Advances in Bioresearch
Adv. Biores., Vol 10 (3) May 2019: 69-77
©2018 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.10.3.6977

Advances in Bioresearch

ORIGINAL ARTICLE

Performance of chawki and late age rearing fed with different varieties for Double Hybrid (FC1×FC2) during spring (2019) under Sub-tropical condition of Jammu (J & K)

Stanzin Choskit[1], Renu Rani[1], Indumeet Kour[1] , Seema Kumari[1], Farman Ali Shah[1], Tsetan Dolkar[1], Kanwer Vishwajeet Singh[1], Murali, S[2], Arti Devi[2] and Sarar Singh[2]
1. Department of Sericulture, Poonch Campus, University of Jammu - 185101, India
2. Regional Sericultural Research Station, Central Silk Board, Miran Sahib, Jammu - 181101, India
Email ID: dr.mmrl@rediffmail.com

ABSTRACT
The study was conducted to know the performance of double hyhrid (FC1×FC2) where chawki and late age rearing were fed with different varieties during spring (2019). Mature larval weight was significantly maximum when FC-1×FC-2 worms were fed with leaves of variety Vishala (54.89 g/10 larvae) and minimum recorded in S - 1635 (51.10 g/10 larvae). The ERR by number was recorded among different varieties were statistically significant. The S-1635 recorded more ERR by No. (9288.89) and least in G-4 (6689.00). The ERR by weight was recorded highest in the variety S - 146 (18.04 Kg) and showed significantly from other varieties & lowest in G - 4 (11.84 Kg). The pupation rate was recorded non - significant differences with higher pupation rate was recorded in S-146 (95.67 %) and lowest in G-4 (92.33%) respectively. The single cocoon weight was found significant, S-146 recorded highest cocoon weight 2.00 g and lowest in G-4 (1.83 g). The higher shell weight was observed 0.40 g in S-146 & Vishala and lowest shell weight was recorded in G-4 (0.36 g) with statistically significant. There was statistical significant variation of which highest shell ratio was recorded in C-2038 (20.72%) and lowest in G-4 (19.92%). There was significant variation in the defective cocoon per cent among all the varieties, with highest per cent was in G-4 (7.67%) and lowest in S-146 (4.33%). The filament length was found significant Vishala was recorded highest filament length of about 1212 m and lowest in S-1635 (968 m). The denier varied significantly among different varieties, C-2038 which recorded lowest denier of about 2.72 and highest denier was recorded in Vishala (3.02). The renditta varied significantly, Vishala was recorded lowest renditta of about 2.56 and highest renditta was recorded in S-1635 (3.17). The raw silk was significantly varied among different varieties; Vishala was recorded highest raw silk having 39.48 per cent and lowest in S-1635 (31.91 %). Significantly varied reelability among different varieties, Vishala observed highest reelability having 86.32 per cent and lowest reelability was recorded in S-1635 (79.30%). Chawki and late age worms were fed with different varieties, the results shows that, the mulberry varieties viz., S-146, S-1635, G-4, Vishala and C-2038 were fed with double hybrid FC1×FC2 during chawki stage and the variety was fed during late age rearing was S-146 and according to the evaluation index, the mulberry varieties were shortlisted as Vishala having E.I value 56.70 followed by S-146 (52.29) respectively.
Key words: *Double hybrid, Mulberry varieties, Chawki, Late age, Economic parameters, Evaluation index*

Received 24.03.2019 Revised 17.04.2019 Accepted 02.05.2019

How to cite this article:
S Choskit, R Rani, I Kour , S Kumari, F Ali Shah, T Dolkar, K Vishwajeet Singh, Murali, S, A Devi and S Singh. Performance of chawki and late age rearing fed with different varieties for Double Hybrid (FC1×FC2) during spring (2019) under Sub-tropical condition of Jammu (J & K). Adv. Biores., Vol 10 [3] May 2019.69-77.

INTRODUCTION

About 92.20 *per cent* of the silk produced in the world is obtained from mulberry silkworm *Bombyx mori* L. reared solely on mulberry leaves (*Morus* spp.). Leaf quality is an important parameter used for evaluation of varieties aimed at selection of superior varieties for rearing performance [44] & [8]. Growth and development of silkworm *B. mori* L. is known to vary depending on the quality and quantity of mulberry leaf used as food source, which in turn indicated by commercial characteristics of cocoon crop [30] [42] & [4]. Superiority of different mulberry varieties used as food for silkworm larvae greatly affects

the economy of sericulture industry [11]. Nutritive value of mulberry (*Morus* spp.) leaf is a key factor besides environment and technology adoption for better growth and development of the silkworms and cocoon production [33]. It is a confirmed fact that, leaf quality differs among mulberry varieties which in turn responsible for the difference in silkworm rearing performances [8]. Leaves of superior quality enhance the chances of good cocoon crop [34].

