ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 11, Issue 3, pp: (63-71), Month: July - September 2023, Available at: www.researchpublish.com

# Evaluation of Cocoon Economic Traits of Mulberry Silkworm, *Bombyx Mori* L. Under Certain Temperature and Humidity Conditions through Multiple Trait Evaluation Index

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**Published Date: 26-August-2023**

***Abstract:*** **Growth and development of the mulberry silkworm, *Bombyx mori* L. are directly affected by environmental factors like photoperiod, temperature and humidity. Sufficient references on the implications of photoperiod on *B. mori* are available. However, information on the effect of temperature and humidity on *Bombyx* silkworm are scanty. The present communication probes into commercial cocoon characters of *Bombyx mori* as influenced by temperature and humidity conditions through multiple trait Evaluation Index (EI) method. Five temperature conditions (20, 25, 30, 35 and 40 °C) and five humidity conditions (RH; 50, 60, 70, 80 and 90%) were selected. Two popular silkworm hybrids (PM x CSR2, a multivoltine x bivoltine hybrid and CSR2 x CSR4, a bivoltine x bivoltine hybrid) were reared under the above temperature and humidity conditions separately, with LD 12 : 12 photoperiodic condition till the end of cocoon harvest. Three cocoon economic characteristics; cocoon weight, shell weight and shell ratio (%) were evaluated under these enrolled temperature and humidity conditions through multiple trait Evaluation Index method. Based on the results on Evaluation Index (EI), it is established that EI values of all individual cocoon economic traits under different temperature and humidity conditions did not cross the fixed base value (50). EI values under certain temperature and humidity conditions crossed designated base value (EI > 50). When EI values for all cocoon economic traits are averaged, the EI values of all cocoon economic traits crossed (EI > 50) the earmarked base value under 25 °C and 80% RH conditions, indicating that these conditions (25 °C and 80% RH) are best suited for obtaining optimum cocoon economic characters for profitable commercial cocoon crop. The other temperature and humidity conditions did not promise for optimum cocoon economic traits as the average EI values are below designated base value (EI < 50).**

***Keywords:*** **Mulberry silkworm, *Bombyx mori*, cocoon economic traits, temperature, humidity, Evaluation Index (EI).**

## 1. INTRODUCTION

The commercial mulberry silkworm, *Bombyx mori* L., like other insects is influenced by external sources or environment like photoperiod, temperature and humidity. While photoperiod is recognized as the strongest among the environmental factor, affecting the overt phenomena in growth and development, thus multiple traits, temperature and humidity are secondary in importance. Though genetic makeup determines the expression of rearing characteristics in *Bombyx* silkworm, the influence of environmental factors seems to affect all the rearing characters in a directional manner. The impact of photoperiod was extensively studied (Sivarami Reddy, 1993; Lakshminarayana Reddy, 2001). Heterozygotic hybrids have greater vigour, faster growth, better productivity, higher resistance to diseases and unfavourable climatic conditions besides better adaptability expressed in terms of crop stability were reported (Ashoka and Govindan, 1990). The ultimate goal of evolving silkworm breeds and evaluation of their hybrids is the simultaneous genetic improvement in multiple traits (Mano

*et al*., 1993; Singh and Subba Rao, 1993; Vidyunmala *et al*., 1998; Ahmed *et al*., 2013). However, all these studies are mainly on evaluating the economic silkworm rearing characters in standard rearing packages (Krishnaswami, 1986; Krishnaswami *et al*., 1973; Datta, 1992; Kanika Trivedy, 2015). Evaluation of such characters under different temperature and humidity conditions are limited (Lakshminarayana Reddy *et al*., 2003). In this direction, a common evaluation index (Mano *et al*., 1993; Singh and SubbaRao, 1993) based on the variation index value, a method used in educational system in Japan to determine student's merit (Mano *et al*., 1993) has been emphasized (Vidyunmala *et al*., 1998). It is to be remembered that the multiple trait evaluation index (Mano *et al*., 1993; Vidyunmala *et al*., 1998; Ahmed *et al*., 2013) was adapted to judge the superiority of various silkworm hybrids in a constant photoperiod, temperature and humidity conditions. Studies on evaluation of two specific silkworm hybrids under varied temperature and humidity conditions are reported in the present study using two popular commercial mulberry silkworm hybrids (PM x CSR2 and CSR2 x CSR4) and photoperiod (LD 12 : 12).

