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Effect of Feeding Different Maturity Leaves and Intermixing of the Leaves on Commercial Characters of Bivoltine Hybrid Silkworm (*Bombyx mori* L.)

V. K. Rahmathulla*, Tilak Raj, M. T. Himanthraj, G. S. Vindya and R. G. Geetha Devi
Central Sericultural Research and Training Institute, Mysore 570008, India.

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The study evaluated the influence of feeding different maturity leaves *i.e.*, tender, medium, coarse and mixed leaves of three different maturity during late larval stages of new bivoltine race ($CSR_3 \times CSR_6$). The data were compared with shoot feeding and control batches in which conventional feeding method was followed. The most of the larval and cocoon characters were recorded significantly higher in tender leaves fed batches followed by T4 batch (2 times tender and 1 time coarse leaves). Lowest melting percentage (1.494%) was recorded in T4 and highest (4.69%) was recorded in coarse leaf (T3) fed batches. Significantly higher post cocoon parameters *viz.*, average filament length, non-breakable filament length, renditta and raw silk percentage were recorded in tender leaves fed batches.

Key words: Different maturity leaf feeding, New bivoltine hybrid, Cocoon characters, Reeling characters

Introduction

The growth and development of silkworm larvae and economic characters of cocoons are influenced largely by the nutritional quality of mulberry leaves fed. Matsumara *et al.* (1958) reported that, out of the various factors responsible for success of cocoon crop mulberry leaf quality stood first (38.2%). The quality of mulberry leaves varies significantly with factors such as soil fertility, agronomical practices, planting system and environmental condition (Bongale *et al.*, 1991; Datta, 1992). The quality and composition of mulberry leaf is reported to vary with age of leaf on the shoot. The nutritional value of the top tender leaves was found to be higher as compared to middle leaves and coarse leaves. Several workers (Narayanan *et al.* 1967; Krishnaswami *et al.* 1970; Basu *et al.* 1995) reported that feeding the silkworms with tender leaves resulted in better performance and enhanced commercial characters of cocoon. Sudo (1981) observed that there was a linear regression equation with significant minus correlation between leaf order and larval weight and cocoon characters. Benchamin and Jolly (1986) reported that silkworm larva prefers to consume the leaves that contain high moisture and less dry matter. Periaswamy (1994) reported that water content of leaf play a significant role on food utilization and growth in phytophagous insects. Basavarajappa and Savanurmath (1997) observed that on feeding over matured and wet leaves enhanced the incidence of grasserie and cocoon melting. Vage and Ashoka (1999) reported that when 5th instar larvae fed with tender shoots up to 3 days followed by matured shoots marked better values of cocoon characters. Elumalai *et al.* (2001) reported that coarse leaves feeding enhance the most of the economic characters of bivoltine pure races. Recently for rearing productive bivoltine hybrids (CSR series) shoot feeding technology is adopted in which mixed leaf feeding is followed and gaining popularity in the field. Further, sericulturists have a belief that tender leaf feeding during late age causes grasserie diseases. Hence, it was essential to study the effect of feeding different maturity leaves (tender, medium and coarse) and intermixing of different maturity leaves during the late larval stage of silkworm and its effect on growth and commercial characters of new bivoltine silkworm.

Materials and Methods

Central Sericultural Research and Training Institute, Mysore has bred bivoltine silkworm hybrid ($CSR_3 \times CSR_6$)

*To whom correspondence should addressed.
Central Sericultural Research and Training Institute, Mysore 57008, India. Tel: +0821-362992; Fax: +91-0821-362845;
E-mail: rahmathullavk@yahoo.co.in

and it was used as a experimental material by feeding V1 mulberry leaves maintained under irrigated condition as per the procedure laid by Kawakami (2001). In the present experiment mass rearing was conducted up to third moult, by following 3 feed schedule (7 a. m., 3 p. m. and 10 p. m.)

Mulberry branches were divided into three regions namely top tender portion, middle mature portion and bottom over mature portion according to the growth and maturity of leaves and the leaves obtained from them were designated as tender, medium and coarse. These leaves as per chemical analysis showed considerable differences in regard to crude protein, total sugar, starch, reducing sugar, total carbohydrate, fibre and ash besides the moisture content.

After third moult, the larvae were divided into 8 groups and each group three replicates, for each replicate 250 larvae were maintained by feeding leaves as mentioned below.