Silkworm, *B. mori* L. is a monophagous insect, feeding exclusively on the mulberry leaves (*Morus* spp.) and an important plant forming the backbone of sericulture industry. Silkworm is gregarious in habit and it grows ten thousand times in weight from hatching to seriposition. Single worm eats about 20 g of leaf throughout its larval life with 90 *per cent* of it in the last two instars to produce large quantity of silk. Different hybrids of silkworm differ in their nutritional requirements, body growth and cocoon parameters. Feed consumption has a direct impact on larval weight, cocoon weight, silk production and number of eggs laid by a moth. Mulberry leaf quality is one of the key factors influencing the growth and development of silkworm, as the insect derives all the nutrients from mulberry leaf itself [3]. High commercial exploitation of *B. mori* L. has led to the evaluation of many silkworm races and mulberry varieties which has increased both silk production as well as mulberry leaf yield [2]. Successful rearing of silkworm depends on three major factors; mulberry leaf, environment and silkworm hybrid. Mulberry leaf solely contributes about 38.20 *per cent* towards successful rearing/quality cocoon production, besides environmental conditions which contributes about 37.00 *per cent* [14].

Better the quality of mulberry leaves greater are the possibilities of obtaining good cocoon crops. Since the production of good quality cocoons depends on providing good quality leaves to silkworm, the development of superior quality leaf has become one of the prime objectives in mulberry breeding programme. Different quality traits such as leaf moisture content, proteins, carbohydrates, nitrogen, amino acids and chlorophyll are responsible for leaf quality [7]. About 70 *per cent* protein of Silk is directly derived from mulberry leaves. The nutrient contents of mulberry leaves have a great affects on the growth of Silkworm, Cocoon crop and finally on raw-silk-yield. Worm health and cocoon characters are highly affected by quality and quantity of food [20] & [35]. The efficiency of converting the ingested and digested food into body, cocoon and cocoon shell varies among the Silkworm breeds under the influence of mulberry varieties and season [1]. Keeping this background in mind the present study was envisaged to identify suitable mulberry varieties for commercial silkworm production under sub-tropical conditions of Jammu region.

MATERIAL AND METHODS

Location

The experiment trial was undertaken at Regional Sericultural Research Station (RSRS), Miran Sahib, Jammu. The rearing was conducted in lab to know the performance of double hybrid (FC1×FC2) reared on different mulberry varieties with chawki and late age with selected mulberry variety i.e. S-146 during spring (2019).

Collection of data

Suitable elite mulberry varieties *viz*., C - 2038, S - 146, Vishala, G - 4 and S - 1635 were used for the study and collected the data to know the rearing performance of double hybrid of silkworm from five varieties with three replications, each replication having 300 worms. The rearing performance of silkworms was collected at the stage of third instars onwards. For each variety details of the following economic parameters were recorded *viz*., larval weight, cocoon weight, shell weight, shell ratio, silk filament length and denier.

Statistical analysis

The experimental data collected on various economic and yield parameters were subjected to Fisher's method of analysis of variance (ANOVA) as per methods outlined [17]. Critical difference (CD) was calculated wherever the 'F' test was found significant. The data are presented with the level of significance at 5 *per cent*. The data pertaining to economic traits *viz*., fifth age larval duration, total larval duration, pupation percentage, cocoon yield by ERR, cocoon weight, cocoon shell weight, cocoon shell percentage, average filament length, denier, raw silk percentage, renditta, reelability and neatness was recorded. Evaluation Index was workout as per the procedure suggested [26].

Results

Rearing parameters recorded during chawki and late age feeding with different varieties

The rearing parameters was recorded where the different mulberry varieties were fed during chawki stage i.e. C - 2038, S - 146, Vishala, G - 4 and S - 1635 and during late age rearing with selected mulberry variety *viz*., S-146 and recorded the following pre - cocoon and post - cocoon parameters on double hybrid (FC1×FC2).

Fifth instar larval duration (h)

The fifth instar larval duration was non significantly varied among different varieties and was recorded as 6 days for all the varieties (Table 1).

Total larval duration (h)

There was non significant variation in the total larval duration with all the varieties and recorded total larval duration of about 25 days 5 h (Table 1).

Mature larval weight (g)

Mature larval weight was significantly maximum when the FC - 1 × FC - 2 worms were fed with leaves of variety Vishala (54.89 g/10 larvae) followed by G - 4 (52.10 g/10 larvae), S - 146 (52.08 g/10 larvae) and C - 2038 (51.50 g/10 larvae). Whereas, significantly minimum mature larval weight was recorded in silkworm fed with leaves of S - 1635 (51.10 g/10 larvae) and all the varieties showed statistically significant among each other (Table 1).

Effective Rate of Rearing (ERR)

The ERR by number was recorded among different varieties were statistically significant. The variety S-1635 recorded more ERR by No. (9288.89) followed by S-146 (9244.44), Vishala (8600.00), C-2038 (8288.89) and least in G-4 (6689.00) (Table 1).

The ERR by weight was recorded highest in the variety S - 146 (18.04 Kg) and showed significantly from other varieties followed by S - 1635 (16.92), Vishala (16.47) & C-2038 (14.06) & lowest was observed in G - 4 (11.84 Kg) (Table 1).

Pupation rate (%)

The pupation rate was obtained from the mulberry varieties fed with double hybrid recorded non - significant differences with higher pupation rate was recorded in S - 146 (95.67 %) followed by S - 1635 (95.00 %), Vishala (94.87 %) and C - 2038 (92.67 %). The lowest pupation was recorded in G - 4 (92.33 %) respectively (Table 1).

