International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 14, Issue 10, 2022, pp.-11720-11726.
Available online at https://bioinfopublication.org/pages/jouarchive.php?id=BPJ0000217

Research Article

EVALUATING THE EFFECTS OF FEEDING LOCAL MULBERRY VARIETIES ON THE QUANTITATIVE CHARACTERISTICS OF A SILKWORM BIVOLTINE HYBRID IN THE SUBTROPICAL POONCH DISTRICT OF JAMMU AND KASHMIR, INDIA

AASIA MAJID[1], RUBIA BUKHARI*[1], SEEMA LANGER[2] AND ARADHANA SHARMA[3]
[1]PGDepartment of Sericulture, University of Jammu, Poonch Campus, 185101, Jammu and Kashmir, India
[2]Department of Zoology, University of Jammu, Jammu and Kashmir, 185101, India
[3]Department of Sericulture Development of Jammu and Kashmir, Jammu, India
*Corresponding Author: Email - rubiabukhari@gmail.com

Received: September 12, 2022; Revised: October 10, 2022; Accepted: October 11, 2022; Published: October 30, 2022

Abstract: The current study entitled was carried out at PG Department of Sericulture, University of Jammu. The present study was conducted on Silkworm Bivoltine Hybrid $FC_1 \times FC_2$, comprising of four treatments *viz.* single feeding (24 hrs. gap), 2 feedings (12 hrs. gap), 3 feedings (8 hrs. gap) and 4 feedings (6 hrs. gap). Various commercial characters were studied. The data was statistically examined, and Manos' Evaluation Index (E.I.) approach was used to evaluate the data cumulatively. The study revealed that, 4 feedings per day was statistically at par with 3 feedings in terms of various parameters. At egg stage, fecundity, hatching and brushing percentage showed statistically significant results. The average E.I. for fecundity, hatching percentage and brushing percentage observed in 4 feeding frequency treatment was highest followed by 3 feeding frequency treatment. Denier recorded significantly higher value for 4 and 2 times feeding frequency followed by 3 times and least for single times feeding frequency. The Cumulative Evaluation Index (E.I.) values for the complete commercial parameters have also been calculated. Maximum value has been seen in the treatment four followed by treatment three and treatment two and the least Cumulative Evaluation Index (E.I.) has been observed in the treatment one. From this experiment it can safely be concluded that four and three feedings are obligatory for obtaining successful cocoon crop at field level.

Keywords: *Silkworm, FC_1 X FC_2, Feeding, Frequency, Mano's Evaluation Index, Economic parameters*

Citation: Aasia Majid, *et al*., (2022) Evaluating the Effects of Feeding Local Mulberry Varieties on The Quantitative Characteristics of A Silkworm Bivoltine Hybrid in The Subtropical Poonch District of Jammu and Kashmir, India. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 14, Issue 10, pp.-11720-11726.

Academic Editor / Reviewer: Dr N Umashankar Kumar

Introduction

Comparing bivoltine silk to univoltine and multivoltine silk, bivoltine silk is the most precious and costly silk, and the quality of the silk is entirely reliant on the calibre of the feed it consumes. The only feeding stage in the silkworm's lifecycle is the larva. The monophagous insect, *Bombyx mori* L., solely eats mulberry leaves. The presence of the morin in mulberry leaves is what causes silkworms to consume mulberry leaves for food. In order to create silk thread, which is the royal thread in the global textile industry, feeding is thus the most crucial stage in the life cycle of the silkworm. The creation of cocoons is greatly influenced by the silkworms' proper nutrition. For good outcomes in terms of the cocoon, feeding frequency is just as crucial as meal quality. When raising silkworms, determining the frequency of feeding is a crucial phenomenon. It has been discovered that silkworms only need 20 minutes to consume the leaves that are given to them [1].

Sericulture contributes significantly to the economy of the UT of Jammu and Kashmir by giving most of the rural population a source of income. Among all the varieties of silk in our nation, bivoltine silk, which is of the highest quality and rarity, is produced in Jammu and Kashmir and only Jammu and Kashmir has it due of the ideal environmental factors. The chemical components that are needed in mulberry leaves for silkworm feeding include water (80%), protein (27%), carbohydrates (11%), mineral matter, vitamins, and various extracts, among others. Due to the presence of morin [2], mulberry leaves must have favourable physical characteristics including softness, tightness and thickness in order to be readily consumed by silkworms [3].

Legay (1958) [4] Claimed that the nutritional content of mulberry leaves is essential for developing high-quality cocoons and that silk production is reliant on larval feeding.

The goal of the current study is to compare feed rationing and its effects on economic characteristics in order to determine the ideal food quantity and feeding frequency for Poonch district subtropical climate. The purpose of the experiment was to determine the quantity and frequency of feed needed for the obligatory and facultative phases to produce excellent cocoons. The goal of the current study is to evaluate the effects of feeding local mulberry varieties and its impact on economic characters to spot out the most appropriate quantum of food and feeding frequency of silkworm bivoltine hybrid $FC_1 \times FC_2$ under the subtropical conditions of Poonch District of UT Jammu and Kashmir.

Materials and Methods

This experiment was conducted in the month of March and April at Department of Sericulture, Poonch Campus to observe the impact of different feeding frequencies on the traits of bivoltine silkworm and make it useful for the commercial purposes at a large scale. The experimental research material for the study was comprised of four feeds which involved one feed per day (24 hours gap), two feeds per day (12 hours gap), three feeds per day (8 hours gap), four feeds per day (6 hours gap). The bivoltine silkworm $FC^1 \times FC^2$ was taken for the purpose of experiment and was taken care of with everything it takes. The experiment was laid out in CRBD (Completely Randomised Block Design) with four replications. The data was recorded for various characters and subjected to angular transformation for statistical analysis. The whole rearing process was done as per the standard techniques of Dandin, *et al*., (2003) [5]. The worms of the three diseases free layings were brushed and reared upto 3rd moult. The spacing, food and cleaning was done as per requirement and four feedings of chopped mulberry leaves was given in a day.

The timing of the feed was fixed at 8.00 am, 12.00 noon, 15.00 p.m. and 18.00 p.m. a day upto 3rd instar. After third moult, the worms were reared in four replicates for different treatments and each replicate consisted of 100 worms. Ripe worms were picked for seriposition and spinning was conducted on plastic collapsible mountages. The cocoons were harvested on sixth day after mounting. Data was recorded so as to observe the economic traits at egg stage, larval stage, cocoon stage and post-cocoon stage after the experiment.

