1.46±0.13	9.83±0.57
	14L:10D	578.33±29.09	88.39±6.95	2.68±0.53	1.24±0.02	0.15±0.03	1.08±0.05	12.67±2.99	783.66±69.64	0.12±0.01	1.38±0.02	9.03±1.08
	12L:12D	574.33±15.90	89.81±1.23	2.91±0.29	1.36±0.04	0.21±0.03	1.14±0.01	15.88±2.03	843.33±37.28	0.13±0.01	1.38±0.15	10.59±1.17
	Control	606±14.64	89.9±1.27	3.28±0.30	1.31±0.06	0.2±0.06	1.07±0.052	15.51±4.42	868.33±60.05	0.14±0.005	1.63±0.13	8.91±0.71
MU303	16L:08D	526.66±18.61	83.28±4.84	2.34±0.05	1.23±0.02	0.17±0.04	1.05±0.05	14.38±3.31	572.33±5.95	0.11±0.01	1.77±0.23	10.97±1.24
	14L:10D	523.66±25.86	81.56±2.88	2.266±0.04	1.25±0.02	0.16±0.01	1.08±0.02	13.03±0.92	528±34.44	0.12±0.008	2.04±0.14	10.46±0.63
	12L:12D	542.66±34.88	85.88±4.77	2.52±0.05	1.26±0.05	0.17±0.04	1.09±0.01	13.56±3.32	571±21.96	0.12±0.01	1.95±0.24	10.12±1.02
	Control	550.66±40.88	87.90±2.27	2.15±0.053	1.18±0.05	0.12±0.01	1.05±0.04	10.68±0.40	585±35.77	0.13±0.01	2.07±0.13	8.69±0.62
PM	16L:08D	455.66±7.28	80.31±0.76	1.44±0.04	1.14±0.01	0.14±0.005	1.023±0.01	12.71±0.42	481±14.77	0.11±0.008	2.05±0.20	10.44±0.98
	14L:10D	452.66±50.13	86.85±7.12	1.38±0.07	1.16±0.03	0.14±0.01	1.03±0.01	12.01±1.13	459.66±6.47	0.11±0.008	2.1±0.17	10.97±0.86
	12L:12D	469.66±9.39	89.03±1.34	1.35±0.06	1.16±0.01	0.12±0.02	1.03±0.01	10.86±2.08	480.66±13.69	0.12±0.01	2.33±0.18	9.26±0.94
	Control	485±27.20	89.54±4.61	1.44±0.04	1.17±0.01	0.13±0.005	1.03±0.01	11.64±0.26	495±11.62	0.11±0.01	2.06±0.22	10.18±1.34

The photoperiodic cycle of 16L:08D have a broader significance in the APM1. The highest fecundity obtained in the G7 of APM1 revealed that the photoperiodic cycle of 16L:08D is optimum in enhancing the fecundity at 7th generation of this strain. However, increase in the fecundity is not beneficial if the hatchability percentage is low. In the present study, we have confirmed that the photoperiodic period of 16L:08D is potential in increasing the hatchability percentage in PM at G2. Generally, the quantity of cocoon production is radically depending on the fecundity and fertility [4]. Hence it is essential to focus on increasing the hatchability percentage along with the fecundity. Our results confirmed the significance of photoperiodic cycle of 16L:08D in the enhancement of fecundity & hatchability in two different strains independently.