Single cocoon weight (g)

The single cocoon weight was found significant differences among varieties, S-146 performed well during rearing which recorded highest cocoon weight 2.00 g followed by Vishala (1.98 g), S-1635 (1.89 g) & C-2038 (1.85 g). The lowest cocoon weight was recorded in G - 4 (1.83 g) (Table 1).

Single shell weight (g)

The cocoon obtained from the silkworm double hybrid recorded significant differences with different mulberry varieties with higher shell weight was observed 0.40 g in S - 146 & Vishala followed by S - 1635 & C - 2038 (0.38 g). The lowest shell weight was recorded in G - 4 (0.36 g) (Table 1).

Shell ratio (%)

There was statistical significant variation in the shell ratio among the varieties, however the hybrid performed better during rearing for the different varieties, of which highest shell ratio was recorded in C - 2038 (20.72 %) followed by S - 1635 (20.16 %), Vishala (20.02 %) and S - 146 (20.00 %). The lowest shell ratio was recorded in G - 4 (19.92 %) (Table 1).

Defective cocoon (%)

There was significant variation in the defective cocoon *per cent* among all the varieties, however the varieties were recorded defective cocoons during rearing for the different varieties with highest *per cent* was in G - 4 (7.67 %) followed by C - 2038 (7.33 %), Vishala (6.33 %) and S - 1635 (5.00 %). The lowest defective cocoon *percentage* was recorded in S-146 (4.33 %) (Table 1).

Post cocoon parameters recorded during chawki and late age feeding with different varieties

Average Filament length (m)

The filament length was found significant differences among different mulberry varieties; Vishala was recorded highest filament length of about 1212 m followed by C-2038 (1095 m), G - 4 (1066 m) and S-146 (1026 m). The lowest filament length was recorded in S-1635 (968 m) (Table 2).

Denier

The denier varied significantly among different varieties, C - 2038 which recorded lowest denier of about 2.72 followed by G-4 (2.76) S-146 (2.91) and S-1635 (2.93) respectively. The highest denier was recorded in Vishala (3.02) (Table 2).

Renditta

The renditta varied significantly among different varieties, Vishala which was recorded lowest renditta of about 2.56 followed by C - 2038 (2.67), G - 4 (2.89) and S - 146 (3.00). The highest renditta was recorded in S - 1635 (3.17) respectively (Table 2).

Raw silk (%)

The raw silk was significantly varied among different varieties; Vishala was recorded highest raw silk having 39.48 *per cent* followed by C - 2038 (37.77 %), G - 4 (34.86 %) and S - 146 (33.74 %). The lowest raw silk *per cent* was recorded in S - 1635 (31.91 %) (Table 2).

Reelability (%)

Significantly varied reelability among different varieties, Vishala observed highest reelability having 86.32 *per cent* followed by S - 146 (82.00 %), G - 4 (81.55 %) and C - 2038 (80.54 %) respectively. The lowest reelability was recorded in S - 1635 (79.30 %) (Table 2).

Evaluation index for mulberry varieties used during chawki and late age rearing with different varieties

The mulberry varieties *viz*., S-146, S-1635, G-4, Vishala and C-2038 were fed with double hybrid FC1 × FC2 during chawki stage and the variety was fed during late age rearing was S - 146 and according to the evaluation index, the mulberry varieties were shortlisted as Vishala having E.I value 56.70 followed by S - 146 (52.29) respectively (Table 3; Fig. 1).

Discussion

Mature larval weight (g)

Mature larval weight was significantly maximum when the FC-1×FC-2 worms were fed with leaves of variety Vishala (54.89 g/10 larvae) followed by G - 4 (52.10 g/10 larvae), S - 146 (52.08 g/10 larvae) and C - 2038 (51.50 g/10 larvae). Whereas, significantly minimum mature larval weight was recorded in silkworm fed with leaves of S - 1635 (51.10 g/10 larvae) and all the varieties showed statistically significant among each other.

The variation in larval weight may be due to the difference in nutritional composition of the leaf. Larval weight was maximum during fifth instar. This may be due to maximum food consumption and growth rate during fifth instar. The present results are comparable with the findings, who observed significant differences in weight of larvae when the silkworm larvae were fed on mulberry varieties *viz*., Kanav-2, Kosen, LM-1, LM-2, Mysore Local, S-30, S-36, S-41 and S-54 [41]. The results reported that, the nutritive quality of leaves Tr-10 and MR-2 varieties were found superior, as larvae fed on these two varieties have shown higher values larval weight [40]. The evaluation of seven mulberry genotypes and concluded SKM-27 recorded the highest larval weight (52.59 g) [19] and also observed better larval growth with different mulberry varieties [23] & [43].

Effective Rate of Rearing (ERR)

The ERR by number was recorded among different varieties were statistically significant. The variety S-1635 recorded more ERR by No. (9288.89) followed by S - 146 (9244.44), Vishala (8600.00), C - 2038 (8288.89) and least in G - 4 (6689.00). The ERR by weight was recorded highest in the variety S - 146 (18.04 Kg) and showed significantly from other varieties followed by S - 1635 (16.92), Vishala (16.47) & C-2038 (14.06) & lowest was observed in G - 4 (11.84 Kg).