Results and Discussion

Egg Stage

The experimental trial was started after IIIrd moult. However, upto IIIrd age mass rearing was conducted after brushing randomly 3 dfls (disease free layings) for each treatment and average fecundity, hatching percentage and brushing percentage of four treatments was calculated. Numerically, higher value of (466.00 ± 5.61) for fecundity was recorded in 4th treatment *i.e.,* 4 feeding frequency followed by (436.50 ± 1.50). In case of 3rd treatment *i.e.,* 3 feeding frequency (8 hrs gap), 2nd treatment with 2 feeding frequency recorded a value of (423.50 ± 3.62) and least was observed in 1 feeding frequency having 24 hrs gap (406.75 ± 3.12). (F-cal = 44.33; df= 3; P= 0.000001). Different feeding frequencies record significant variations in terms of hatching as it depicted 96.42 ± 1.17 value for treatment 4th, 93.59 ± 1.38 for treatment 3rd, 91.34 ± 0.44 for treatment 1st in comparison to 2 feeding frequency having 89.97 ± 0.88 for treatment 2nd (F-cal = 10.76; df= 3; P= 0.001019). In case of brushing percentage character 92.82 ± 0.68 for 4th treatment, 90.04 ± 0.68 for 3rd treatment, 87.95 ± 0.78 for 1st treatment and 87.21 ± 1.28 for 2nd treatment was recorded (F-cal = 7.31; df= 3; P= 0.004795). The E.I. value > 50 was recorded for fecundity obtained were as 51.98 and 51.00 for 3 and 2 feeding frequencies respectively. The E.I. value for hatching percentage with 4 feeding frequencies was 55.00. Similarly, E.I. values for brushing percentage recorded was as 54.48 for 4 feedings frequencies per day. The average E.I. for fecundity, hatching percentage and brushing percentage observed in 4 feeding frequency treatment was highest at 53.33 followed by 3 feeding frequency treatment with EI value at 50.33 surpassing the benchmark of >50 [Table-1, 2].

Table-1 Mean Performance values of FC_1 X FC_2 bivoltine silkworm hybrid for Egg traits

Frequency of Feeds/day	Fecundity	Hatching %	Brushing %
1 feed	406.75 ± 3.12	91.34 ± 0.44	87.95 ± 0.78
2 feed	423.50 ± 3.62	89.97 ± 0.88	87.21 ± 1.28
3 feed	436.50 ± 1.50	93.59 ± 1.38	90.04 ± 0.68
4 feed	466.00 ± 5.61	96.42 ± 1.17	92.82 ± 0.68
CD @ 5 (%)	1.715	3.215	2.779
SE (m±)	3.760	1.032	0.892
CV (%)	1.736	2.760	2.505

Table-2 Evaluation Index (E.I.) values of FC_1 X FC_2 bivoltine silkworm hybrid for egg traits.

Frequency of Feeds/day	Fecundity (Nos.)	Hatching percentage	Brushing percentage	Total	Avg. E.I.
1	50.00	48.00	50.00	148.00	49.33
2	50.00	50.00	50.00	150.00	50.00
3	51.00	50.00	50.00	151.00	50.33
4	50.98	55.00	54.48	160.46	53.33

The feeding frequency shows vary significantly in terms of fecundity, hatching and brushing. However, the feeding frequency varied considerably in per se performance so far as fecundity, hatching and brushing percentage were concerned. Fecundity is an important trait for variability of a commercial grainage. Variation in fecundity was found in different feeding frequencies, which resulted in fluctuation of egg number per brood. Tazima (1957) [6] asserts that the mother moth's genotype and the surrounding environment now of oviposition are the key determinants of fertility. The species which grow larger but feed at lower rates and pass-through extended adult life span display very low egg production efficiency [7[. The adequate quantity of offered mulberry leaves is important in silkworm rearing, which affected the fecundity of females, weight of larvae and growth rate [8]. The results are supported by Salem (1974) [9]. Hatching and brushing being two important commercial characters which have direct co-relation with number of worms brushed that ultimately contribute for yield potential both by cocoon weight and number. High percentage of hatching and brushing generally results into more cocoon production.

Hatching and brushing percentage was similar in different feeding frequencies studied for Silkworm Bivoltine Hybrid $FC_1 \times FC_2$. The increased percentage of fertilized eggs was the cause of increased hatching and brushing percentage. It was also discovered that when the quantity of born larvae was larger, the brushing characteristics value was higher. The reason for lower hatching and brushing was due to higher number of unfertilized egg percentage. It was also observed that whenever the late born larvae were higher in number, the value for brushing trait was lower. It might be caused by the physiological status of embryonic development and environmental factors may be due to the physiological status of embryonic development as well as environmental variables such as; temperature, light and humidity during incubation of eggs [6]. Results are in accordance with those obtained by Abd El-Sayed, *et al.*, (2005) [10] who recorded that the hatching and brushing were statistically significant in all conducted treatments of larval starvation throughout the rearing period.

Larval Stage

Larval duration being important, influences rearing duration, labour input and leaf consumption that are directly related to the cost of production and silk productivity. The larval developmental period (D:Hr) varied significantly in terms of IVth instar duration as (5.50 ± 0.28 for 2nd, 5.25 ± 0.25 for 1st, 5.00± 0.40 for 3rd and 4.75± 0.25 for 4th treatment (F-cal =1.11; df= 3; P= 0.382). Fifth instar larval duration with (7.81± 0.20), (7.32± 0.22), (7.23 ± 0.25) and (7.05 ± 0.36) for single, 2, 3 and 4 times feeding frequencies (F-cal 1.44; df=3; P = 0.279). Total larval duration with (27.50± 0.29), (27.00± 0.40), (26.50 ± 0.65) and (26.25 ± 0.94) for single, 2, 3 and 4 times feeding frequencies (F-cal 0.79; df=3; P = 0.524). However, in the event of experiment, the greatest larval duration in the IVth instar was discovered *i.e.,* single feeding frequency (5.50 ± 0.28); Vth instar (7.81± 0.20) for single feeding frequency and in total larval duration (27.50± 0.29) for single feed [Table-3]. The data presented in [Table-3] revealed that IVth and Vth instar larval duration contributes maximum for silk attributing character. At larval stage the E.I. value > 50 was recorded for IVth instar larval duration with single, 2, 3 and 4 feeding frequencies were 50.00. The E.I. value for Vth instar larval duration obtained with 2nd feed was 50.00.