## 2. MATERIALS AND METHODS

Two mulberry silkworm (*B. mori*) hybrids; one from multivoltine x bivoltine hybrid, PM x CSR2 and another from bivoltine x bivoltine hybrid, CSR2 x CSR4 that are popularly exploited for commercial silkworm rearing in the contemporary Indian sericulture are selected. The eggs of silkworm, commonly called as DFLs (disease free layings; each DFL is group of 400 to 500 silkworm eggs laid by a single silk moth on a single day on specific sheet of paper) of the two hybrids were procured from the Silkworm Seed Production Centre (SSPC), National Silkworm Seed Organization (NSSO), Central Silk Board (CSB), Madanapalli, India. The DFLs were transported, during evening cool hours to the Department of Sericulture, Sri Krishnadevaraya University, Anantapur; where the investigations were carried out. The DFLs, at the work spot were immediately spread into the pre disinfected plastic rearing trays (Nilkamal, India).

The silkworm rearing method followed was that as advocated by Krishnaswami (1986). The chawki (young age; I & II instar silkworm larvae) rearing was not conducted to maintain uniformity in experimental conditions all through the experimentation. Hatched out larvae from the egg sheet, collected into pre-disinfected rearing trays were daily fed three times (06.00, 14.00 and 22.00 h) of the day on fresh mulberry (*Morus* sp., V1 variety) leaves except during larval-to-larval ecdysis (moulting). The larvae under moult were not disturbed. The rearing was conducted under natural solar day – LD 12 : 12 condition. The 24 h natural solar day was divided into 12 h dark part (scotophase) and 12 h light part (photophase). The photophase was initiated from 06.00 h and lasted at 18.00 h local time. Similarly, the scotophase was imposed from 18.00 h and continued up to 06.00 h local time. A 60 W bulb, as light source for illuminating the experimental animals during photophase of rearing period was arranged above the rearing tray, its height from the rearing tray was so monitored that the light intensity at the surface, where the experimental animals are exposed, did not exceed 50 lux (Sivarami Reddy, 1993).

Two categories of experimental conditions, temperature and humidity were adopted. In the first instance, experimentation was conducted with temperature. Five temperature regimes, 20, 25, 30, 35 and 40 °C were maintained separately in an environmental chamber (Kolarstat). Five replications, with 1 DFL per each temperature condition were maintained. The photoperiod (LD 12 : 12) and relative humidity (RH, 80%) conditions were common to this set of experimentation. In the second set of experimentation, humidity condition was studied. Five relative humidity (RH) regimes, 50, 60, 70, 80 and 90% were maintained separately in an environmental chamber (Kolarstat). Five replications, with 1 DFL per each RH condition were maintained. The photoperiod (LD 12 : 12) and temperature (25 °C) conditions were common in this experimentation.

Three important cocoon economic parameters; cocoon weight, shell weight and shell ratio (%) were considered. At the end of experimental silkworm rearing, cocoons of PM x CSR2 were harvested on the 6$^{th}$ day of spinning and those of CSR2 x CSR4 were harvested 8$^{th}$ day of spinning (Kanika trivedy, 2015). Known number (20 cocoons) were randomly selected from each replication and weighed separately on electronic balance. Average cocoon weight was calculated for each replication and recorded for further calculation. After taking the cocoon weight, the cocoons were cut-opened; pupae inside cocoon were isolated from cut-opened cocoons and discarded. Cut opened cocoon shells were accurately weighed and recorded. Shell ratio over cocoon weight was calculated as; shell ratio (%) = (shell weight/cocoon weight) x 100. Analysis of data: The data were treated for average and standard deviation. Further, data were analyzed statistically (ANOVA). The crude data simultaneously were computed for Evaluation Index (EI) and for Average EI value according to Mano *et al.* (1983) as described by Singh and Subba Rao (1993), Vidyunmala *et al.* (1998) and Ahmed *et al.* (2013). The floor value fixed to designate EI of a trait's acceptability was > 50, *i.e*., when EI > 50, the trait is accepted to be considered as superior.

