Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 1087-1091
Received: 04-11-2017
Accepted: 05-12-2017

Mokshe Sajgotra
Department of Sericulture, Govt. Degree College, Udhampur, Jammu and Kashmir, India

Vikas Gupta
KVK- Leh, SKUAST-Kashmir, Jammu and Kashmir, India

Deldan Namgyal
KVK- Leh, SKUAST-Kashmir, Jammu and Kashmir, India

Correspondence
Mokshe Sajgotra
Department of Sericulture, Govt. Degree College, Udhampur, Jammu and Kashmir, India

Effect of mulberry varieties on commercial characters of bivoltine silkworm, *Bombyx mori* L.

Mokshe Sajgotra, Vikas Gupta and Deldan Namgyal

Abstract
The investigation was carried out to evaluate the nine mulberry varieties viz., Tr-8, Tr-10, V-1, C-776, China white, S-54, S-146, NS-2 and Sujanpur to find out the varietal difference on the growth and development of bivoltine silkworm hybrid CSR2 × CSR4 for commercial character expression. Mulberry variety China white was treated as control and the performance of selected mulberry varieties was compared with the control. Observations were made on twelve economically important traits of each stage viz., larval (larval weight and larval survival percentage), cocoon (cocoon yield per 10,000 larvae (by weight and by number), single cocoon weight, single shell weight and shell ratio percentage) and post cocoon (total filament length, non-breakable filament length and denier) and was analyzed both individually and cumulatively. The data was analyzed using Evaluation index (E.I.) method. 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.

Keywords: Mulberry Varieties, Effect, Bivoltine**,** Silkworm, Commercial, Characters, Evaluation Index.

Introduction
Silkworm, *Bombyx 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 20g of leaf throughout its larval life with 90 percent 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 (Bahar *et al.*, 2011) [2]. High commercial exploitation of *Bombyx 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 (Babu *et al.*, 2014) [1]. 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 (Gangwar, 2010) [11], besides environmental conditions which contributes about 37.00 per cent. 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 (Bongale and Chaluvachari, 1995) [3]. Appropriate selection of the cultivars based on the plant morphology, disease resistance, biochemical properties and their effect on growth and cocoon yield parameters of *Bombyx mori* races/hybrids in different agro-climatic conditions is essential to select and exploit promising cultivars for better sericulture practices. Various mulberry varieties differ from each other in various characters and the best evaluator of mulberry is the silkworm itself. Criteria have been developed for evaluation through bioassay of silkworm larvae. Impact of particular mulberry variety on particular silkworm hybrid can be evaluated on the basis of growth/development, survival and finally cocoon production, which directly determines the silk productivity (Shankar and Devaiah *et al.*, 1995) [25]. Thus silkworm bioassay becomes an important tool for evaluation of mulberry variety. Keeping this background in mind the present study was envisaged to identify suitable mulberry varieties for commercial silkworm production under sub-tropical climatic conditions of Jammu region.

Materials and Methods

The present investigation was conducted during autumn 2016-17 at Department of Sericulture, Government Degree College, Udhampur with an intention to identify and evaluate different mulberry varieties on metric trait of silkworm hybrid for commercial exploitation. The experimental research material for the proposed study comprised of nine mulberry varieties viz., Tr-8, Tr-10, V-1, C-776, S-54, S-146, NS-2, China white and Sujanpur. The mulberry variety Sujanpur was treated as control. Bivoltine silkworm hybrid, CSR2 × CSR4 was taken for the study. The experiment was laid out in Completely Randomized Block Design (CRBD) with three replications. Standard rearing techniques as suggested by Dandin *et al*. (2003) [6] were followed. After brushing, the silkworms were reared on nine mulberry varieties separately. Each replication had a population size of 200 larvae. Ripe worms were picked for seriposition and spinning was conducted on collapsible plastic mountages. The cocoons were harvested on fifth day during autumn season after mounting. Data was recorded replication-wise for all commercial traits viz., larval duration, larval weight, larval survival percentage, cocoon yield per 10,000 larvae (by weight and by number), single cocoon weight, single shell weight, shell ratio percentage, total filament length, non-breakable filament length and denier. The data was recorded for various traits and was then analyzed using multiple trait index (Evaluation index) method. The Evaluation Index method developed by Mano *et al.* (1993) [17] was found to be very useful in selecting potential hybrids. Data on the economically important traits was collected, pooled and analyzed. The Evaluation Index (E.I.) was calculated as per the procedure:

Evaluation Index (E.I.)