The E.I. value for 4 feeding was 49.98 followed by 49.97 for 3 and single feeding per day respectively. Similarly, E.I. values for total larval duration recorded was 52.00 for 2 feeding per day and 50.00 for single, 3 and 4 feedings per day respectively. The average E.I. for IVth instar, Vth instar and total larval duration observed in 2 feeding frequency treatment was highest at 50.66 followed by 4, 3 and single feeding frequency treatment with EI value at 49.99 [Table-4]. Similar observations were made by Minagawa and Otsuka (1975) [11] and Basu, *et al.*, (1994) [12]. Silkworms are voracious eaters of mulberry during its larval stages and around 80 per cent leaf is consumed in last two instars [13]. Highlighting the importance of food intake [14] reported that to produce 1 g larval dry weight, requirement of ingestion and digestion of food is 4.2 mg and 1.8 mg respectively. The intake of food during total larval life is also reflected by the weight of 10 mature larvae. The data presented in [Table-3] revealed that different feeding treatments exhibited significant results in respect of weight of single mature larvae (g) (F-cal = 106.98; df = 3; P = 0.000) where it was maximum in 4th treatment *i.e.,* 4 feedings (5.22 ± 0.10) followed by 3rd treatment *i.e.,* 3 feedings (4.79 ± 0.03), 4.16 ± 0.07 for 2nd treatment *i.e.,* 2 feedings and least in case of 1st treatment *i.e.,* single feed (3.69 ± 0.05). Length of single mature larvae (cm)(F- cal. = 2.35; df = 3; P = 0.123) where it was maximum in 4th treatment *i.e.,* 4 feedings (8.25 ± 0.10) followed by 1st treatment *i.e.,* 1 feedings (7.83 ± 0.12), 7.75 ± 0.25 for 3rd treatment *i.e.,* 3 feedings and least in case of 2nd treatment *i.e.,* 2 feed (7.75 ± 0.10). However, no significant difference was observed in length of single mature larvae (cm)among various feeding treatments and larval survival percentage (F-cal = 5.63; df = 3; P = 0.012) was observed maximum in case of single feedings (81.97 ± 0.87) followed by 4 feedings (81.12 ± 0.25), 3 feedings (80.52 ± 0.82) least in case of 2 feed (77.08 ± 0.54). Larval mortality percentage (F- cal = 5.63; df = 3; P = 0.012) where it was observed minimum in 1st treatment *i.e.,* single feed (7.99 ± 0.87); 4th treatment *i.e.,* 4 feedings (8.84 ± 1.25) followed by 3rd treatment *i.e.,* 3 feeding (9.44 ± 0 .82) whereas maximum was observed in 2nd treatment *i.e.,* 2 feedings (12.90 ± 0.54).

Table-3 Mean Performance values of FC_1 X FC_2 bivoltine silkworm hybrid for Larval and Cocoon traits.

Frequency of Feeds/day	IV[th] Instar duration (D:Hrs.)	V[th] Instar duration (D:Hrs.)	Total larval duration (D:Hrs.)	Weight of single Mature larvae (g)	Length of single mature larvae (cm)	Larval Survival %	Larval Mortality %	ERR	Pupation Percentage	Dead cocoon percentage	Good cocoon percentage	Defective cocoon Percentage	Volume of cocoon per replication (no.)	Cocoon yield replication By wt.		By No.
														Green Cocoon	Dry Cocoon	
1	5.25 ± 0.25	7.81± 0.20	27.50± 0.29	3.69 ± 0.05	7.83 ± 0.12	81.97 ±0.87	7.99 ± 0.87	96.30 ±0.60	80.41 ± 0.30	3.25±3.01	93.76 ± 0.90	6.24 ± 0.90	81.75 ± 1.11	121.75 ± 1.18	92.75 ± 0.85	82.00 ± 1.08
2	5.50 ± 0.28	7.32± 0.22	27.00± 0.40	4.16 ± 0.07	7.75 ± 0.10	77.08 ±0.54	12.90 ± 0.54	96.72 ± 1.17	83.63 ± 0.31	3.25 ±1.55	95.22 ± 1.66	4.77 ± 1.66	85.25 ± 1.80	124.75 ± 1.25	95.00 ± 0.58	84.75 ± 1.11
3	5.00± 0.40	7.23 ± 0.25	26.50 ± 0.65	4.79 ± 0.03	7.75 ± 0.25	80.52 ± 0 .82	9.44 ± 0 .82	94.86 ± 0.80	83.62 ±0.22	2.25 ±0.53	96.96 ± 0.67	3.04 ± 0.67	91.25 ± 0.85	133.25 ± 5.27	96.25 ± 1.70	88.50 ± 1.56
4	4.75± 0.25	7.05 ± 0.36	26.25 ± 0.94	5.2 ± 0.10	8.25 ± 0.10	81.12 ±0.25	8.84 ± 1.25	95.93 ± 6.33	90.75 ±0.61	2.05±0.86	97.78 ± 0.94	2.22 ± 0.94	92.75 ± 0.61	133.00 ± 13.68	95.50 ± 4.87	89.25 ± 2.78
CD @ 5 (%)	N.S.	N.S	N.S	0.203	N.S	1.819	2.819	N.S.	2.236	N.S	3.449	3.449	N S	N.S	N.S	5.517
SE (m±)	0.306	0.27	0.625	0.065	0.157	0.905	0.905	3.256	0.718	1.488	1.107	1.107	1.448	7.38	2.632	1.771
CV (%)	11.949	7.34	4.662	2.922	3.968	2.257	18.487	6.685	2.151	4.157	2.813	1.654	2.685	11.514	5.548	4.112

Table-4 Evaluation Index (E.I.) values of FC_1 X FC_2 bivoltine silkworm hybrid for IV[th], V[th] and total larval duration.