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## 3. RESULTS

Evaluation of cocoon economic characters of PM x CSR2 under varied temperature regimes: Data recorded for three cocoon economic characters under varied temperature (20, 25, 30, 35 and 40 °C) reared commonly under LD 12 : 12 and RH of 80% are presented in Table 1.

**Table 1:** Recorded data on three cocoon economic parameters in multivoltine x bivoltine (PM x CSR2) mulberry silkworm, *Bombyx mori* L. under five experimental temperature conditions. Data are mean of 5 replications. Common rearing conditions were LD 12 : 12 and 80% RH.

| Temperature (°C) | Cocoon weight (g) | Shell weight (g) | Shell ratio (%) |
|---|---|---|---|
| 20 | 1.732 | 0.316 | 18.240 |
| 25 | 1.820 | 0.332 | 18.230 |
| 30 | 1.830 | 0.333 | 18.174 |
| 35 | 1.814 | 0.327 | 18.046 |
| 40 | 1.682 | 0.308 | 18.317 |
| Mean | 1.776 | 0.323 | 18.201 |
| SD (±) | 0.065 | 0.011 | 0.101 |

From the table, it is seen that differences in only cocoon weight and shell weights are statistically significant at 5% level while those of shell percentage are not. Maximum values for cocoon weight and shell weights are found with temperature of 25 and 30 °C. The remaining temperature conditions (20, 35 and 40 °C) resulted in less value for both cocoon weight and shell weight.

The macroscopic data on three cocoon economic parameters were computed for Evaluation Index (EI) values and presented in Table 2. Examination of EI values (Table 1.) for cocoon economic traits of PM x CSR2 under different temperature regimes revealed that only few temperature conditions resulted in EI > 50. Thus, none of the characters did show uniformity in EI expression. EI was more than 50 (EI > 50) for only 25 °C condition. When the EI of individual traits are averaged, only two temperature, 25 and 30 °C conditions resulted in EI > 50 and EI at 25 °C emerged as the highest EL (EI = 56).

**Table 2:** Computed Evaluation Index (EI) values on three cocoon economic parameters in multivoltine x bivoltine (PM x CSR2) mulberry silkworm, *Bombyx mori* L. under five experimental temperature conditions. Common rearing conditions were LD 12 : 12 and 80% RH.

| Temperature (°C) | EI for Cocoon weight | EI for Shell weight | EI for Shell ratio | EI total value | EI average value | SD (±) |
|---|---|---|---|---|---|---|
| 20 | 43.339 | 43.294 | 53.802* | 140.435 | 46.812 | 6.054 |
| 25 | 56.796* | 58.092* | 52.849* | 167.737 | 55.912** | 2.731 |
| 30 | 58.325** | 58.835** | 47.286 | 164.446 | 54.815* | 6.525 |
| 35 | 55.878* | 53.813* | 34.572 | 144.264 | 48.088 | 11.751 |
| 40 | 35.662 | 35.966 | 61.491** | 133.118 | 44.373 | 14.825 |

* *Indicates EI > 50 and ** indicated highest EI*

An attempt was made to represent the data on average EI values in graphic form in Figure 1. Perusal of Figure 1 indicated that only two temperature conditions (25 and 30 °C) resulted in EI > 50 and that under 25 °C was the highest (EI = 56), while the differences in average EI values between 25 and 30 °C was not significant. The other three temperature conditions, 20, 35 and 40 °C resulted in EI < 50.

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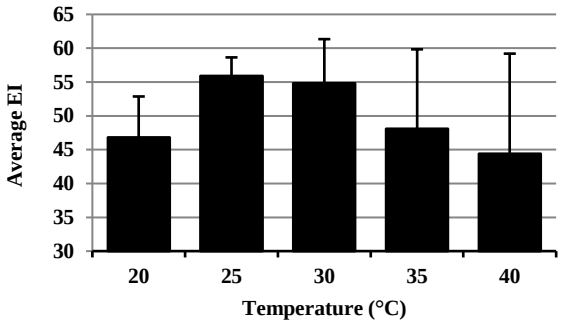


**Figure 1:** Graphical representation of average Evaluation Index values for cocoon economic traits (average EI of cocoon weight, shell weight and shell ratio) in multivoltine x bivoltine (PM x CSR2) mulberry silkworm, *Bombyx mori* L. hybrid under five experimental temperature conditions. Common rearing conditions were LD 12 : 12 and 80% RH.