The Evaluation Index (E.I.) was calculated as:

Evaluation Index = [(A–B/C) × 10] + 50

Where, **A** = Value obtained for a particular trait of a particular hybrid combination.
B = Mean values of a particular trait of all the hybrid combinations.
C = Stand deviation of a particular trait of all the hybrid combinations.
10 = Standard Unit.
50 = Fixed Value.

The E.I. value fixed for the selection of hybrid is 50 or >50 for the traits. The hybrid, which scored above the limit, is considered to possess greater economic value.

Results and Discussion

The silkworm (*Bombyx mori* L.) is an economically beneficial insect and survives only on mulberry leaves (*Morus* spp.) The quality of mulberry leaves plays an important role in the nutrition of silkworm and in turn cocoon/silk production for the success of sericulture industry (Choudhary *et al*., 1999) [5].

Commercial Character Expression of Silkworm for Different Mulberry Varieties

Larval Stage

Silkworms are voracious eaters of mulberry during its larval stages and around 80 percent leaf is consumed in last two instars (Fakuda, 1960) [10]. Highlighting the importance of food intake Horie *et al*. (1978) [12] reported that for the production of 1 gram 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 larval weight. In present study a maximum larval weight was recorded in mulberry variety S-146 (E.I. 61.71) fed worms followed by Tr-8 (E.I. 61.08) fed worms (Table 1). This may be attributed to higher digestibility of food leading to higher weight gain during V instar. Yamamoto and Gamo (1976) [28] also reported positive correlation between food ingestion and weight of mature larvae. The current research revealed that the variety S-146 is best for larval growth of CSR2 × CSR4 silkworm hybrid. This reflects higher consumption of mulberry leaves. The present study reveals that the bivoltine worms which consumed more mulberry leaves and attained robust growth at larval stage resulted in the higher larval weight and ultimately cocoon weight, shell weight and raw silk production. Present finding is supported by Kumar *et al.,* (2013) [14] who found similar results. The larval survival percentage being an important character contributes to produce more number of cocoons for higher cocoon yield. A high larval survival percentage was recorded in worms fed on varieties S-146, C-776 and Tr-8. Maximum E.I. value for larval survival was recorded in worms fed on S-146 (60.90) mulberry variety closely followed by C-776 (57.83) (Table 1). Insignificant differences in this parameter does not truly represent the impact of feed type since other factors such as environment and handling of worms also plays an important role in obtaining successful rearing. Kumar *et al.,* (2013) [15] also did not reported variation in larval survival when fed on different varieties of leaf.

Cocoon Stage

Silkworm cocoon is important commercial and economic product of rearing. Cocoon characters are commercially most important and do have close relation with mulberry leaves as food. Malik *et al.* (2006) [16] suggested that effective rate of rearing (by weight and by number), good cocoon percentage, pupation percentage, single cocoon weight, shell weight and shell ratio percentage are important parameter for quality cocoon crop. Varietal effect of different mulberry varieties was studied on cocoon parameters. The cocoon yield per 10,000 larvae (by weight) depicted maximum E.I. value of 61.16 in variety S-146 followed by variety NS-2 with E.I. value of 58.11 and China white (56.97). Lowest E.I. value of 27.50 was obtained by feeding Sujanpur variety (Table 2). Maximum E.I. value for cocoon yield per 10,000 larvae (by number) was recorded in variety S-146 (61.52) followed by variety C-776 (59.89) and NS-2 (51.80), while as the lowest E.I. value for this trait was observed in Sujanpur (27.50) fed worms (Table 2). The higher yield (by weight and by number) in these varieties treated worms may be due to higher larval survival rate. Positive correlation for cocoon yield, single cocoon weight and hatching percentage has been reported by Jayaswal *et al*. (1999) [13] which is in conformity with present findings. Saratchandra *et al.* (2002) [23] also reported mulberry varietal effect on cocoon yield by weight and number. Good cocoon and pupation percentage is a positive sign for cocoon reeling performance as well as seed production. These are generally influenced by rearing environment and other a biotic factor. Maximum E.I. value of 64.13 for good cocoon percentage was recorded by feeding S-146 variety followed by C-776 (61.51), while as variety Sujanpur scored a minimum E.I. value of 29.60 (Table 2). For pupation rate, maximum E.I. value of 62.60 was scored by S-146 and C-776 fed worms followed by NS-2 (55.34) and China white (53.62) with lowest E.I. value of 30.60 in Sujanpur fed worms (Table 2). Uniformity in these characters can be attributed to the rearing practices rather than food type. Major factors among