Frequency of Feeds/day	IV[th] Instar larval duration (D:Hrs.)	V[th] Instar larval duration (D:Hrs.)	Total larval duration (D:Hrs.)	Total	Avg. E.I.
1	50.00	49.97	50.00	149.97	49.99
2	50.00	50.00	52.00	152.00	50.66
3	50.00	49.97	50.00	149.97	49.99
4	50.00	49.98	50.00	149.98	49.99

Table-5 Evaluation Index (E.I.) values of FC_1 X FC_2 bivoltine silkworm hybrid for larval traits

Frequency of Feeds/day	Weight of single mature larvae (g)	Length of single mature larvae (cm)	Larval Survival(%)	Total	Average EI
1	49.99	50.00	50.00	149.99	49.99
2	50.00	49.99	50.00	149.99	49.99
3	49.92	61.14	50.25	161.31	53.77
4	50.00	50.00	54.55	154.55	51.52

Table-6 Evaluation Index (E.I.) values of FC_1 X FC_2 bivoltine silkworm hybrid for cocoon traits

Frequency of Feeds / day	ERR	Cocoon yield per replication (By Wt.)			Pupation %	Dead Cocoon %	Good Cocoon %	Defective Cocoon %	Volume of cocoon per replication (no.)	Total	Avg. E.I.
		Green Cocoon	Dry Cocoon	By No.							
1	41.00	48.65	47.15	44.35	50.00	49.99	50.00	49.99	41.00	422.13	46.90
2	50.00	48.98	49.05	45.76	50.93	50.00	50.27	45.02	50.00	440.75	48.89
3	50.00	42.89	45.25	42.94	54.70	50.03	50.72	43.00	50.00	470.17	47.72
4	51.00	69.31	69.00	66.94	57.14	52.39	50.00	41.99	51.00	510.55	56.53

Table-7 Mean Performance values of FC_1 X FC_2 bivoltine silkworm hybrid for cocoon and pupal traits

Frequency of Feeds / day	Single cocoon weight (g)	Single shell weight (g)	Shell ratio Percentage	Weight of single pupa (g)	Size of single pupa (cm)
1	1.20 ± 0.05	0.22 ± 0.04	25.30 ± 0.33	1.02 ±0.02	2.62 ± 0.05
2	1.40 ± 0.02	0.27 ± 0.07	25.88 ± 0.30	1 .05 ±0.03	2.63 ± 0.08
3	1.60 ± 0.06	0.31 ± 0.05	26.25 ± 0.21	1.25 ± 0.02	2.75 ± 0.07
4	1.75 ± 0.06	0.40 ± 0.26	28.42 ± 0.95	1.42 ±0.04	2.10 ± 0.70
CD @ 5 (%)	0.104	0.043	1.667	0.110	N.S
SE (m±)	0.034	0.014	0.535	0.035	0.355
CV (%)	4.508	9.160	4.045	5.936	28.156

Table-8 Evaluation Index (E.I.) values of FC_1 X FC_2 of bivoltine silkworm hybrid for cocoon traits

Frequency of Feeds/day	Single cocoon weight	Single shell weight	Shell ratio %	Total	Avg. E.I.
1	49.26	50.00	56.77	156.03	52.01
2	50.73	48.21	77.15	176.09	58.69
3	51.47	51.79	74.53	177.79	59.26
4	50.73	48.21	81.16	180.01	60.03

Table-9 Evaluation Index (E.I.) values of FC_1 X FC_2 of bivoltine silkworm hybrid for Pupal traits

Frequency of Feeds/day	Weight of single pupa (g)	Size of single pupa (cm)	Total	Avg. E.I.
1	47.86	45.00	92.86	46.43
2	49.86	46.75	96.61	48.31
3	50.00	49.00	99.00	49.05
4	52.20	53.25	105.45	52.73

The E.I. value for weight of 10 mature larvae in different feeding frequency treatments recorded was maximum in case of 4 and 2 feeding frequencies at 50.00 followed by single feed (49.99) and 3 feeding frequency (49.92). However, for of length of single mature larvae the E.I. value was maximum in case of 3 feeding treatment (61.14) followed by 4 feed and single feeding treatment recorded (50.00) and 2 feeding frequency treatment recorded E.I value of 49.99. Similarly, for of larval survival percentage the E.I. value was maximum in case of 4 feeding frequency treatment (54.55) followed by 3 feeding frequency treatment (50.25); single feeding, and 2 feeding frequency treatment recorded E.I value of 50.00. The average E.I. value for weight of 10 mature larvae, length of single mature larvae and larval survival percentage was higher in 3 feeding frequency treatment (53.77) followed by 4 feeding frequency treatment (51.52) surpassing the benchmark of >50 [Table-5].

Das, *et al.,* (1994) [15] and Kedir, *et al.,* (2015) [16] reported that, 3 to 4 times feeding per day resulted in higher larval weight, lower larval mortality and shorter larval duration than 2 or single time feeding per day. Similar observations were made by Basu, *et al.,* (1994) [12] and Chandrashekar (1996) [17].

Commercial larval survival is a key factor from the perspective of the rearer. The significant variation for larval survival can be attributed to more incidences of silkworm diseases and weakness due to starvation. Similar observations were made by Koul (1998) [18] and Nagasawa, *et al.,* (2006) [19] and it was reported that feeding at regular intervals throughout larval period was very important for optimum growth and development of the worms.

Cocoon Stage

Minagawa and Otsuka (1975) [20] have reported inter relationship between multiple characters in silkworm. Cocoon yield (by wt. and by no.) was significantly affected by feeding frequencies. The following observations on cocoon parameters were recorded for different feeding frequency treatments on experimental material of silkworm hybrid FC_1 x FC_2. The analyzed data on cocoon parameters are presented in [Table-3] and it reveals that the ERR (F-cal = 0.90; df = 3; P = 0.4681) was maximum with 2 feedings a day (96.72 ± 1.17) followed by single feedings (96.30 ± 0.60) 4 feedings (95.93 ± 6.33) and 3 feeding a day (94.86 ± 0.80).

Table-10 Mean Performance values of FC_1 X FC_2 bivoltine silkworm hybrid for post cocoon traits

Frequency of Feeds/day	Total filament length (m)	Raw silk percentage	Filament size (Denier)
1	713.01 ± 4.79	17.54 ± 0.23	2.52 ± 0.03
2	889.38 ± 4.54	17.89 ± 0.20	2.55 ± 0.02
3	869.31 ± 4.84	19.02 ± 0.02	2.54 ± 0.08
4	961.78 ± 11.54	21.18 ± 0.09	2.80 ± 0.01
CD @ 5 (%)	2.043	0.493	0.126
SE (m±)	7.075	0.158	0.040
CV (%)	1.649	1.239	3.108

Table-11 Evaluation Index (E.I.) values of FC_1 X FC_2 bivoltine silkworm hybrid for post cocoon traits

Frequency of Feeds/day	Total filament length (m)	Raw silk percentage	Filament size Denier	Total	Avg. E.I.
1	50.00	45.66	50.00	145.66	46.78
2	50.44	46.41	50.00	146.85	48.95
3	55.86	54.88	56.42	167.16	55.72
4	59.60	61.64	49.25	170.49	56.83