The results observed that Berhampore variety was better than Kosen and Mandalaya with regard to effective rate of rearing and mean cocoon weight [23]. The varieties S-36, RFS- 135 and C-776 are equally good in their leaf yield and cocoon yield [37]. Further, the observations in Karnataka that K2 was superior to Mysore local for realizing gain in all cocoon characters [24] and also observed that S1 mulberry variety showed distinct varietal effect on all economic cocoon characters [38] and advocated the standard rearing technologies [21] [22] & [5]. The investigations reported that yield/10,000 larvae by weight was maximum in genotypes SKM-27 and SKM-48 which occupied 3rd and 4th rank as their performance [19].

Pupation rate (%), Single cocoon weight (g), Single shell weight (g) and Shell ratio (%)

The pupation rate was obtained from the mulberry varieties fed with double hybrid recorded non - significant differences with higher pupation rate was recorded in S-146 (95.67 %) followed by S -1635 (95.00 %), Vishala (94.87 %) and C-2038 (92.67 %) and lowest pupation was recorded in G-4 (92.33 %) respectively.

The single cocoon weight was found significant differences among varieties, S-146 performed well during rearing which recorded highest cocoon weight 2.00 g followed by Vishala (1.98 g), S-1635 (1.89 g) & C-2038 (1.85 g) and the lowest cocoon weight was recorded in G-4 (1.83 g). The cocoon obtained from the silkworm double hybrid recorded significant differences with different mulberry varieties with higher shell weight was observed 0.40 g in S-146 & Vishala followed by S-1635 & C-2038 (0.38 g) and lowest shell weight was recorded in G-4 (0.36 g).

These results are in parallel to the findings, who evaluated the feed quality of 25 mulberry varieties utilizing two popular silkworm races *viz*., the crossbreed PM×CSR2 and PM×NB4D2 with significant differences observed among them. Significant differences were observed for cocoon weight when the

larvae were fed on different mulberry varieties [40] and also results reported that the silkworm growth and cocoon characters were optimum when the leaves of V-1, V-4 and S-36 were fed to the larvae.

There was statistical significant variation in the shell ratio among the varieties, however the hybrid performed better during rearing for the different varieties, of which highest shell ratio was recorded in C-2038 (20.72 %) followed by S-1625 (20.16%), Vishala (20.02%) and S-146 (20.00%) and lowest shell ratio was recorded in G-4 (19.92%). There was significant variation in the defective cocoon *per cent* among all the varieties, however the varieties were recorded defective cocoons during rearing for the different varieties with highest *per cent* was in G-4 (7.67%) followed by C-2038 (7.33%), Vishala (6.33%) and S-1635 (5.00%). The lowest defective cocoon *percentage* was recorded in S-146 (4.33%).

The evaluation of three improved Japanese mulberry cultivars *viz*., Ichinose, Goshoerami and Kokuso - 27 for nutritional potential by feeding experiments. The feeding of Ichinose leaves resulted in higher weight of matured larvae and improvement of economic traits of cocoon such as cocoon and shell weight and silk percentage as compared to other two varieties [10]. The studies on interaction of different silkworm breeds with different mulberry varieties. The varieties S30, S36 and S54 registered high cocoon and shell weight, and silk percentage whereas cocoon melting was very low with S54 [16] & [15]. Data pertaining to the rearing parameters *viz*., larval weight, ERR, single cocoon weight, shell weight and cocoon shell ratio revealed that except larval duration (which differed significantly among the four genotypes) the other parameters were non-significant by [25].

The evaluation of 25 mulberry varieties and their feed quality by utilizing two popular silkworm races *viz*., the crossbreed PM×CSR2 and PM×NB4D2. Significant differences were observed for all the characters *viz*., larval weight, survival rate, cocoon weight, shell weight, shell ratio, average filament length and filament denier, when the larvae were fed on different mulberry varieties [40]. The studies on the efficiency of six varieties of mulberry leaves namely V-1, DD, S-36, S-41, Mysore Local and Khurda Local under laboratory condition. It was found that, maximum shell weight was in V1 and S36 and V-1 varieties of mulberry leaves are recommended for feeding in order to achieve better silk yield [6].

Post cocoon parameters

The filament length was found significant differences among different mulberry varieties; Vishala was recorded highest filament length of about 1212 m followed by C-2038 (1095 m), G-4 (1066 m) and S-146 (1026 m). The lowest filament length was recorded in S-1635 (968 m). The denier varied significantly among different varieties, C-2038 which recorded lowest denier of about 2.72 followed by G-4 (2.76) S-146 (2.91) and S-1635 (2.93) respectively. The highest denier was recorded in Vishala (3.02).

The renditta varied significantly among different varieties, Vishala which was recorded lowest renditta of about 2.56 followed by C-2038 (2.67), G-4 (2.89) and S-146 (3.00) and the highest renditta was recorded in S-1635 (3.17) respectively. The raw silk was significantly varied among different varieties; Vishala was recorded highest raw silk having 39.48 *per cent* followed by C-2038 (37.77 %), G-4 (34.86 %) and S-146 (33.74 %). The lowest raw silk *per cent* was recorded in S-1635 (31.91 %). Significantly varied reelability among different varieties, Vishala observed highest reelability having 86.32 *per cent* followed by S-146 (82.00 %), G-4 (81.55 %) and C-2038 (80.54 %) respectively and lowest reelability was recorded in S-1635 (79.30 %).