these include spacing, hygiene, seriposition material and appropriate time for picking of mature larvae for seriposition. Similar observations have been made by Das and Sikadar (1999) [7]. The cocoon weight, shell weight and shell ratio are the important commercial parameters. The cocoon weight has a negative correlation with shell ratio but positive correlation with shell weight, whereas shell weight has a positive correlation with shell ratio. In the present study, highest E.I. value for single cocoon weight of 64.33 was scored by variety S-146 fed worms followed by NS-2 (58.88) and Tr-10 with E.I. value of 58.44, whereas variety Sujanpur fed larvae scored lowest E.I. value of 30.22 (Table 2). This can be attributed to good food digestion for these varieties. Worms fed on mulberry variety S-146 scored maximum E.I value of 66.00 followed by S-54 (61.00), whereas, lowest E.I. value of 29.00 was recorded by feeding variety C-776 for single shell weight (Table 2). This indicates that leaf quality of mulberry varieties is superior which gets converted into silk at higher rates and have a high potential for economic exploitation. Similar trend with respect to shell weight was observed by Maqbool *et al.* (2008) [18]. Shell ratio percentage indicates the amount of raw silk that can be reeled from a given quantity of fresh cocoons. In the present study, maximum E.I. value of 61.23 was recorded in Sujanpur and S-54 varieties fed worms followed by variety Tr-8 (59.17) whereas, lowest E.I. value of 31.50 was obtained in variety C-776 (Table 2). This might be due to higher ingestion, digestion and conversion factors. These results corroborate with the findings of Chandraju *et al.* (2013) [4]. Tikader and Qadri (2009) [26] assessed the leaf quality of selected mulberry germplasm accession using CSR2 × CSR4 hybrid for shell ratio percentage in different seasons and reported that significant variation existed which is in accordance with our findings. Saratchandra *et al.* (2002) [23] reported that superior mulberry varieties results in better cocoon parameter while as, Trivedy *et al.* (2006) [27] reported superiority of triploids mulberry varieties for achieving better cocoon characters.

Post-Cocoon Stage

Post cocoon/reeling characters may not be of much importance to rearer but have greater significance not only from reeler's point of view but also from industrial view. Three post-cocoon parameter viz. total filament length, non-breakable filament length and denier (filament size) mainly contribute towards the end product i.e. silk. In the present study, E.I. value for total filament length was maximum in variety S-146 fed worms (63.22) followed by the China white (62.40) and Tr-10 (58.32), whereas, minimum E.I. value (37.09) was scored by Sujanpur (Table 3). This finding can be attributed to longer larval duration and higher larval weight (Satenahalli *et al.*, 1999) [24]. Rajalakshmi *et al.* (2000) [22] opines that the quality of a good hybrid is to have minimum or no breaks during the process of reeling. Variety S-146 fed worms scored maximum non-breakable filament length having E.I. value of 65.02 followed by mulberry variety C-776 with E.I. value of 60.47, while as the mulberry variety Sujanpur fed worms scored lowest E.I. value of 36.29 only (Table 3). Similar were the findings of Kumar *et al.* (2013) [14]. Denier represents the thinness or thickness of the filament and it was found to be maximum for varieties Tr-8 and V-1 fed worms (E.I. 63.44) and minimum for variety C-776 (E.I. 40.34) respectively (Table 3). Denier being genetically controlled trait and as such it may not have significant co-relation with other parameters. The results are in close conformity with those reported by Murthy *et al.* (2013) [20].