Table-12 Cumulative Evaluation Index (E.I.) values of bivoltine silkworm hybrid (FC_1 X FC_2) on different feeding schedules per day for commercial traits

Feeding Frequency		T-1	T-2	T-3	T-4
		24 hrs gap	12 hrs gap	8 hrs gap	6 hrs gap
Fecundity		50.00	50.00	51.00	50.98
Hatching		48.00	50.00	50.00	55.00
Brushing		50.00	50.00	50.00	54.48
ERR (Effective rate of rearing)		41.00	50.00	50.00	51.00
Cocoon yield per replication	Green cocoon Wt.	48.65	48.98	42.89	69.31
	Dry cocoon Wt.	47.15	49.05	45.25	69.00
	No.	44.35	45.76	42.94	66.94
Pupation percentage		50.00	50.93	54.70	57.14
Dead cocoon percentage		49.99	50.00	50.03	52.39
Good cocoon percentage		50.00	50.27	50.72	50.00
Defective cocoon percentage		49.99	45.02	43.00	41.99
Volume of cocoon per replication		41.00	50.00	50.00	51.00
Single cocoon weight		49.26	50.73	51.47	50.73
Single shell weight		50.00	48.21	51.79	48.21
Shell ratio percentage		56.77	77.15	74.53	81.16
Total filament length		50.00	50.00	55.86	59.60
Raw silk percentage		45.66	45.66	54.88	61.64
Filament size		50.00	50.00	56.42	49.25
Total		871.82	911.76	925.48	1019.82
Avg. E.I.		48.43	50.65	51.42	56.66

However, no significant difference was observed in ERR per cent among various feeding treatments. Cocoon yield by weight (green cocoon weight) (F-cal= 0.62; df = 3; P = 0.6126) was maximum observed with 4 and 3 feedings a day (133.00 ± 13.68); (133.25 ± 5.27) followed by 2 feedings (124.75 ± 1.25) superior over single feeda day (121.75 ± 1.18). The weight of dry cocoons (F-cal= 0.33; df = 3; P = 0.8053) was maximum with 3 feeding a day (96.25 ± 1.70) followed by 4 and 2 feedings a day (95.50 ± 4.87); (95.00 ± 0.58) superior over single feeda day (92.75 ± 0.85). However, no significant difference was observed in cocoon yield by weight (green cocoon wt. and dry cocoon wt.) among various feeding treatments. By number (F-cal= 3.65; df = 3; P = 0.0445), the maximum numbers of cocoons per replication was with 4 feedings *i.e.,* (89.25 ±2.78) followed by 3 feeding and 2 feeding a day (88.50 ± 1.56); (84.75 ± 1.11) and significantly superior over single feed (82.00 ± 1.08). In case of pupation percentage (F =28.61; df = 3; P = 0.000009) was also higher in 4th treatment with 4 feeding frequency *i.e.,* (90.75 ± 0.61). However, with 3 and 2 feeding treatments were found (83.62 ± 0.22); (83.63 ± 0.31) and least pupation percentage was scored by single feeding treatment frequency (80.41 ± 0.30).

Dead cocoon percentage (F-cal = 0.22 df = 3; P = 0.8785) was also higher in treatments with single feeding and 2 feeding *i.e.,* (3.25 ± 3.01) and (3.25 ± 1.55) respectively. The minimum dead cocoon was found in the treatment 4 feed and 3 feeding frequency a day *i.e.,* (2.05 ± 0.86) and (2.25 ± 0.53) respectively. The maximum good cocoon percentage and defective cocoon percentage (F-cal =5.61; df = 3; P = 0.012) were found in the treatment 4 feed a day *i.e.,* (97.78 ± 0.94); (2.22 ± 0.94) respectively followed by 3 feedings (96.96 ± 0.67); (3.04 ± 0.67), 2 feedings (95.22 ± 1.66); (4.77 ± 1.66) and single feed a day (93.76 ± 0.90); (6.24 ± 0.90) and data shows significant difference among all the treatments [Table-4].

However, volume of cocoon per replication (no.) (F-cal =0.69; df = 3; P = 0.5755) was observed maximum in case of 4 feedings (92.75 ± 0.61) followed by 3 feedings (91.25 ± 0.85) 2 feedings (85.25 ± 1.80) and significantly superior over single feed a day (81.75 ± 1.11).

The ERR (Effective rate of rearing) recorded highest E.I. value of 51.00 for 4 feeding frequency, (50.00) for 3 and 2 feeding frequencies, and least (41.00) in single feed frequency schedule [Table-6]. The cocoon yield per replication (by green cocoon wt.) recorded highest E.I. value of 69.31 for 4 feeding frequency, (48.98) for 2 feeding frequency, (48.65) for 1 feeding frequency and least (42.89) in 3 feed frequencies schedule. However, the cocoon yield per 10,000 larvae (by dry cocoon wt.) recorded highest E.I. value recorded in 4 feeding frequency treatment (69.00) followed by 2 and single feeding frequency regime (49.05); (47.15) respectively. The least value (45.25) observed in 3 feeding frequencies schedule. Maximum E.I. value 66.94 for cocoon yield per replication (by no.) was recorded in 4 feeding frequency treatment followed by 2 feeding frequency regimes (45.76). While as, single feed frequency stood at E.I value of 44.35. Lowest E.I. value of 42.94 was recorded in case of 3 feeding frequency treatment.

For pupation rate, maximum E.I. value of 57.14 followed by (54.70) and (50.93) were recorded for 4, 3 and 2 feeding frequencies respectively. Single feed treatment recorded E.I value of 50.00. Dead cocoon percentage is an undesirable character and maximum E.I. value of 52.39 for this parameter was depicted by 4 feeding frequency followed by 3 feeding treatment (50.03) and 2 feedings (50.00). Lowest E.I. value of 49.99 was recorded in single feed treatment. Maximum good cocoon percentage with E.I value of 50.72 was scored by 3 feeding treatment frequency followed by 2 feeding (50.27) and for 4 feeding and single feed treatment *i.e.,* (50.00). Defective cocoons percentage is also an undesirable character.