Evaluation of cocoon economic characters of PM x CSR2 under varied humidity regimes: Cocoon economic traits of single cocoon weight, shell weight and shell ratio (%) were also evaluated for PM x CSR2 under five humidity conditions, RH; 50, 60, 70, 80 and 90%. A temperature of 25 °C and photoperiod of LD 12 : 12 were common for the studies. Data on the three cocoon economic traits under varied humidity conditions are presented in Table 3. It is evident that RH of 80% resulted in high values for single cocoon and shell weight, while shell ratio was almost static. The differences in single cocoon and shell weights are statistically (5% level) significant while those among shell ratio are not.

**Table 3:** Recorded data on three cocoon economic parameters in multivoltine x bivoltine (PM x CSR2) mulberry silkworm, *Bombyx mori* L. under five experimental humidity conditions. Data are mean of 5 replications. Common rearing conditions were LD 12 : 12 and 25 °C temperature.

| Relative Humidity (RH, %) | Cocoon weight (g) | Shell weight (g) | Shell ratio (%) |
|---|---|---|---|
| 50 | 1.732 | 0.316 | 18.240 |
| 60 | 1.811 | 0.330 | 18.230 |
| 70 | 1.839 | 0.335 | 18.188 |
| 80 | 1.874 | 0.343 | 18.305 |
| 90 | 1.773 | 0.320 | 18.057 |
| Mean | 1.806 | 0.329 | 18.204 |
| SD (±) | 0.056 | 0.011 | 0.092 |

When macroscopic data on cocoon economic traits of PM x CSR2 under experimental humidity are computed for Evaluation Index (Table 4), EI was observed crossing the designated floor value of 50 (EI > 50) for certain humidity conditions only while that for the other humidity conditions were less that 50 (EI < 50).

**Table 4:** Computed Evaluation Index (EI) values on three cocoon economic parameters in multivoltine x bivoltine (PM x CSR2) mulberry silkworm, *Bombyx mori* L. under five experimental humidity conditions. Common rearing conditions were LD 12 : 12 and 25 °C temperature.

| Relative Humidity (RH, %) | EI for Cocoon weight | EI for Shell weight | EI for Shell ratio | EI total value | EI average value | SD (±) |
|---|---|---|---|---|---|---|
| 50 | 36.673 | 38.253 | 53.858* | 128.785 | 42.928 | 9.499 |
| 60 | 50.921* | 51.239* | 52.820* | 154.981 | 51.660* | 1.017 |
| 70 | 55.994* | 55.230* | 48.278* | 159.502 | 53.167* | 4.251 |
| 80 | 62.291** | 63.108** | 60.974** | 186.372 | 62.124** | 1.077 |
| 90 | 44.121 | 42.170 | 34.070 | 120.360 | 40.120 | 5.330 |

* *Indicates EI > 50 and ** indicated highest EI*

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EI for cocoon weight was less than 50 (EI < 50) for 50 and 90% RH condition while for the other humidity conditions (60, 70 and 80%), EI was more than 50 (EI > 50). Similar observations were observed in EI values for shell weight also. Thus, EI for shell weight was over 50 (EI > 50) for RH conditions of 60, 70 and 80% and was less than 50 (EI < 50) for RH of 50 and 90%. Interestingly, EI was more than 50 (EI > 50) for shell ration with all the experimental conditions studied. Average EI values were more than 50 (EI > 50) for three humidity regimes, 60, 70 and 80% while it was less than 50 (EI < 50) for RH of 50 and 90%. In all the cases, EI was highest with RH of 80% only.