The studies on disease free eggs of silkworm hybrids MY1×CSR2 were utilized. The treatments were V-1, Kanva-2, BER-1, BER-779, Mizosava, A-1, S-30, S-34, S-36, and S-54. Observations on the different economic traits of silkworm, *B. mori* L. were taken. Larval weight varied in the range of 33.77 g to 40.67 g. Variety V-1 (40.67 g), Larval duration was observed in the range of 21.04 days to 22.28 days. Variety BER-1 (21.04 days), Single cocoon weight 1.664 g to 1.863 g. The highest single cocoon weight was V-1 (1.863 g), Single shell weight 0.297 g to 0.364 g. Maximum shell weight V-1 (0.364 g), Shell percentage 17.60 per cent to 19.82 *per cent*. Maximum yield variety V-1 (18.63 Kg), was observed significantly superior, Cocoon filament length in the range of 680.00 m to 836.66 m. Longest filament length variety V-1 (836.66 m). These findings will help the sericulturists in finding suitable variety for getting more economic returns from silkworm rearing. It is observed that V-1 is becoming popular in Marathwada region [31].

Differences in silk quality parameters between the accessions might be due to difference in the nutritional contents in leaves of different accessions and larval duration during fifth instar. These results are in conformity with the findings who reported significant differences in all the characters *viz*., cocoon weight, shell weight, shell ratio, average filament length and filament denier, when the larvae were fed on different mulberry varieties [40]. The food quality influences the weight of the cocoon, silk yield and physicochemical properties of silk thread. The evaluation of seven mulberry genotypes through bioassays and reported that the highest filament length was recorded in Ichinose (1206 m) [19]. The results

reported that higher amino acids and protein content are of particular importance to the silkworm larvae because of their active utilization for the synthesis of silk protein [39].

The investigations of conducted bioassays on silkworm hybrid N×YB and reported maximum cocoon yield/ 10,000 larvae by weight in CCB9 (19.93Kg) followed by CCB5 (19.91Kg). While maximum shell ratio was found in CCB3 (17.49 %) followed by CCB4 (16.90 %) and maximum non-breakable filament length in CCB8 (857 m) followed by CCB3 (843 m) [9]. A critical evaluation study comprising five mulberry varieties *viz*., S1708, MS5, C10, C6 and M5 was conducted for their leaf quality through silkworm moulting and rearing using crossbreed ($PM \times NB_4D_2$) silkworms. Results revealed that, in moulting tests, silkworm larvae reared on S1708 mulberry leaves recorded highest larval weight (25.03 mg) and moulting ratio (84.96 %) and lowest larval weight (17.04 mg) and moulting ratio (71.06 %) recorded in silkworms reared on C6 leaves during II moult. Silkworms reared on S1708 leaves recorded highest larval weight (39.08 mg), cocoon weight (1.90 g), shell weight (0.41 g), shell percentage (21.66 %), filament length (957.57 mts), reelability (86.88 %), renditta (6.06), denier (2.08) and E.R.R (88.31 %), whereas lower larval weight (26.20 g), cocoon weight (1.30 g), shell weight (0.19 g), shell percentage (16.18 %), filament length (722.60 mts), reelability (56.12 %), renditta (8.30), denier (2.62) and E.R.R (78.86 %) were observed in C6 mulberry leaves [28].

Evaluation Index for mulberry varieties used during chawki rearing and late age rearing

Chawki and late age worms were fed with different varieties, the results shows that, the mulberry varieties *viz*., S-146, S-1635, G-4, Vishala and C-2038 were fed with double hybrid FC1×FC2 during chawki stage and the variety was fed during late age rearing was S-146 and according to the evaluation index, the mulberry varieties were shortlisted as Vishala having E.I value 56.70 followed by S-146 (52.29) respectively.

Mulberry (*Morus* spp.) is an important plant forming the backbone of sericulture as it is the only food for silkworm. Due to its importance in silk producing areas, multiple varieties of mulberry have been developed suited to different agro climates and topographies. The observations reported that due to heterozygous nature of mulberry, variability is high [13] and variations in characters have also been reported [12]. According to multiple character analysis, evaluation index formed a good tool for determining the superiority of mulberry varieties. They however advocated the inclusion of feeding response to give the holistic results [27] & [32].

Seven mulberry varieties recorded mean evaluation index (E.I.) values of >50 ranging from 50.01 to 60.29, whereas, control (Sujanpur) scored E.I. value of 35.10 only. Three mulberry varieties, S-146 (60.29), Tr-8 (52.42) and Tr-10 (52.17) recorded average E.I. value >52 for all the characters under sub-tropical conditions [36].

Table 1. Economic parameters recorded during chawki and late age feeding with different varieties on double hybrid ($FC_1 \times FC_2$) silkworm, *Bombyx mori* L.