Higher percentage of defective cocoons results in higher cocoon loss. In the present study, single feed treatment exhibited higher defective cocoons percentage and it stood with E.I. value of 49.99 followed by 2 and 3 feeding frequency (45.02), (43.00) respectively while as least E.I. value of 41.99 was found in 4 feeding frequency [Table-8]. Maximum E.I. value 51.00 for volume of cocoon per replication (no.) was recorded in 4 feeding frequency treatment followed by 3 and 2 feeding frequency regime (50.00). Lowest E.I. value of 41.00 was recorded in case of single feed treatment and remained at lowest rank [Table-6]. The average E.I. value for The E.I. analysis for seven cocoon parameters *viz*., ERR, cocoon yield per replication by weight (green cocoon weight and dry cocoon weight), and by number, pupation percentage, dead cocoon percentage, good cocoon percentage, defective cocoon percentage and volume of cocoon per replication (no.) were higher in 4 feeding frequency treatment (56.53) surpassing the benchmark of >50.

The data presented in [Table-7] revealed that different feeding treatments exhibited significant results in respect of single cocoon weight (F-cal 51.36; df=3; P=0.000), single shell weight (F-cal = 30.35; df = 3; P = 0.000007) and shell ratio percentage (F-cal = 6.46; df = 3; P = 0.0075) significantly different when compared among different feeding frequency treatments and was found maximum with 4 feedings *i.e.*,, (1.75 ± 0.06), (0.40 ± 0.26) and (28.42 ± 0.95) respectively, followed by 3 feedings (1.60 ± 0.06), (0.31 ± 0.05) and (26.25 ± 0.21), 2 feedings (1.40 ± 0.02), (0.27 ± 0.07) and (25.88 ± 0.30) and single feed a day (1.20 ± 0.05), (0.22 ± 0.04) and (25.30 ± 0.33). The data revealed that there is significant difference among all the treatments. However, weight of single pupa (g) (F-cal = 28.49; df = 3; P = 0.000010) where it was maximum in 4th treatment *i.e.,* 4 feedings (1.42 ± 0.04) followed by 3rd treatment *i.e.,* 3 feedings (1.25 ± 0.02), (1.05 ± 0.03) for 2nd treatment *i.e.,* 2 feedings and least in case of 1st treatment *i.e.,* single feed (1.02 ± 0.02). Size of single pupa (cm)(F-cal. = 0.66; df = 3; P = 0.5906) where it was maximum in 3rd treatment *i.e.,* 3 feedings (2.75 ± 0.07) followed by 2nd treatment *i.e.,* 2 feedings (2.63 ± 0.08), 2.62 ± 0.05 for 1st treatment *i.e.,* single feed and least in case of 4th treatment *i.e.,* 4 feeding (2.10 ± 0.70). However, no significant difference was observed in size of single pupa (cm)among various feeding treatments. The variation in cocoon and pupal parameters recorded in different treatments are also showed in [Table-7].

Silkworm cocoon is the important and economic product of rearing. Single cocoon weight is important from yielding/reeling point of view. The manifestations for different parameters of this stage recorded are as under. In 3 feeding treatment highest E.I. values of 51.47 closely followed by 4 and 2 feeding treatment frequency scored E.I values of (50.73) respectively. Least value of (49.26) was recorded in case of single feed treatment. The E.I. value for single shell weight are presented in [Table-8] and reveals that 3 feeding frequency scored maximum E.I. value of 51.79 followed by single feed, 4 and 2 feedings which remain at bench mark of 50.Shell ratio being most important parameter depicts quality and quantity of actual silk content of a cocoon. Maximum E.I. value of 81.16 was observed in 4 feeding frequency treatment followed by 2 feeding frequency (77.15) and 3 feeding frequency (74.53). Lowest E.I. value of 56.77 was observed in case of single feed treatment [Table-8].

Among 4 feeding frequency treatments for important commercial cocoon parameters the average E.I. value for SCW, SSW and Silk ratio percentage was higher in 4 feeding frequency treatment (60.03) followed by 3 feeding treatment (59.26) and for 2 (58.69). The average E.I. value for SCW, SSW and SR percentage was least in case of 1st treatment *i.e.*, single feeding frequency (52.01) and remained at lowest rank [Table-8].

The Evaluation Index (E.I) value for weight of single pupa (g) was maximum in 4 feeding frequency as 52.20 followed by 50.00 for 3 feeding frequency. Whereas, minimum E.I. values of 47.86 was scored by single feed system, followed by 2 feeding frequency treatments 49.86. 4 feeding frequency treatments scored maximum size of single pupa (cm) with E.I. values of 53.25 followed by 49.00 for 3 feeding frequency and 46.75 for 2 feeding frequency. Single feed frequency recorded E.I value of 45.00.

The average E.I. value for weight of single pupa (g) and size of single pupa (cm) was higher in 4 feeding frequency treatment (52.73) surpassing the benchmark of >50 followed by 3 feeding treatment (49.05) and for 2 (48.31) and was minimum (46.43) in case of 1st treatment *i.e.,* single feed [Table-9]. The observations are in accordance with the findings of Nath (1990) [21]. Malik, *et al.,* (1998) [22] suggested that cocoon yield/10,000 larvae by wt. and no., pupation percentage, good cocoon percentage, single cocoon weight, shell weight and shell ratio percentage are important parameters for quality cocoon crop. Pupation percentage and good cocoon percentage are positive signs for cocoon reeling performance as well as seed production. These are generally influenced by rearing environment and other abiotic factors. Good cocooning can be the attribute of rearing spacing, hygiene, seriposition material and appropriate time for picking mature larvae for seriposition. There was a significant feeding frequency variation in respect of good cocoon percentage. One crucial economic factor that affects a breed's or hybrid's variability is the pace at which young are produced. This character shows greater evidence of the connection between genetics and environment. Low heritability for pupation rate and is prone to large variations in different environmental condition and management [23]. The observations are in accordance with the findings of Sinha, *et al*., (2007) [24] and Basu, *et al.,* (1994) [12]. Similar were the observations recorded by Bali, *et al*., (2004) [25] and Basavaraja, *et al.,* (1993) [26]. Saratchandra, *et al*., (2022) [27] has reported superior triploid mulberry varieties responsible for higher cocooning characters. Shell weight has a positive co-relation with cocoon shell ratio. The current findings indicate significant variability in the expression of single shell weight among different feeding frequencies. Significant value was recorded by feeding 4 times frequency followed by 3 and 2 times for the said trait. Similar were the finding of Ahmed, *et al*., (2015a) [28] and Ibrahim, *et al*., (2017) [29]. Higher shell ratio percentage is important for silk filament and different feeding frequencies behaved differently in respect of shell ratio. However, the differences among themselves were non-significant. Maximum shell ratio with respect to per se performance was observed for feeding frequency of 4 times followed by 3 and 2 times, whereas, feeding frequency of single time recorded the minimum value. High fecundity may be the reason for low value of shell ratio as fecundity and shell ratio are negatively correlated as reported by Koul (1989) [30]. These results are like those reported by Sehnal (1985) [31]; and Abd El-Sayed, *et al*., (2005) [10]. Bali, *et al.,* (2003) [3] who studied the effect of starvation on cocoon weight. They found a decrease in the cocoon shell weight due to deprivation during feeding period. The results are in accordance with the findings of Bali, *et al*., (2004) [25]; Saratchandra, *et al*., (2001) [32] and Krishnaswami, *et al*., (1977) [33].