Identification and Evaluation of Superior Varieties

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. Fotadar and Dandin (1997) [9] reported that due to heterozygous nature of mulberry, variability is high. Variations in characters have also been reported by Dorcus and Vivekanandan (1991) [8]. Munshi *et al.* (2001) [19] and Pandit *et al.* (2006) [21] reported that for multiple character analysis, evaluation index formed a good tool for determining the superiority of mulberry varieties. They however advocated the inclusion of feeding response too to give the holistic results. The important commercial traits of silkworm on which silk industry sustains are weight of ten mature larvae, larval survival percentage, cocoon yield per 10,000 larvae (by weight and by number), good cocoon percentage, pupation percentage, single cocoon weight, single shell weight, shell ratio percentage, total filament length, non-breakable filament length and denier. The estimates worked out by evaluation index (E.I.) method for twelve commercial parameters for selected varieties fed worms were pooled. On the basis of pooled E.I. values, seven mulberry varieties viz., C-776 (50.01), NS-2 (50.21), China white (50.94), V-1 (51.19), Tr-10 (52.17), Tr-8 (52.42), and S-146 (60.29) surpassed the E.I. bench mark value > 50 (Table 4). Mulberry variety S-146 ranked 1st on cumulative score of twelve important commercial traits with cumulative E.I. value of 60.29 followed by Tr-8 (52.42) and Tr-10 (52.17). However, control variety stood at E.I. value of 35.10 only (Table 4).

Conclusion

Based on the investigation, it can be concluded that mulberry variety, C-776 (50.01), NS-2 (50.21), China white (50.94), V-1 (51.19), Tr-10 (52.17), Tr-8 (52.42), and S-146 (60.29) surpassed the E.I. bench mark value > 50. Thus, based on the Evaluation Index values for qualitative and quantitative two mulberry varieties viz. S-146 (60.29), Tr-8 (52.42) and Tr-10 (52.17) were identified as potential varieties both by evaluation and ranking through E.I. values respectively. These varieties can be commercially exploited for sub-tropics for autumn season after multi locational trials.

Table 1: Evaluation Index (E.I.) values of hybrid CSR2 × CSR4 fed on different mulberry varieties for larval traits

Traits → Mulberry Variety ↓	Larval weight (g)	Larval Survival Percentage
Tr-8	61.08	55.70
Tr-10	59.15	52.12
V-1	54.35	53.55
C-776	52.00	57.83
S-54	42.38	51.40
S-146	61.71	60.90
NS-2	36.66	59.99
China white	46.21	40.25
Sujanpur (control)	36.42	27.81

Table 2: Evaluation Index (E.I.) values of hybrid CSR2 × CSR4 fed on different mulberry varieties for cocoon traits

Traits → Mulberry Variety ↓	Cocoon yield/10,000 larvae		Good cocoon percentage	Pupation Percentage	Single cocoon weight (g)	Single shell weight (g)	Shell ratio percentage
	By weight (kg)	By number					
Tr-8	52.66	55.03	49.48	48.35	42.44	49.00	59.17
Tr-10	49.23	46.94	45.81	46.60	58.44	53.50	44.10
V-1	49.49	51.80	49.48	46.60	50.77	53.00	53.56
C-776	51.01	59.89	61.51	62.60	39.11	29.00	31.50
S-54	44.16	45.31	45.30	43.69	54.00	61.00	61.23
S-146	61.16	61.52	64.13	62.60	64.33	66.00	54.79
NS-2	58.11	51.80	53.14	55.34	58.88	52.50	42.05
China white	56.97	50.17	51.58	53.62	52.22	50.50	47.80
Sujanpur (control)	27.16	27.50	29.60	30.60	30.22	39.00	61.23

Table 3: Evaluation Index (E.I.) values of hybrid CSR2 × CSR4 fed on different mulberry varieties for post-cocoon traits

Traits → Mulberry Variety ↓	Total filament length (m)	Non-breakable filament length (m)	Denier (d)
Tr-8	40.15	52.49	63.44
Tr-10	58.32	53.93	57.93
V-1	47.70	41.17	63.44
C-776	54.85	60.47	40.34
S-54	41.17	38.29	56.55
S-146	63.22	65.02	44.13
NS-2	44.85	46.83	42.41
China white	62.40	55.48	44.13
Sujanpur (control)	37.09	36.29	38.27

Table 4: Evaluation Index (E.I.) values of hybrid CSR2 × CSR4 fed on different mulberry varieties for commercial traits.