Variety	LD (D:h)	5th LD (D:h)	LW (g.)	ERR/10000 larvae		SCW (g.)	SSW (g.)	SR (%)	PR (%)	DC (%)
				NO.	Wt. (Kg)					
S -146	25.05	6.00	52.08	9244.44 (96.13)	18.04	2.00	0.40	20.00 (26.55)	95.67 (78.07)	4.33 (12.00)
S -1635	25.05	6.00	51.10	9288.89 (96.37)	16.92	1.89	0.38	20.16 (26.66)	95.00 (77.09)	5.00 (12.90)
G - 4	25.05	6.00	52.10	6689.00 (81.75)	11.84	1.83	0.36	19.92 (26.49)	92.33 (74.31)	7.67 (16.06)
VISHALA	25.05	6.00	54.89	8600.00 (92.72)	16.47	1.98	0.40	20.02 (26.57)	94.87 (78.21)	6.33 (14.56)
C - 2038	25.05	6.00	51.50	8288.89 (90.96)	14.06	1.85	0.38	20.72 (27.06)	92.67 (74.55)	7.33 (15.70)
CD @ 5 (%)	-		1.14	5.66	1.86	0.03	0.01	0.16	-	0.12
Sem±	0.006		0.36	1.77	0.58	0.01	0.005	0.05	2.53	0.04
CV (%)	0.03		1.19	3.35	6.54	1.05	2.32	0.33	5.73	0.48

Note: LD – Larval duration; D-days; H-hours; LW- Larval weight; ERR- effective rate rearing; PR- pupation rate; SCW- Single cocoon weight; SSW- Single shell weight; SR – Shell ratio; PR-Pupation rate; DC- defective cocoon; Values in parentheses are statistically transformed

Table 2. Post cocoon parameters recorded during chawki and late age feeding with different varieties on double hybrid ($FC_1 \times FC_2$) silkworm, *Bombyx mori* L.

Variety	AFL (mtrs)	Denier	Renditta	Raw Silk (%)	Reelability (%)
S146	1026.00	2.91	3.00	33.74 (35.49)	82.00 (64.94)
S1635	968.00	2.93	3.17	31.91 (34.38)	79.30 (62.91)
G4	1066.00	2.76	2.89	34.86 (36.17)	81.55 (64.53)
VISHALA	1212.00	3.02	2.56	39.48 (38.91)	86.32 (68.26)
C2038	1095.00	2.72	2.67	37.77 (37.90)	80.54 (63.79)
CD @ 5 (%)	5.40	0.08	0.06	0.03	2.26
Sem±	1.69	0.02	0.02	0.01	0.70
CV (%)	0.27	1.52	1.28	0.05	1.89

Note: AFL- Average filament length

Table 3. Evaluation index for economic parameters recorded during chawki and late age feeding with different varieties on double hybrid ($FC_1 \times FC_2$) silkworm, *Bombyx mori* L. during spring season (2019)

Variety	LW (g.)	ERR/10000 larvae		SCW (g.)	SSW (g.)	SR (%)	PR (%)	DC (%)	AFL (mtr)	Denier	Renditta	Raw Silk (%)	Reelability (%)	Average
		No.	Wt. (Kg)											
S-146	48.29	57.77	60.34	61.80	60.47	44.91	60.38	37.55	44.79	53.37	55.77	44.07	50.22	**52.29**
S-1635	41.69	58.19	55.84	46.91	46.81	49.79	55.95	42.16	38.41	54.97	62.67	38.09	40.06	**48.58**
G-4	48.44	33.62	35.47	39.90	35.43	42.42	38.20	60.61	49.19	41.34	51.30	47.74	48.53	**44.01**
VISHALA	67.16	51.68	54.01	59.30	58.19	45.64	55.06	51.38	65.24	62.18	37.90	62.85	66.47	**56.70**
C-2038	44.42	48.74	44.34	42.09	49.09	67.25	40.41	58.30	52.37	38.14	42.37	57.26	44.73	**48.42**

Note: LW- Larval weight; ERR- effective rate of rearing; PR- pupation rate; SCW- Single cocoon weight; SSW- Single shell weight; SR – Shell ratio; DC- Defective cocoon; AFL – Average filament length; Values in parentheses are statistically transformed

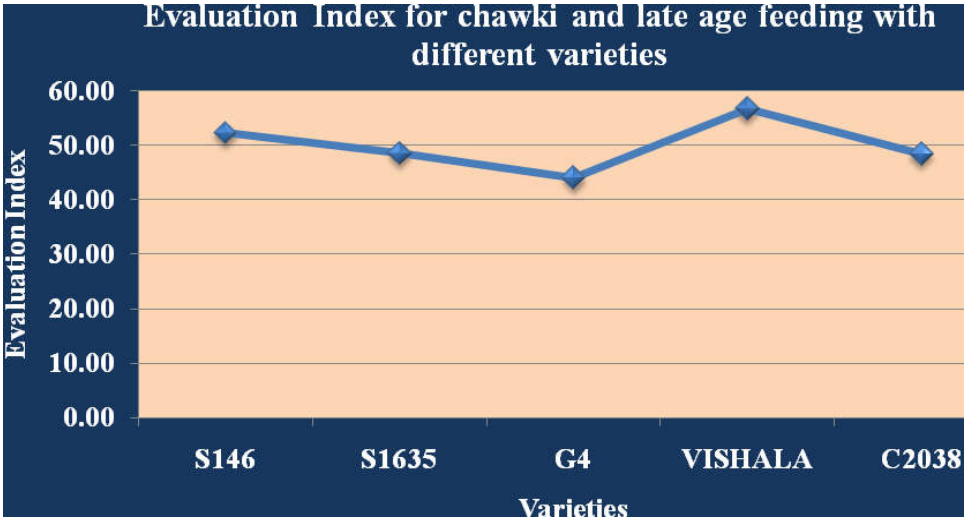

Fig 1. Evaluation index for economic parameters recorded during chawki and late age feeding with different elite mulberry varieties on double hybrid ($FC_1 \times FC_2$) silkworm, *Bombyx mori* L. during spring season (2019)

ACKNOWLEDGEMENT

Authors very thankful to Central Silk Board, Regional Sericultural Research Station, Miran Sahib - 181101, Jammu, J & K, India provided all the necessary facility required for research work.