Post Cocoon Stage

Post cocoon characters have greater significance not only from reelers point of view but also from industrial point of view. Three post-cocoon parameter *viz*. total filament length, raw silk percentage and filament size mainly contribute for quality silk, the product. Increase or decrease in filament length is dependent on increase or decrease in the thickness of silk filament and cocoon shell weight of breed/hybrid [34,35,26].

Following observations were recorded for different parameters of post cocoon characters. For total filament length (m) (F-cal = 219.10; df = 3; P = 0.000) and filament size depicted (F = 11.28; df = 3; P = 0.008) which varied significantly among treatments. Numerically, highest value for total filament length recorded was (961.78 ± 11.54) for 4 feeding frequency followed by 889.38 ± 4.54 and 869.31 ± 4.84 for 2 and 3 feeding system. Least value of 713.01 ± 4.79 was scored by single feed frequency. Similarly, raw silk percentage recorded a value of 21.18 ± 0.09 for 4 feeding regimes followed by 3 feedings 19.02 ± 0.02 and 17.89 ± 0.20 for 2 feeding system. Least value of 17.54 ± 0.23 was recorded in single feed system (F-cal = 30.48; df = 3; P = 0.000007). However, filament size 2.80 ± 0.01 was recorded for 4 feeding regimes followed by 2.55 ± 0.02 for 2 feeding frequency, 2.54 ± 0.08 for 3 feeding frequency and 2.52 ± 0.03 for single feed frequency (F-cal = 11.28; df = 3; P = 0.000830) [Table-10]. In this study, total filament length and raw silk percentage was significantly affected by feeding frequencies. 4 times feeding frequency significantly increased the total filament length and raw silk percentage, however, again there was no significant difference between 4 times and 3 times feeding frequency, whereas, single time feeding frequency significantly recorded decrease in the said trait. This may be due to higher mature larval weight [36].

It is generally said that high fecundity results in lower filament length because these two characters are negatively correlated [37]. Rajalakshmi, *et al*., (2000) [38] opines that the quality of a good hybrid is to have minimum or no breaks during reeling. The results corroborate with the findings of Ibrahim, *et al*., (2017) [29]. In the present study filament size was significantly affected by feeding frequencies. Single time feeding frequency recorded reduced filament size and feeding frequency of 4 times recorded highest filament size. This may be since shorter filament length generally results into comparably thick denier. The results are in close agreement with the findings of Nagasawa, *et al.,* (2006) [19].

The Evaluation Index (EI) value for total filament length (m) was maximum in 4 and 3 feeding frequency as 59.60 and 55.86 respectively followed by 50.44 for 2 feeding frequency. Whereas, minimum E.I. value of 50.00 was scored by single feed system. 4 and 3 feeding frequency treatments scored maximum raw silk percentage with E.I. values of 61.64 and 54.88 followed by 2 feedings (46.41). Single feed frequency recorded E.I value of 45.66. Filament size denotes the thickness/ thinness of the filament. The E.I. value of 49.25 was recorded in 4 feeding frequency, 56.42 for 3 feeding frequency, 50 for 2 feeding and single feed system. Among 4 different feeding treatments the average E.I. value ranged between 56.83 (4 feedings) to 55.72 (3 feedings) as indicated in the [Table-11]. While as, 2 feeding frequency stood at E.I value of 48.95. Lowest E.I. value of 46.78 was recorded in case of single feed treatment. In silkworm (*Bombyx mori* L.), selection for various quantitative characters results in change in their mean to a varying degree and the selection for one character is found to produce correlated change in other quantitative characters of economic importance [34].

The Cumulative Evaluation Index (E.I.) values for the complete sixteen parameters have also been calculated. Maximum value has been seen in the treatment four (56.66) followed by treatment three and treatment two (51.42); (50.65) and the least Cumulative Evaluation Index (E.I.) has been observed in the treatment one (48.43) [Table-12].

For the proper growth and development of insects, optimum feeding frequency plays a very important role [41]. It has been clarified that *Bombyx mori* L. grows very fast and needs adequate feed during the last two larval stages because of real feed consuming stage that is about 80-85% of the total feed [39]. This directly leads to the increase in the body size and dry weight of the cellular mass which are dependent on the rate of environmental conditions in each instar in the rearing bed [28]. In feeding frequency and overcrowding in rearing bed effects the cocoon yield which ultimately leads to the less economics of cocoon crop as overfeeding leads to the wastage of leaf and higher cocoon ratios [36], while overcrowding of silkworm in the rearing bed leads to insufficient consumption of feeds, poor growth, and inferior cocoon quality [39, 40]. Good quality of leaves should be fed to the superior quality of the silkworms to influence both the larval growth and cocoon character of mulberry silkworms. So, it is very much important to determine the quantity of feed required per day for each instar of silkworms and feeding frequency according to environmental conditions.

Conclusion

In the present investigation, based on per se performance values and significant difference estimates at egg, larval, cocoon and post-cocoon stages, 4 and 3 times were found to be superior for silkworm rearing. The data obtained from experimental trial was concluded that by providing 4 feeding in a day one can get good quality and quantity of cocoons, 3 feeding in a day can also give good cocoons in terms of quality and quantity, 2 feedings in a day can give good results in some parameters such as total filament length, and filament size denier single feeding in a day give least results in all the quantitative and qualitative parameters. This may be attributed to the adaptability of silkworm larvae to different feeding frequencies for the rearing of the worms. This ultimately proves food rationing have a key role in cocoon characteristics and quality. Thus, based on per se performance values, significant difference values and higher E.I values; for important commercial traits 4 or 3 feeding frequencies.