Table 7 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at sixth generation

Generation-G6 (7)													
Races	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	635±19.49	82.05±2.89	3.50±0.49	1.4±0.008	0.26±0.005	1.13±0.01	18.80±0.38	822.25±52.13	0.15±0.01	1.60±0.09	9.41±1.05
	14L:10D	604.66±31.50	78.19±1.64	2.77±0.26	1.39±0.018	0.28±0.008	1.11±0.01	20±0.62	799.47±32.95	0.12±0.01	1.36±0.18	11.16±1.45
	12L:12D	584.66±29.26	82.07±6.67	2.81±0.20	1.35±0.08	0.17±0.03	1.18±0.04	12.4±2.18	788.75±20.05	0.14±0.008	1.57±0.09	9.66±0.27
	Control	673±18.26	94.67±3.94	3.43±0.47	1.38±0.01	0.16±0.03	1.21±0.03	12.02±2.25	775.66±43.63	0.14±0.01	1.64±0.13	9.7±0.96
MU303	16L:08D	587.66±8.31	90.39±0.59	2.01±0.098	1.32±0.02	0.17±0.01	1.14±0.01	13.34±1.21	551.33±41.46	0.13±0.01	2.07±0.18	10.32±1.52
	14L:10D	564±11.17	82.76±4.48	1.59±0.40	1.25±0.01	0.13±0.01	1.12±0.013	10.3±0.08	523.66±48.53	0.14±0.01	2.41±0.47	9.09±1.16
	12L:12D	561.33±21.54	80.26±7.22	1.61±0.36	1.28±0.02	0.15±0.03	1.13±0.02	11.63±2.22	550.01±19.67	0.12±0.01	2.06±0.25	10.29±1.32
	Control	562.66±41.58	83.52±10.38	1.93±0.05	1.27±0.02	0.16±0.03	1.10±0.01	12.8±2.29	529.33±39.61	0.13±0.02	2.23±0.59	9.91±2.34
PM	16L:08D	471.33±17.67	89.68±0.75	1.6±0.12	1.21±0.02	0.18±0.03	1.03±0.017	14.8±2.97	468.66±14.70	0.12±0.01	2.41±0.30	9.68±1.48
	14L:10D	433.33±29.08	75.16±3.45	1.37±0.08	1.21±0.02	0.19±0.01	1.02±0.013	15.6±1.17	467.66±24.59	0.13±0.008	2.466±0.05	9.33±0.86
	12L:12D	424.66±40.10	75.2±5.90	1.39±0.28	1.19±0.03	0.17±0.03	1.03±0.01	14.4±2.23	459.33±23.34	0.13±0.01	2.5±0.23	9.38±1.57
	Control	470.33±61.39	88.57±10.15	1.58±0.08	1.18±0.03	0.16±0.04	1.02±0.013	13.4±3.13	452.66±16.62	0.14±0.01	2.8±0.15	8.29±0.86

Table 8 Economic parameters of APM1, MU303 and PM strains imposed to photoperiodic regimes of 16L:08D, 14L:10D and 12L:12D at seventh generation