REFERENCES

1. Anantha Raman, M., Ramananthan, S., Nair, S.G. & Nair, T.V.R. (1995). Farmer's participation in cassava varieties evaluation. RPF, CTCRI, Trivandrum.
2. Babu, M.A.S. (2014). Expression of mixed age characteristics in the developmental marker events of the silkworm, *Bombyx mori* L, Ph.d Thesis., Shri Krishna Devaraya University, Anantpur, India.
3. Bahar, H., Parvaiz, M., Rahman, S. & Islam, R. (2011). Performance of polyvoltine silkworm, *Bombyx mori* L. On different mulberry plant varieties. Entomological research, 41: 46-52.
4. Bari, A., Qaiyyum, M.A. & Ahamed, S. U. (1989). Correlation studies in mulberry which show *Morus alba*, India. J. Seri., 28(1): 11-16.
5. Benchamin, K.V. & Nagaraj C.S. (1987). Silkworm rearing techniques, In: *Appropriate sericulture techniques,* Ed. By M.S. Jolly, Chapter-4, ICTRTS, Mysore, India, pp. 63-106.
6. Bohidar, K., Sahoo. B.S. & Singh, D.K. (2007). Effect of different varieties of mulberry leaves on economic parameters of the silkworm (*Bombyx mori* L.) under Orissa climate. Bull. Ind. Acad. Sci., 11: 60-64.
7. Bongale, U.D. & Chaluvachari (1995). Evaluation of 8 mulberry germplasm varieties by leaf biochemical and bioassay moulting studies. Sericologia, 35: 83-94.
8. Bongale, U.D., Chaluvachari, Mallikarjunappa, R.S., Narahari Rao, B.V., Anantharaman, M.N. & Dandin, S.B. (1997). Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus* spp.). Sericologia, 37(1): 71-81.
9. Chakraborti, S.P., Chakravorty, D., Sengupta, T. & Prathreesh Kumar, P.M. (2004). Primary evaluation of new mulberry lines for their yield and quality bioassay: Annual Report, 19-21. Central Sericultural Research and Training Institute, Berhampore, West Bengal.
10. Dar, H.U., Singh, P.T. & Das, B.C. (1988). Evaluation of mulberry varieties by feeding to *Bombyx mori* L. Indian J. Seric., 27(1): 16-22.
11. Das, B.C. & Sikdar, A.K. (1970). Evaluation of some improved strains of mulberry by feeding experiment. *Indian J. Seric*., 9(1): 26-30.
12. Dorcus, D. and Vivekanandan, M. (1991). Screening of mulberry varieties for rainfed conditions. Sericologia, 31: 233-241.
13. Fotadar, R.K. & Dandin, S.B. (1997). Chemical composition and feeding studies of different elite mulberry genotypes under temperate conditions. Indian Journal of sericulture, 36(1): 22-26.
14. Gangwar, S.K. (2010). The impact of varietal feeding of 8 mulberry varieties on *Bombyx mori* L. Agrick boil J North Am., 1: 350-354.
15. Giridhar, K. & Reddy, S.N. (1991). Effective rate of rearing in bivoltine silkworm, *Bombyx mori* breeds on different mulberry, *Morus* sp. Varieties. Indian J. Seric., 30(1): 88-90.
16. Giridhar, K., Lakshmanan, S., Benchamin, K.V. & Sengupta, K. (1990). Performance of local and Kanva-2 mulberry varieties in respect of leaf and cocoon yields at farmer's level. Indian J. Sericulture, 29(2): 219-226.
17. Gomez, K.A. & Gomez, A. (1984). Statistical Procedure for Agricultural Research - Hand Book. John Wiley & Sons, New York, pp.680.
18. Jalaja Kumar, S. & Ram Rao, D.M. (2008). Characterization of seven mulberry genotypes for their leaf quality and bioassay with silkworm (*Bombyx mori* L*.)* Sericologia, 48(1): 85-93.
19. Khan, I.L., Malik, G.N., Dar, H.U., Baqual, M.F., Malik, M.A. & Raja, T.A. (2007). Evaluation of some mulberry (*Morus* spp.) genotypes through chemo and bio-assay under temperate conditions of Kashmir. Indian Journal of Sericulture, 46(2): 96-102.
20. Koul (1989). Relationship among leaf consumption, body weight and silk production in *Bombyx mori* L. Agrie. serie. Digest, 9(4): 208-210.
21. Krishnaswami, S. (1978). New technology of silkworm rearing. Bulletin no. 2, Central Seri-cultural Research and Training Institute, Mysore, India, pp. 4-8.
22. Krishnaswami, S. (1986). New technology of silkworm rearing. Central Sericultural Research and Training Institute, Mysore, India.
23. Krishnaswami, S., Ahsan, M. & Sriharam, T.P. (1970). Studies on quality of mulberry leaves and silkworm cocoon crop production, Part 2. Quality difference due to maturity. Ind. J. Seric., 9: 11-17.
24. Krishnaswami, S., Kumararai, S. & Vijayaraghavan, K. (1971). Silkworm feeding trials for evaluating the quality of mulberry leaves as influenced by variety, spacing and nitrogen fixation. Indian J. Seric., 10: 79-90.
25. Mallikarjunappa, R.S., Venkateshaiah, H.V., Bongale, U.D., Chandrakala, M.V. & Chaluvachari (2000). Evaluation of improved mulberry genotypes for production of leaf suitable for young age silkworm rearing, with annual 12 leaf harvest schedule. Indian J. Seric., 39(2): 122-126.
26. Mano, Y., Nirmalkumar, S., Bhargava, H.K., Malreddy, N. & Datta, R.K. (1993). A new method to select promising silkworm breeds /hybrid combinations. Indian Silk, 31, p.53.
27. Munshi, N.A., Mallik, G.N., Dar, H.U., Sofi, A.M., Sahaf, K.A., Aijaz, M. & Azad, A.R. (2001). Preliminary evaluation of some open pollinated mulberry (*Morus* spp.) Selections. Journal of research SKUAST-J, 3: 154-157.