The trend in EI values of three cocoon economic traits (single cocoon, shell weights and shell ratio) for PM x CSR2, with five experimental humidity (50, 60, 70, 80 and 90%) conditions are clearly depicted in Figure 2. From Figure 2, it can be noticed that average EI values are more than 50 (average EI > 50) with only three relative humidity conditions (60, 70 and 80%) while they were less than 50 (average EI < 50) for the remaining two relative humidity (50 and 90%). Average EI was highest in PM x CSR2 with relative humidity of 80%, recording 62 (average EI = 62). The differences in average EI values are statistically highly significant (1% level).

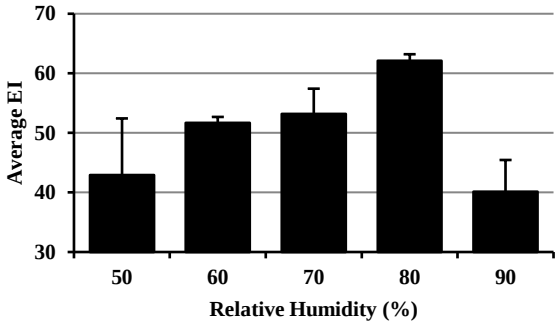


**Figure 2:** Graphical representation of average Evaluation Index (average EI) values for cocoon economic traits (average EI of cocoon weight, shell weight and shell ratio) in multivoltine x bivoltine (PM x CSR2) mulberry silkworm, *Bombyx mori* L. hybrid under five experimental relative humidity conditions. Common rearing conditions were LD 12 : 12 and 25 °C temperature.

Evaluation of cocoon economic characters of CSR2 x CSR4 under varied temperature regimes: Data on three cocoon economic characters, single cocoon, shell weight and shell ratio under varied temperature (20, 25, 30, 35 and 40 °C) reared commonly under LD 12 : 12 and RH of 80% are presented in Table 5. In the case of cocoon economic traits for CSR2 x CSR4 also, it is seen that differences in only cocoon weight and shell weights are statistically significant at 5% level while those of shell percentage are not. Maximum values for cocoon weight and shell weights are recorded with temperature of 25 and 30 °C alone. The remaining three temperature conditions (20, 35 and 40 °C) resulted in less value for both cocoon weight and shell weight. The differences in cocoon weight and shell weights are statistically significant at 5% while those of shell ratio are non significant indicates that the SR (shell ratio) is the racial or hybrid character that gives almost constant value for all the experimental conditions.

**Table 5:** Recorded data on three cocoon economic parameters in bivoltine x bivoltine (CSR2 x CSR4) mulberry silkworm, *Bombyx mori* L. under five experimental temperature conditions. Data are mean of 5 replications. Common rearing conditions were LD 12 : 12 and 80% RH.

| Temperature (°C) | Cocoon weight (g) | Shell weight (g) | Shell ratio (%) |
|---|---|---|---|
| 20 | 1.848 | 0.361 | 19.514 |
| 25 | 1.931 | 0.391 | 20.220 |
| 30 | 1.928 | 0.380 | 19.692 |
| 35 | 1.916 | 0.381 | 19.900 |
| 40 | 1.884 | 0.382 | 20.278 |
| Mean | 1.902 | 0.379 | 19.921 |
| SD (±) | 0.035 | 0.011 | 0.330 |

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On computation of the macroscopic data on three cocoon economic parameters for Evaluation Index (EI) values (Table 6), revealed EI values (Table 6.) for cocoon economic traits of CSR2 x CSR4 under different temperature regimes, only few temperature conditions resulted in EI > 50. Thus, none of the characters did show uniformity in EI expression. EI was more than 50 (EI > 50) for only 25 °C condition. When the EI of individual traits are averaged, only two temperature, 25 and 30 °C conditions resulted in EI > 50 and EI at 25 °C emerged as the highest EL (EI = 56).