T1	Tender leaf including apical bud
T2	Medium leaf
T3	Coarse leaf
T4	First feeding tender; second feeding coarse and third feeding tender leaf
T5	First feeding tender; second feeding medium and third feeding coarse leaf
T6	Mixing of tender, medium and coarse leaf for each feeding
T7	Control (Conventional leaf feeding method)
T8	Shoot rearing in late age *i.e.*, 4^{th} and 5^{th} instar

T7 was kept as a control and for this batch young larvae were fed with tender leaves having high moisture and protein content. Whereas in the late age, the silkworm larvae were fed with medium leaves and last two or three days of 5^{th} instar the silkworm larvae were fed with coarse leaves. At the time of the resumption after every moult tender leaves were given (Krishnaswami, 1978)

In T8, the young silkworms were fed with chopped leaves up to second moult. In third, fourth and fifth instar, shoots was provided to silkworms harvested from 60 – 70 days old mulberry garden.

After completion of the rearing and mounting operations the cocoons were harvested on sixth day and the parameters such as larval duration, larval weight, effective rearing rate, single cocoon weight, single shell weight, shell ratio and melting percentage were recorded. Subsequently the cocoons were subjected to reeling operations and the following parameters like average filament length, non-breakable filament length (NBFL), denier, raw silk percentage, raw silk recovery percentage, renditta, reelability and neatness were recorded. The experiment was repeated three times in different seasons and the data were pooled, tabulated and statistically analysed by ANOVA test. The standard error and critical difference (C. D.) were calculated by using following formulae.

Standard error (S. E.) difference = $\sqrt{Ve(1/r_1 + 1/r_2 + 1/r_3)}$

Where Ve is pooled error mean square and r_1 r_2 and r_3 are the numbers of replication of the treatments.

Critical difference (C. D.) = (S. E.) difference × α% for error degrees of freedom.

Where α indicates level of significance.

Results and Discussion

The larvae fed on tender leaves, showed significantly highest larval weight (65.7 g) (Table 1) followed by T4 (62.7 g) and least was recorded in T3 (47.9 g). The results show a clear-cut increase in body weight, volume and size of the worms by feeding with tender leaves. This is supported by the study conducted by Basu *et al.* (1995). No significant difference was noticed in T5 (56.5 g) and T6 (57.0 g) compared to the T7 (57.8 g). But a significant difference was recorded when T5 and T6 were compared with T8 (54.5 g). Rashid *et al.* (1993) reported that growth rate and digestibility of any insect depends on nutritional quality and water content in its food. Narayanan *et al.* (1967) also revealed that tender leaf having higher nutritional value, which might have favored the growth of the silkworms, and then increasing the cocoon characters. Tender leaf feeding reduced 5^{th} instar larval duration in T1 (174 hrs) followed by treatment T4 (193 hrs). Significantly longest larval duration (Table 1) was observed in T3 (211 hrs). There was no significant difference observed between T5 (197 hrs) and T6 (196 hrs).

Effective rate of rearing (ERR) by number observed was significantly higher in T1 (9849) followed by T4 (9787) and T5 (9364). It means that survival rate and cocoon formation rate were higher in the tender leaf treatment. Significantly lowest value of ERR by number was recorded in T8 (9064). It can be concluded in the present study tender leaves feeding enhances the ERR by number. It can also be concluded that loss of larvae in T3 and T2 was more and this result is coinciding with the finding of Vage and Ashoka (1999).

ERR by weight showed higher value in T1 (24.95 kg) followed by T4 (22.79 kg). This shows that the larvae fed on tender leaves built good cocoons, which were having good survival rate as well as more cocoon weight. Significantly lowest ERR by weight (17.05 kg) was recorded in T3. According to Bongale *et al.* (1991) the leaf quality becomes nutritionally poor with the passage of time. No significant difference was observed between T5 (21.85 kg), T6 (22.36 kg) and T7 (21.63 kg).

Highly significant difference of cocoon weight was

Table 1. Effect of feeding different maturity leaves and intermixing of the leaves during late larval instars on yield and cocoon characters of silkworm

Treatments	10 fully grown larval weight (g)	Larval duration (hrs)	ERR by number	ERR by weight (kg)	Single cocoon weight (g)	Single shell weight (cg)	Shell ratio (%)
T1	65.7	174	9848	24.95	2.50	66.6	26.82
T2	54.9	200	9114	19.81	2.11	54.1	25.21
T3	47.9	211	9219	17.05	1.84	42.6	23.39
T4	62.7	193	9787	22.79	2.35	61.0	26.02
T5	56.5	197	9364	21.85	2.29	57.0	24.91
T6	57.0	196	9154	22.36	2.29	57.8	25.40
T7	57.8	195	9202	21.63	2.25	56.1	25.29
T8	54.5	198	9064	20.78	1.94	50.5	25.26
SE ±	0.26	0.279	98.06	0.229	0.017	0.06	0.254
C. D. at 5%	0.744	0.803	281.7	0.658	0.513	1.80	0.731
F-Test	**	**	**	**	**	**	**

**Significant at 1% level; C. D., Critical difference; and S. E., Standard error.

observed between T1 (2.50 g) and other treatments (Table 1). Highest cocoon weight was recorded in T1 followed by T4 (2.35 g) and T6 (2.29 g). T3 treatment showed significantly least cocoon weight (1.84 g). No significant difference was recorded when T5 (2.29 g) and T6 (2.29 g) were compared to T7 (2.25 g). However, a significant difference was observed when treatments T5 and T6 were compared with treatment T8 (1.94 g).