Mulberry Variety → Traits ↓		Tr-8	Tr-10	V-1	C-776	S-54	S-146	NS-2	China white	Sujanpur (control)
Larval weight		61.08	59.15	54.35	52.00	42.38	61.71	36.66	46.21	36.42
Larval Survival Percentage		55.70	52.12	53.55	57.83	51.40	60.90	59.99	40.25	27.81
Cocoon yield per 10,000 larvae	By wt.	52.66	49.23	49.49	51.01	44.16	61.16	58.11	27.16	56.97
	By no.	55.03	46.94	51.80	59.89	54.31	61.52	51.80	27.50	50.17
Good cocoon percentage		49.48	45.81	49.48	61.51	45.30	64.13	53.14	51.58	29.60
Pupation percentage		48.35	46.60	46.00	62.60	43.69	62.60	55.34	53.62	30.60
Single cocoon weight		42.44	58.44	50.77	39.11	54.00	64.33	58.88	52.22	30.22
Single shell weight		49.00	53.50	53.00	29.00	61.00	60.00	52.50	50.50	39.00
Shell ratio percentage		59.17	44.10	53.56	31.50	61.23	54.79	42.05	47.80	61.23
Total filament length		40.15	58.32	47.70	54.85	41.17	63.22	44.85	62.40	37.09
Non-breakable filament length		52.49	53.93	41.17	60.47	38.29	65.02	46.83	55.48	36.29
Filament size		63.44	57.93	63.44	40.34	56.55	44.13	42.41	44.13	38.29
Av. E.I.		52.42	52.17	51.19	50.01	49.46	60.29	50.21	50.94	35.10

References

1. Babu T Madhu, Seenaiah R, Basha P Akbar, Naik S Thimma. Studies on the biochemical and bioassay different varieties of mulberry (*Morus alba* L.) leaves fed by silkworm in relation to silk production. International Journal of Biological & Pharmaceutical Research. 2014; 5(8):664-667.
2. Bahar Md, Habibullah, Parvez Mahmud Al, Rahman Saidur, Islam Rejaul. Performance of polyvoltine silkworm *Bombyx mori* L. on different mulberry plant varieties. Entomological Research. 2011; 41:46-52.
3. Bongale UD, Chaluvachari. Evaluation of eight mulberry germplasm varieties by leaf biochemical and bio-assay moulting studies. Sericologia. 1995; 35:83-94.
4. Chandraju S, Girija Nagendraswamy, Chidan Kumar CS, Shree Harsha Kumar SS. Influence on the overall performance of the mulberry silkworm, *Bombyx mori* L. CSR2 × CSR4 hybrid cocoon reared with V-1 mulberry leaves irrigated by distillery spentwash. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2013; 4(2):299-304.
5. Choudhary PC, Shukla P, Ghosh B, Sengupta K. Effect of spacing, crown height and method of pruning on mulberry leaf yield, quality of cocoon yield. Indian Journal of Sericulture. 1999; 30(1):46-53.
6. Dandin SB, Jayant J, Giridhar K. Handbook of Sericulture Technologies. 2003. Central Silk Board, Bangalore, India.
7. Das BC, Sikadar AK. Evaluation of some improved strains of mulberry by feeding experiment. Indian Journal of Sericulture. 1999; 9(1):26-30.
8. Dorcus D, Vivekanandan M. Screening of mulberry varieties for rainfed conditions. Sericologia. 1991; 31:233-241.
9. Fotadar RK, Dandin SB. Chemical composition and feeding studies of different elite mulberry genotypes under temperate conditions. Indian Journal of Sericulture. 1997; 36(1):22-26.
10. Fukuda S. Biochemical studies on the formulation of silk protein. Par IX. The direct and indirect formulations of silk protein during the growth of silkworm larvae. Bulletin Agricultural Chemical Society, Japan. 1960; 24:296-401.
11. Gangwar SK. Impact of varietal feeding of eight Mulberry varieties on *Bombyx mori* L. Agriculture and Biology Journal of North America. 2010; 1(3):350-354.