28. Murthy, V.N.Y., Ramesh, H.L., Lokesh, G., Munirajappa & Yadav, B.R.D. (2013). Assessment of six mulberry (*Morus*) germplasm varieties through moulting and bioassay parameters by using crossbreed silkworms, *Bombyx mori* L. For commercial exploitation in Kolar district, Karnataka, India. International research journal of biological sciences, 2(9): 69-75.
29. Nagaraju (2002). Application of genetic principles in improving silk production. Current science, 83(4): 409-415.
30. Opender Koul, Tiku, K., Saxena, B.P. & Atal, C.K. (1979). Growth and silk production in *Bombyx mori* L. Feed on 3 different varieties of mulberry. Indian J. Seric., 18(1): 1-5.
31. Pakhale, S.G., Bothikar, P.A., Lande, U.L. and Shendage, S.A. (2014). Evaluation of some mulberry varieties for rearing performance and economic traits of silkworm (*Bombyx mori* L.). Journal of Environmental Science, Toxicology and Food Technology, 8(12): 63-65.
32. Pandit, R.K., Bali, R.K. & Koul, A. (2006). Evaluation index: a tool for evaluating mulberry genotypes. Journal of research SKUAST-J, 5: 186-190.
33. Purohit, K.M. & Pawan Kumar (1996). Influence of various agronomical practices in India on leaf quality in mulberry: *A review.* Serciologia, 36(1): 27-39.
34. Ravi Kumar, C. (1988). Western Ghats as a bivoltine region prospects challenges and strategies of its development. Indian silk, 26(9): 39-54.
35. Remadevi, O.K., Magadum, S.B., Benchamin, K.V. & Datta, R.K. (1993). Mutual correlation among the nutritional and economic characters of the multivoltine silkworm, *Bombyx mori* L. (Lepidoptera: Bombycidae). Indian J seric., 32(2): 189-195.
36. Sajgotra, M., Vikas Gupta & Deldan Namgyal (2018). Effect of mulberry varieties on commercial characters of bivoltine silkworm, *Bombyx mori* L. Journal of Pharmacognosy and Phytochemistry, **7**(1): 1087-1091.
37. Saratchandra, B., Rajanna, L., Philomena, K.L., Paramesh, C., Ramesh, S.P., Jayappa, T. & Sabitha, M.G. (1992). An evaluation of elite mulberry varieties for good yield and quality through bioassay. Sericologia, 32(1): 127-134.
38. Sengupta, K., Mukherjee, S.K., Sikdar, A.K., Mustafi, J.C. & Sengupta, D. (1973). A coordinated study on the effect of variety, spacing in cultivation and levels of nitrogen fertilization of mulberry on the cocoon yield and cocoon characters of multivoltine silkworm, (*Bombyx mori* L.). Indian J. Seric., 12: 39-45.
39. Sujathamma, P. & Dandin, S.B. (2000). Leaf quality evaluation of mulberry (*Morus* spp.) genotypes through chemical analysis. Indian J. Seric., 39: 117-121.
40. Sujathamma, P., Dandin, S.B. & Savitri, G. (2001). Quality evaluation of mulberry (*Morus* spp.) genotypes through bioassay under Rayalaseema conditions of Andhra Pradesh. Indian J. Seri., 40: 27-34.
41. Tayade, D.S., Jawale, M.D. & Unchegaonkar, P. K. (1988). Evaluation of some improved strains of mulberry by feeding experiment under Marathwada conditions. Indian Journal of Sericulture, 22(2): 92-94.
42. Thangamani, R. & Vivekanandan, M. (1984). Physiological studies and leaf nutrient analysis in the evaluation of best mulberry varieties. Sericologia, 24: 317-324.
43. Verma, S.K. & Kushwaha, K.S. (1970). Comparative growth of the silkworm, *Bombyx mori* L. race Bulupolu reared on different mulberry varieties. Indian J. Agric. Sci., 40(12): 1079-1107.
44. Yokoyama, T. (1963). Sericulture. Annual review of entomology, 8: 287-306.

Copyright: © 2019 Society of Education. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.