The previous studies conducted by Narayanan *et al.* (1967), Sudo (1981), Bongale *et al.* (1991) and Krishnaswami *et al.* (1970) proved that tender leaves are having more water as well as protein content. This protein content of the tender leaves is absorbed by the silkworm epithelium tissue of the gut and is transferred to the body matter as well as in to the cocoon formation.

Significantly highest shell weight was recorded in T1 (66.6 cg) followed by T4 (61.0 cg). In T3, significantly lowest shell weight was recorded (42.6 cg). No significant difference was observed between T5 (57.0 cg) and T6 (57.8 cg). However, significant difference of shell weight was found between T5 and control (T7) and T8. But, in T6 and control (T7) there was no significant difference was recorded (Table 1). As there is a general belief that larvae fed with more tender leaves do not spin good cocoons and only pupal moisture increases. But this impression is disproved in the present study, that leaf moisture not only increases the pupal moisture but also increases the shell weight. The result of the present study was supported by the study of Vage and Ahoka (1999).

Significantly high shell ratio (26.82%) was recorded in T1 (Table 1) and lowest value of shell ratio was recorded in T3 (23.39%). There was no significant difference among the treatments like T5, T6, T7 and T8. The study results

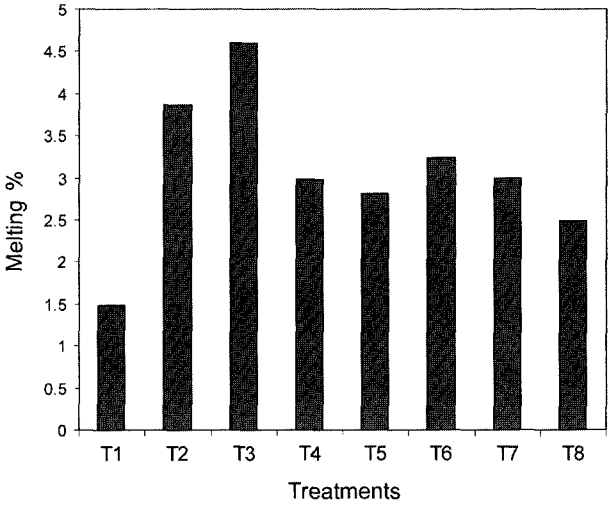

Fig. 1. Effect of feeding different maturity leaves and inter mixing of the leaves on melting.

were coincided with results of Vage and Ahoka (1999), Sundareswaran *et al.* (1997) and Quader *et al.* (1992).

Melting percentage indicates pupal mortality of cocoons mainly due diseases. Lowest melting percentage was found in T1 (1.41%) and significantly highest melting percentage (Fig. 1) was recorded in T3 (4.60%) followed by T2 (3.90%). This shows that coarse and medium leaves not only affect the cocoon weight, shell weight and shell ratio but also the melting percentage significantly. From the above results it can be concluded that when the leaf is of good quality having sufficient nutrients essentials for the growth and development of silkworm, melting percentage of cocoons can be reduced considerably. Benchamin and Jolly (1986) reported that growth and deve- lopment of the

Table 2. Effect of feeding different maturity leaves and intermixing of the leaves during late larval instars of silkworm. on reeling characters

Treatment	Average Filament length (m)	NBFL (m)	Denier	Renditta (kg)	Raw silk (%)	Raw Silk Recovery (%)	Reelability (%)	Neatness (%)
T1	1467	1272	2.90	4.91	20.92	75.61	88.41	95.00
T2	1256	1148	2.76	5.23	18.40	73.24	87.87	94.33
T3	1088	946	2.82	5.61	17.76	76.26	87.64	94.67
T4	1369	1163	2.91	5.04	20.26	76.40	86.10	94.83
T5	1249	1112	2.83	5.54	18.16	73.20	85.44	94.17
T6	1183	1105	2.91	5.22	18.76	78.50	85.52	94.17
T7	1306	1218	2.86	5.25	20.08	76.85	88.52	94.33
T8	1174	1047	2.88	5.38	18.28	76.10	85.30	94.17
SE ±	16.09	18.36	0.031	0.061	0.175	0.955	0.677	-
C. D. at 5%	46.52	52.75	0.091	0.176	0.504	2.745	1.947	-
F-Test	**	**	*	**	**	**	**	NS

**Significant at 1% level; *Significant at 5% level; and NS, Non significant.

larvae and subsequent cocoon crop production depend on leaf quality especially the nutrient contents.