Application of research: The cumulative result based on the evaluation index (E.I) values from the present investigation indicates that rearing of silkworm for feeding frequency of 4 and 3 times feeds per day for commercial traits of bivoltine hybrid $FC_1 \times FC_2$ are suitable for commercial rearing at field level and can be easily utilized for commercial rearing without affecting the qualitative and quantitative commercial characters.

Research Category: Sericulture

Acknowledgement / Funding: Authors are thankful to PG Department of Sericulture, University of Jammu, Poonch Campus, 185101, Jammu and Kashmir, India. Authors are also thankful to Division of Sericulture and School of Biotechnology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu for providing lab facilities and support for research.

****Research Guide or Chairperson of research: Dr Rubia Bukhari**
University: University of Jammu, Poonch, 185101, Jammu and Kashmir, India
Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: University of Jammu, Poonch Campus, 185101

Cultivar / Variety / Breed name: *Bombyx mori* L.

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Rajalakshmi E., Bhargava S.K. and Thiagarajan V. (1994) *Indian Textile Journal*, 105(11), 83-84.
[2] Tribhuwan S. and Mathur S.K. (1989) *Indian Silk*, 28(5), 39-40.
[3] Bali K., Ram R.K. and Koul A. (2003) *Journal of Research SKUAST-J*., 2(2), 169-177.
[4] Legay J.M. (1958) *Annual review of Entomology*, 3, 76- 86.
[5] Dandin S.B., Jayant J. and Giridhar K. (2003) *Handbook of Sericulture Technologies. Central Silk Board, Bangalore.*
[6] Tazima Y. (1957) *Report on Sericulture Industry in India. Central Silk Board, Bombay, India*, 1957, 29-37.
[7] Muthukrishnan J. and Pandian T.J. (1987) *Indian academic sciences animal science*, 96(3), 171–179.
[8] Hosseini Moghaddam S.H. (2005) *The principals of silkworm breeding. Guilan University press, Iran.*
[9] Salem M.S. (1974*) PhD Thesis Faculty of Agriculture, Cairo University, Giza.*
[10] Abd El-Sayed A., Arram G., Hataba N., and M. Abd ElSamad, (2005) *Paper presented at the 3rd International Poultry Conference, 4-7 Apr., 2005, Hurghada–Egypt.*
[11] Minagawa I., Otsuka Y. (1975) *Japanese J. of Breeding*, 25, 251-257.
[12] Basu R., Roychoudhury N., Shamsuddin M., Sen S.K. and Sengupta K. (1994) *Environment and Ecology*, 10(4), 937-941.
[13] Fukuda T. (1960) *Bullet Agric. Chem., Soc., Jap*.,24, 396-401.
[14] Horie Y. and Watanabe K. (1978) *Applied Entomology and Zoology*, 18(1), 70-80.
[15] Das P., Rahmathulla V.K., Ramesh M., and Rajan R.K. (1994) *J. Appl. Sci. Environ. Manage*., 11(4), 81-84.
[16] Kedir Sh., Metasebia T., Ahmed I., Abiy T., Kassa B., Samuel M., Bereke H. and Eshetu Y. (2015) *Journal of Science and Sustainable Development (JSSD)*, 4(3), 93-97.

[17] Chandrashekar S. (1996) *M.Sc. thesis, University of Agricultural Sciences, Bangalore, India.*
[18] Koul A. (1998) *Agric. Sci. Digest*., 9(4), 208-209.
[19] Nagasawa H., Nagata S., Matsumoto S., Nakane T., Ohara A., Morooka N., Konuma T. and Nagai C. (2006) *Bombyx mori Original Research Article*, (3)1-8.
[20] Minagawa I., Otsuka Y. (1975) *Japanese Journal of Breeding*, 25, 251-257.
[21] Nath B. (1990) *Thesis, Sri Krishnadevaraya University, Anantapur, India.*
[22] Malik G.N., Kamili A.S., Wani S.A., Dar H.L., Ahmed R. and Sofi A.M. (1998) *SKAUST Journal of Research*, 4, 83-87.
[23] Gamo, T. & Hirabayashi, T. (1983) *Japanese Journal of Breeding*, 33, 191-194.
[24] Sinha, R.K., Kumaresan P. and Raje, S. U. (2007) *Caspian Journal of Environmental Sciences*, 5(1), 11-17.
[25] Bali R.K., Ram K., Singh D., Koul A. (2004) *GEOBIOS*, 29(1), 3-4.
[26] Basavaraja H.K., Mano Y., Kumar N.S., Mal., Reddy N. and Datta R.K. (1993) *Indian Silk*, 31, 53.
[27] Saratchandra B., Rajanna L., Philomena K.L., Paramesh C., Ramesh S.P., Jayappa T., et al. (2022) *Sericologia*, 32(1), 127-134.
[28] Ahmed I., Metasebia T., Kedir S.H. and Abiy T. (2015a) *Journal of Science and Sustainable Development,* 3(2), 45-56.
[29] Ibrahim A., Tilahun A., Terefe M. and Shifa K. (2017) *Academic Research Journal of Agricultural Sciences and Research*, 5(1), 20-26.
[30] Koul A. (1989) Agric. Sci. Digest., 9(4), 208-209.
[31] Sehnal F. (1985) *Annual Review of Entomology*, 3(1), 80-100.
[32] Saratchandra B., Krishna N., Rov G. C., Sengupta A.K., Sen S.K. and Chaudhuri A. (2001) *International Journal Industrial Entomology*, 2(2), 110-117.
[33] Krishnaswami S., Singh K. and Raghuraman R. (1977) *Annual Report, Central Sericultural Research & Training Institute, Mysore*, 108-110.
[34] Kobari K., Fujimoto N. (1966) *Nissenzatsu*, 36(6), 427-434.
[35] Nagaraju J. (1990) *Ph.D. Thesis, University of Mysore, Mysore, India*.
[36] Ahmed I., Kedir S.H., Abiy T. And Metasebia T. (2015b) *Science, Technology and Arts Research Journal*, 4(2), 48-52.
[37] Ram K., Bali R.K., Koul A. (2003) *Journal of Research SKUAST-J.*, 2(2), 169-177.
[38] Rajalakshmi E., Chauhan T.P.S., Kamble S.B.T., Mahadevaiah B.M. (2000) *Indian Journal of Sericulture*, 39(1), 21-23.
[39] Krishnaswami S. Noamani M.K.R. and Ahsan M. (1988) *Indian Journal of Sericulture*, 9(1), 1-10.
[40] Mahmoud M.M. and El-Hattab S.M. (2008) *Alexandria Science Exchange Journal*, 33(4), 249-253.