**Table 6:** Computed Evaluation Index (EI) values on three cocoon economic parameters in multivoltine x bivoltine (CSR2 x CSR4) mulberry silkworm, *Bombyx mori* L. under five experimental temperature conditions. Common rearing conditions were LD 12 : 12 and 80% RH.

| Temperature (°C) | EI for Cocoon weight | EI for Shell weight | EI for Shell ratio | EI total value | EI average value | SD (±) |
|---|---|---|---|---|---|---|
| 20 | 34.853 | 33.470 | 37.670 | 105.993 | 35.331 | 2.1400 |
| 25 | 58.406** | 60.613** | 59.069* | 178.088 | 59.363** | 1.1323 |
| 30 | 57.608* | 50.746* | 43.065 | 151.419 | 50.473* | 7.2754 |
| 35 | 54.129* | 52.257* | 49.370 | 155.755 | 51.918* | 2.3977 |
| 40 | 45.004 | 52.913* | 60.827** | 158.744 | 52.915* | 7.9114 |

* *Indicates EI > 50 and ** indicated highest EI*

An attempt was made to represent the data on average EI values in graphic form in Figure 3. Perusal of Figure 3 indicated that all humidity conditions, except RH 50 resulted in EI > 50. The EI value under 25 °C was the highest (EI = 59). The differences in average EI values between 25 and 30 °C are significant. Other three temperature conditions, 30, 35 and 40 °C also resulted in EI > 50 and the differences in average values for cocoon economic traits for CSR2 x CSR4 were statistically highly (1%) significant. Least average EI was observed with temperature of 20 °C (average EI = 35).

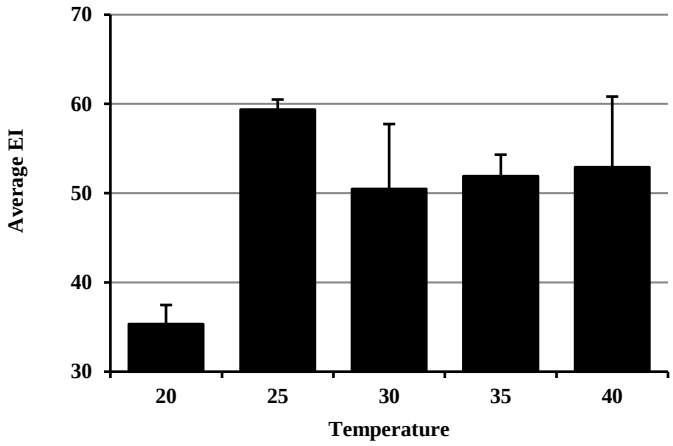


**Figure 3:** Graphical representation of average Evaluation Index values for cocoon economic traits (average EI of cocoon weight, shell weight and shell ratio) in multivoltine x bivoltine (CSR2 x CSR4) mulberry silkworm, *Bombyx mori* L. hybrid under five experimental temperature conditions. Common rearing conditions were LD 12 : 12 and 80% RH.

Evaluation of cocoon economic characters of CSR2 x CSR4 under varied humidity regimes: Cocoon economic traits, single cocoon weight, shell weight and shell ratio (%) were also evaluated for CSR2 x CSR4 under five humidity conditions, RH; 50, 60, 70, 80 and 90%. A temperature of 25 °C and photoperiod of LD 12 : 12 were common for the studies. Data on the three cocoon economic traits under varied humidity conditions are presented in Table 7. It is evident that RH of 80% resulted in high values for single cocoon and shell weight, while shell ratio was almost static for all the relative humidity regimes studied. The differences in single cocoon and shell weights are statistically (5% level) significant while those among shell ratio are not.

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**Table 7:** Recorded data on three cocoon economic parameters in multivoltine x bivoltine (CSR2 x CSR4) mulberry silkworm, *Bombyx mori* L. under five experimental humidity conditions. Data are mean of 5 replications. Common rearing conditions were LD 12 : 12 and 25 °C temperature.

| Relative Humidity (RH, %) | Cocoon weight (g) | Shell weight (g) | Shell ratio (%) |
|---|---|---|---|
| 50 | 1.892 | 0.384 | 20.272 |
| 60 | 2.052 | 0.412 | 20.096 |
| 70 | 2.062 | 0.414 | 20.070 |
| 80 | 2.210 | 0.444 | 20.072 |
| 90 | 1.874 | 0.376 | 20.068 |
| Mean | 2.018 | 0.406 | 20.116 |
| SD (±) | 0.138 | 0.027 | 0.088 |

When macroscopic data on cocoon economic traits, single cocoon, shell weights and shell ratio (%)CSR2 x CSR4 under experimental humidity conditions are computed for Evaluation Index (Table 8), EI was observed crossing the designated floor value of 50 (EI > 50) for certain humidity conditions only while that for the other humidity conditions were less that 50 (EI < 50).