Generation-G7 (8)												
Races	Treatment	Fecundity	Hatchability (%)	Larval weight	Cocoon weight	Shell weight	Pupal weight	Shell ratio	Filament length	Filament weight	Denier	Renditta
APM1	16L:08D	647.33±2.25	94.99±3.25	3.47±0.29	1.43±0.03	0.29±0.03	1.14±0.008	16.3±5.97	812±31.44	0.13±0.02	1.48±0.18	10.97±1.9
	14L:10D	598.66±9.85	90.18±0.79	2.9±0.24	1.36±0.04	0.24±0.04	1.12±0.017	17.53±3.17	794.33±23.26	0.15±0.01	1.65±0.16	9.13±1.005
	12L:12D	587.66±25.71	87.58±5.58	2.82±0.18	1.366±0.04	0.25±0.03	1.11±0.01	18.46±2.10	769.66±8.82	0.11±0.008	1.22±0.06	12.43±0.74
	Control	638.66±35.66	86.53±4.95	3.40±0.18	1.35±0.06	0.21±0.05	1.13±0.01	15.63±2.99	806.66±9.30	0.15±0.018	1.63±0.18	8.86±1.02
MU303	16L:08D	568.33±14.37	89.15±3.58	2.98±0.10	1.31±0.02	0.19±0.008	1.12±0.02	14.4±0.62	586±11.73	0.13±0.008	1.93±0.13	10.13±0.85
	14L:10D	561.66±13.66	79.9±0.15	2.65±0.16	1.26±0.01	0.17±0.02	1.08±0.04	13.73±1.98	562.66±9.85	0.12±0.008	1.88±0.15	10.53±0.93
	12L:12D	549±20.25	76.006±5.71	2.48±0.14	1.26±0.01	0.19±0.04	1.07±0.03	15.23±3.12	564.33±3.61	0.11±0.01	1.75±0.24	11.23±1.32
	Control	581±12.09	91.53±2.84	2.87±0.17	1.27±0.02	0.19±0.02	1.09±0.04	14.9±1.99	586±10.73	0.12±0.01	1.866±0.18	10.38±1.26
PM	16L:08D	486.33±4.92	94.16±0.89	2.78±0.38	1.2±0.02	0.17±0.02	1.03±0.008	14.1±1.67	488±8.94	0.13±0.008	2.33±0.13	9.23±0.59
	14L:10D	481.33±3.72	87.2±1.88	2.77±0.49	1.19±0.03	0.15±0.04	1.04±0.008	12.96±3.36	476±7.64	0.10±0.005	1.96±0.13	11.23±0.91
	12L:12D	443.33±37.91	79.8±1.74	2.83±0.26	1.24±0.008	0.18±0.03	1.05±0.04	15±3.05	452.66±14.03	0.12±0.018	2.42±0.29	10.23±1.77
	Control	470.33±3.61	81.2±6.86	3.14±0.04	1.18±0.06	0.15±0.05	1.02±0.01	13.16±3.92	464±11.41	0.12±0.018	2.36±0.28	9.66±1.06

The larval weight and shell ratio have been drastically enhanced by treatment of 16L:08D in APM1 at G6. Whereas the same treatment of 16L:08D has been proven to be beneficial in enhancing the Shell weight in APM1 of G7. Apart from this, the photoperiodic cycle of 14L:10D has been essential in the increasing the cocoon and pupal weight in APM1 at G0. This reveals that, the APM1 is more sensitive to the photoperiodic cycle of 16L:08D. the larvae, pupae, cocoon and shell weight are known to be enhanced by the amount and quality of food consumed. Further, the pupal and cocoon weight are known to be regulated not only by feeding habitat but also by the concentration of juvenile hormone. In the present work, we have determined the impact of species-specific photoperiodic cycle in the enhancement of such essential economic parameters. However, the connection between the photoperiodic cycle, feeding habitate and juvenile hormone is not evaluated in the present study.

Apart from this, the photoperiodic cycle of 16L:08D is proved to be beneficial in increasing the filament length in APM1 at G5. However maximum increase of filament weight was also reported in APM1 of G2 but was influenced by the photoperiodic cycle of 12L:12D. This reveals that the filament length and weight can be drastically controlled in APM1 at G5 and G2 with varied photoperiodic cycle. Generally, filament length is considered as one of the essential factors in the sericulture that regulates the reeling speed [3]. Our study demonstrates the improvement procedure in the filament length and weight through photoperiodic cycle in different strains of silkworm at different generation. Finally, the photoperiodic treatment of 14L:10D was proven to be ideal in the enhancement of denier value in APM1 at G0. Whereas the same photoperiodic regimes are tended to be referred as responsible for the concurrent highest renditta in the APM1 at G3. This reveals that, significance of photoperiodic treatment in the APM1 for manifestation of better denier value and renditta.

CONCLUSION

Overall, our results confirmed that the photoperiodic treatment in the egg stage can helps in enhancement of several economic parameters in the silkworm at different generation. The present study has revealed the essence of photoperiodic treatment of 16L:08D is most beneficial in the enhancement of majority of economic characters in the silkworm. Further, the APM1 have been proven to me most responsive strain for varied photoperiodic treatment at different generation.

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