It was observed that the larvae fed on tender leaves (T1) have produced significantly longest (Table 2) filament length (1,467 m) and was followed by T4 treatment (1,369 m). Coarse leaf fed treatment showed significant reduction in the filament length (1,088 m). Significant difference was recorded between T1 treatment and control T7 (1,306 m). This indicates that the larvae fed on the coarse leaf during late age have spun cocoons with lowest filament length. As a whole the study results concluded that filament length could be increased if the worms are fed with the leaves of good moisture and protein content. This result is supported by the findings of Basu *et al.* (1995), Vage and Ashoka (2000) and Rajashekharagouda and Lakshmikanth (1998).

Non-breakable filament length (NBFL) is also a very essential for the determination of filament continuity and more number of breaks resulted from inferior quality cocoons. It was found that significantly higher NBFL was found in treatment T1 (1,272 m) followed by T4 (1,163 m). Significantly least NBFL (946 m) was found in T3. The study result show that not only filament length is more in case of T1 (tender leaves fed batches) but it also has less breaks and good filament continuity and it is preferred by the reelers.

Highest value of denier was recorded in T4 (2.91), T6 (2.91) and T1 (2.90). Significantly lowest denier was recorded in T3 (2.82). It shows the least thickness of the silk filament was found in T3 treatment (Table 2). These results were comparable with the observation of Basu *et al.* (1995); Vage and Ashoka (2000). Rajashekharagouda and Lakshmikanth (1998) reported that feeding tender leaves to fifth instar silkworm recorded lowest denier than compared to the control treatments. Denier of T4 treatment (2.91) was on par with T1 (2.90). No significant difference was observed when T5 (2.83) , T6 (2.91) and T8 (2.88) were compared with the control T7 (2.86).

Renditta shows that how much cocoon quantity is required to produce 1 kg of raw silk by weight. The results show that when silkworm fed on tender leaves during late larval stages recorded significantly lower renditta was recorded (4.91 kg) followed by T4 (5.04 kg) and T6 (5.22 kg). Significantly higher renditta value was recorded in T3 treatment (5.61 kg). By feeding the silkworm with tender leaves during late larval stages decreases the renditta or increases the shell weight. Thus, present results are comparable with the findings of Basu *et al.* (1995).

The result showed that raw silk percentage was significantly higher in T1 (20.92%) followed by T4 (20.26%) and control (20.08%). Significant difference was observed between T1 (20.92%), T2 (18.40%) and T3 (17.76%). As a whole raw silk percentage was significantly higher in the tender leaf over the medium, coarse and control treatments.

Raw silk recovery percentage (RSR%) was found highest (Table 2) in T6 (78.50%) followed by the control T7 (76.85%). Least RSR% was recorded in the T2 treatment (73.24%) in which larvae were fed with medium leaves. The results indicated that raw silk recovery percentage was not affected when the worms were fed with different quality leaves. However, mixture of tender medium and coarse leaf fed treatments recorded significantly higher RSR%.

Reelability expresses the easiness of unwinding of filament from the cocoons during the process of reeling. More the reelability percentage means cocoons are good for reeling. In the present study reelability recorded high-

est in case of control T7 (88.52%) followed by T1 (88.41%). Significant difference was recorded when T1 and T7 were compared with the T8 (85.30%), in which shoot rearing was practiced. No significant difference was noticed among the treatments T1 & T2, T1 & T3 and T2 & T3. In treatments like T4 (86.10%), T5 (85.44%), T6 (85.52%) and T8 (85.30%) recorded significantly low values of reelability when compared with the control (T7).

Although neatness is a racial character it is less affected by the external factors. Even though T1 treatment has shown significantly higher neatness (95.00%) followed by the T4 (94.83%). Similarly, comparison of T5 (94.17%) and T6 (94.17%) with control T7 (94.33%) and T8 (94.17%), showed that there was no significant difference among them.

From the above results obtained in the present study and discussion it is obvious that tender leaves are the best for silkworm in all the respects. These leaves have shown tremendous increase in almost all the commercial characters and less incidences of diseases. So, that sericulturist must have to try to produce as much as succulent and tender leaves as possible by irrigating the mulberry garden frequently and by adopting recommended package of practices. The rearing of the silkworms should be commenced in such a way that at that time leaf in the garden should be tender and succulent. If it becomes late the leaf will be over matured and the nutritional value of such leaves get decreased. So, over matured garden can be regarded as the worst garden from the quality angle of view. It was clear from the above study that in case of shoot rearing method, if the shoots are not given exchanging the tip and bottom direction, the growth and development of larvae in the same bed may differ and this can lead to create unequal worms because of difference in nutritional quality of top and bottom leaves.

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