**Table 8:** Computed Evaluation Index (EI) values on three cocoon economic parameters in multivoltine x bivoltine (CSR2 x CSR4) mulberry silkworm, *Bombyx mori* L. under five experimental humidity conditions. Common rearing conditions were LD 12 : 12 and 25 °C temperature.

| Relative Humidity (RH, %) | EI for Cocoon weight | EI for Shell weight | EI for Shell ratio | EI total value | EI average value | SD (±) |
|---|---|---|---|---|---|---|
| 50 | 40.893 | 41.728 | 67.739** | 150.360 | 50.120* | 15.264 |
| 60 | 52.457* | 52.423* | 47.782 | 152.663 | 50.888* | 2.689 |
| 70 | 53.180* | 52.937* | 44.834 | 150.951 | 50.317* | 4.750 |
| 80 | 63.877** | 63.963** | 45.038 | 172.878 | 57.626** | 10.902 |
| 90 | 39.592 | 38.949 | 44.607 | 123.148 | 41.049 | 3.098 |

⁎ *Indicates EI > 50 and ** indicated highest EI*

EI for cocoon weight was less than 50 (EI < 50) for 50 and 90% RH condition while for the other humidity conditions (60, 70 and 80%), EI was more than 50 (EI > 50). Similar observations were observed in EI values for shell weight also. Thus, EI for shell weight was over 50 (EI > 50) for RH conditions of 60, 70 and 80% and was less than 50 (EI < 50) for RH of 50 and 90%. Interestingly, EI was more than 50 (EI > 50) for shell ration with all the experimental humidity conditions studied, except for RH of 90%. Average EI values were more than 50 (EI > 50) for four humidity regimes, 50, 60, 70 and 80% while it was less than 50 (EI < 50) for RH of 90%. In all the cases, EI was highest with RH of 80% only.

The trend in average EI values of three cocoon economic traits (single cocoon, shell weights and shell ratio) for CSR2 x CSR4, with five experimental humidity (50, 60, 70, 80 and 90%) conditions are clearly depicted in Figure 4. From Figure 4, it can be noticed that average EI values are more or less touching the designated floor value (50) with three humidity (50, 60 and 70%) conditions. The average EI was highest (EI = 58) with RH of 80% for CSR2 x CSR4. The last RH (RH of 90) recorded average EI of less than 50 (average EI < 50). The differences in average EI values are statistically highly significant (1% level).

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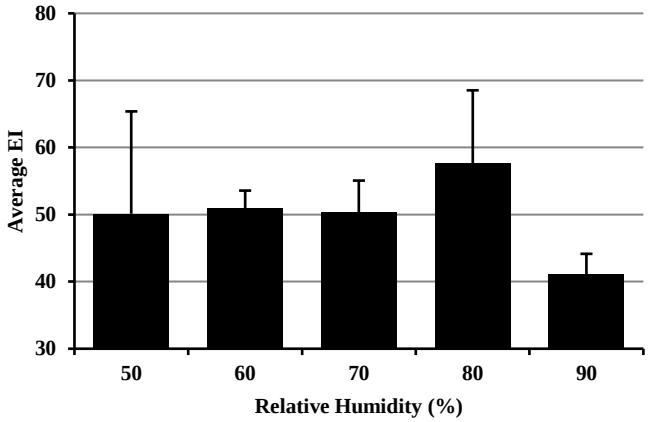


**Figure 4:** Graphical representation of average Evaluation Index (average EI) values for cocoon economic traits (average EI of cocoon weight, shell weight and shell ratio) in multivoltine x bivoltine (CSR2 x CSR4) mulberry silkworm, *Bombyx mori* L. hybrid under five experimental relative humidity conditions. Common rearing conditions were LD 12: 12 and 25 °C temperature.