12. Horie Y. Recent advances of nutritional physiology and artificial diet of the silkworm in Japan. Korean Journal of Sericulture Science. 1995; 37:235-243.
13. Jayaswal KP, Singh T, Sen SK. Correlation between economic parameters and their application in silkworm breeding. Indian Silk. 1999; 1:25-27.
14. Kumar H, Satyapriya Y, Kumar M, Elangovan V. Effect of different mulberry varieties and seasons on growth and economic traits of bivoltine silkworm (*Bombyx mori*). Journal of Entomology. 2013; 10(3):147-155.
15. Kumar R, Singh A, Sharma J. Comparative performance of two different mulberry varieties on silkworm rearing in spring season. International Journal of Science and Nature. 2013; 4 (4):651-653.
16. Malik GN, Massoodi MA, Kamili AS, Sofi AM. Studies on heterosis in some bivoltine silkworm (*Bombyx mori* L.) crosses. Journal of Sericulture. 2006; 6(1&2):47-49.
17. Mano Y, Kumar NS, Basavaraja HK, Reddy NM, Datta RK. A new method to select promising silkworm breeds/combinations. Indian Silk. 1993; 31:53.
18. Maqbool A, Malik GN, Dar HV, Kamili AS, Gulzaffar. Evaluation of some bivoltine silkworm (*Bombyx mori* L.) genotype under different seasons. Indian Journal of Sericulture. 2008; 4(2):147-155.
19. Munshi NA, Mallik GN, Dar HU, Sofi AM, Sahaf KA, Aijaz M, Azad AR. Preliminary evaluation of some open pollinated mulberry (Morus spp.) selections. Journal of Research SKUAST-J. 2001; 3:154-157.
20. Murthy VNY, Ramesh HL, Munirajappa. Impact of feeding selected mulberry germplasm varieties on silkworm *Bombyx mori* L. through bioassay techniques for commercial exploitation. Asian Journal of Natural and Applied Sciences. 2013; 2(4):56-64.
21. Pandit RK, Bali RK, Koul A. Evaluation index: A tool for evaluating mulberry genotypes. Journal of Research SKUAST-J. 2006; 5:186-190.
22. Rajalakshmi E, Chauhan TPS, Kamble SBT, Mahadevaiah BM. Evaluation of newly evolved bivoltine hybrids of *Bombyx mori* L. for silk yield contributing traits under hill conditions. Indian Journal of Sericulture. 2000; 39(1):21-23.
23. Saratchandra B, Rajanna L, Philomena KL, Paramesh C, Ramesh SP, Jayappa T, Sabitha MG. An evaluation of elite mulberry varieties for good yield and quality through bioassay. Sericologia. 2002; 32(1):127-134.
24. Satenahalli SB, Govindan R, Goud JV, Magadum SB. Genetic parameters and correlation coefficient analysis in silkworm *Bombyx mori* L. Mysore Journal of Agriculture Sciences. 1999; 24:491-495.
25. Shankar MA, Devaiah MC. Effect of feeding mulberry leaves deficient in secondary nutrients on larval growth, development, cocoon weight and silk quality. Sericologia; 1995. 34(3):511-518.
26. Tikader A, Qadri SMH. Rearing performance of ten elight mulberry (*Morus* spp.) genotype. Indian Journal of Sericulture. 2009; 48(1):68 -71.
27. Trivedy K, Nair KS, Aswani Kumar C, Prithviraj Urs, Sarkar A. Evaluation of nutritive value of elite mulberry genotypes through determination of dietary efficiency of silkworm, *Bombyx mori* L. Bulletin of Indian Academy of Sericulture. 2006; 10(1):7-14.
28. Yamamoto T, Gamo T. Studies on the breeding in relation to the improvement of food utilization in silkworm, *Bombyx mori* L. Mutual relationship among the amount of food digested, digestibility and several quantitative characters in the silkworm reared on artificial diet. Journal of Sericulture Sciences. 1976; 45(1):81-86.