## 4. DISCUSSIONS

In the present study only three cocoon economic parameters; single cocoon weight, shell weight and shell ratio (%), with two popular silkworm hybrids; PM x CSR2 and CSR2 x CSR4, were considered. These traits of two silkworm hybrids were tested with five temperature and five relative humidity regimes. Silkworm breeds and hybrids were tested and selected for better expressed economic traits (Singh and Subba Rao, 1993; Mano *et al*., 1993; Vidyunmala *et al*., 1998; Ahmed *et al*., 2013). In the present study, silkworm hybrids (PM x CSR2 and CSR2 x CSR4) are common and already popular hybrids in the contemporary Indian sericulture industry. The cocoon economic traits were tested under varied temperature (20, 25, 30, 35 and 40 °C) and relative humidity (50, 60, 70, 80 and 90%) regimes. From the macroscopic data on cocoon economic traits with varied temperature conditions for PM x CSR2 (Table 1) and for CSR2 x CSR4 (Table 5) and these for various relative humidity regimes for PM x CSR2 (Table 3) and for CSR2 x CSR4 (Table 7) clearly indicated that all individual values of traits are different. Even when the macroscopic data are computed for EI values, the situation or trend in all cocoon economic characters started streamlining themselves. Thus, the EI values of PM x CSR2 with experimental temperature conditions (Table 2) and those of CSR2 x CSR4 (Table 6) explains the trend clearly. Further, EI values of cocoon economic traits of PM x CSR2 (Table 4) under different temperature conditions and the same for CSR2 x CSR4 (Table 8) with relative humidity conditions stress the emerging trends. However, different traits reacted differently with studied temperature and humidity conditions. The uncertainty in the individual EI values against different temperature and humidity conditions are understandably cleared when the individual EI values are averaged. The average values for PM x CSR2 with studied temperature conditions (Table 2) and those for CSR2 x CSR4 (Table 6) clearly depicts the emerged trends against temperature. Thus, average EI values were more than 50 (average EI > 50) with 25 and 30 °C and average EI was more than 50 (average EI > 50) with temperatures of 25 to 40 °C. In the case of imposed humidity conditions also, average EI values for PM x CSR2 (Table 4) and for CSR2 x CSR4 (Table 8) also, the situation is clear. The graphic representation of average EI values (Figure 1 to 4) also indicates the certainty in trend emergence. However, there exists still uncertainty. To overcome this uncertainty, the highest average EI values are considered. Thus, highest average EI values for PM x CSR2 with temperature regimes were recorded for the temperature of 25 °C (Table 2 and Figure 1). The same for CSR2 x CSR4 was also seen with 25 °C (Table 6 and Figure 3) only. In the case of relative humidity, highest average EI values observed for PM x CSR2 (Table 4 and Figure 3) as also for CSR2 x CSR4 (Table 8 and Figure 4). At this juncture, it is clear that highest average EI values are observed at 25 °C and with relative humidity of 80% only.

It should be recalled that for silkworm rearing, different levels of temperatures were recommended (Krishnaswami, 1986; Krishnaswami *et al*., 1973; Datta, 1992; Kanika Trivedy, 2015) during different phases of entire silkworm rearing period like incubation of silkworm eggs for hatching, chawki (young) age silkworm rearing and late age silkworm rearing. For late age silkworm rearing, a temperature of 25 °C was suggested. Similarly, relative humidity of 80% was suggested in all the silkworm rearing technologies (Krishnaswami, 1986; Krishnaswami *et al*., 1973; Datta, 1992; Kanika Trivedy, 2015).

Therefore, highest average EI for all the cocoon commercial characters with temperature of 25 °C and with RH of 80% is fully justified irrevocably. Brussel (1970) opined that temperature plays primary and direct role while humidity plays a secondary and indirect role on insects. The fact is more true for purely domesticate commercial silkworm, *B. mori* too. The reports of Lakshminarayana Reddy *et al*, (2003) also confirmed the above. Narasimhulu *et al*, (2020) viewed that temperature affects in a charring mode while humidity in desiccative way. Therefore, temperature of 25 °C and humidity of 80% are more suited for commercial silkworm rearing, as the average EI were (EI > 50) highest over the other temperature and humidity conditions. Other temperature conditions (20, 35 and 40 °C) and humidity conditions (RH; 50, 60, 70 and 90%) are not suitable for silkworm commercial rearing.

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