Chapter - II

Review of Literature

2. REVIEW OF LITERATURE

2.1. Impact of Mulberry Varieties on the Bivoltine Silkworm Rearing

Mulberry (*Morus* sp.), a sole food plant of the silkworm , *Bombyx mori* L., is cultivated for leaf production . Performance of mulberry varieties with respect to yield and quality of leaf varies with region and thus one variety performing better in a region may not be better elsewhere. Kasiviswanathan *et al.*(1977) observed that Kanva -2 and Berhampore significantly increased the mulberry leaf yield over local variety. Again , comparative merits of four varieties of mulberry viz. Kanva , S54 , Kosen and LM -2 on two bivoltine breeds (NB7 and NB18) and a hybrid race (PMxNB18) showed that the S54 gave higher values for different characters namely , larval duration , larval weight , single cocoon weight and silk yield (Tayade and Jawala , 1984 ; Periaswami and Radhakrishnan , 1985 Tayade *et al* , 1988).Another variety, the S41 was reported better by Govindan *et al* . (1987), Bheemanna (1988), Bheemanna *et al* . (1989) . The variety S36 was found to be superior over other (Theodar and Vivekanandan , 1992). Giridhar and Reddy (1991) reported that several silkworm breeds reared on the mulberry varieties , S36 , S30 and S54 showed higher values for larval and shell weights. All the economic traits except the silk ratio were poor with the mulberry variety S41.

In West Bengal some research works towards selection of variety with respect to rearing performance of silkworm and production of leaves were performed at different places . Krishnaswami *et al.* (1970) , Dorcus and Vivekanandan (1991), Satyanarayan Raju *et al.* (1990) observed that the performance of Kosen was highly satisfactory , while Venugopala Pillai and Jolly (1985) observed that MR2 variety was superior and closely followed by Kosen so far as rearing performance was concerned . However , Ghosh *et al.* (1992) reported that leaf quality as well as yield of the S1 variety was better in Malda district than other varieties studied. The S1 variety was also observed superior in UP to seven other varieties tested. Better performance of S1 was also reported from Berhampore [Annual Report , Central Sericulture Research and Training Institute (CSR &TI) , 1988 -89) p.134]. Subba Rao *et al.* (1987) recommended TR4 , TR10 and S1 varieties of mulberry for higher leaf yield in Jalpaiguri district

under terai region of West Bengal. Kabir (1987) added another 5 mulberry varieties namely S799 , BC259 , C763 , C776 , Kosen for mulberry cultivation in West Bengal. According to Das *et al.* (1995) nutritive quality of C763 was found superior to that of other varieties (viz S1 , S779 , S1635 , C1730 , C763 , C776 and Kajli) followed by S1630 and C1730 in gangetic plains of West Bengal.

This review of earlier works again proves that there is regional influence of agro-climatic conditions on the quality and yield of mulberry leaves of different varieties. This emphasises the need for selecting zonespecific variety through well cared trials . Nutritive value of mulberry leaves varies among the varieties (Venugopala Pillai and Jolly,1985 ;, Qaiyyum *et al.*, 1992 ; Sarkar *et al.*, 1992 ; Das *et al.*, 1993). The nutritional levels of different cultivars of mulberry influence the larval growth of silkworm , which are ultimately reflected in the economic traits such as effective rate of rearing (ERR) , cocoon and shell weights and silk percentage (Krishnaswami *et al.*, 1970 ; Sudo *et al.*, 1979 ; Li & Sano , 1984 ; Hanif and Islam , 1987 ; Machii and Katagiri , 1990 Satyanarayan Raju *et al.*,1990). Since the principal constituent of silk is protein , leaves with high protein content are more readily accepted by the worms and promote growth better than the varieties with low protein content (Soo Hoo and Fraenkel ,1966). Cultivars having higher yield as well as better nutritional values are always desirable . But in practice , there are wide gap between yield and quality of leaves in most of the varieties . In order to minimise yield-quality gap , various cultural manipulations are required . In fact, attempts have been made in different regions to improve the quality of leaves of high yield varieties through the selection of leaf order of plant (Sudo *et al.*, 1979), age of plant (Sreedharan *et al.*,1988) and different methods of pruning (Quadar *et al.*, 1991).

From the available references it transpires that almost there is no information on the comparative suitability of mulberry varieties in the terai belt of West Bengal .

2.1.1.Quality of leaves

Cocoon crop of silkworms depends upon the developmental vigour of the silkworm breeds , which in turn , is further influenced by the nutrient availability from the leaves fed (Ito and Arai, 1965 ; Radha *et al.*, 1978). Quadar (1991) by assessing 22 mulberry cultivars suggested that the S799 was the best so far as the total protein , sugar , starch and soluble carbohydrate contents

were concerned . Whereas, a maximum amount of moisture , reducing sugar and mineral contents were observed in BSRM-4,Telia and Lup-40 varieties respectively. It was further reported that soluble carbohydrate and starch contents strongly influenced the protein content of mulberry leaves . Sarkar *et al.* (1992) recorded that among the 6 mulberry varieties tested , S1 , S779 and BSRM-5 were relatively better over the others with respect to nutrient contents , while Sinha *et al.* (1993) reported from Ranchi that leaves of S1 variety was better than the K2 in respect of chemical constituents studied (viz. moisture, total nitrogen , total mineral and crude fibre).

Venugopala Pillai and Jolly (1985) found that the MR2 variety had better moisture content and protein level than Roso and Kosen which was ultimately expressed as better rearing performance of silkworm. Satyanarayan Raju *et al.* (1990) observed that the Kosen variety was better than that of Kanva -2 and MR2 varieties in high altitude.

Cherno *et al.* (1982) reported that during summer season when the atmospheric temperature was high and photoperiod was long, mulberry leaves grew efficiently and contained higher nutrient contents.

Nutrient contents of leaves also depend on their age. Sreedharan *et al.* (1988) mentioned that the protein content in the tender mulberry leaves was the maximum , there after , a quantity declined gradually with the age reaching lowest in the mature leaves. Sugar content showed an initial gradual increase which reached at maximum after 24 days and remained steady upto 42nd day of leaf age . Moisture content was also high during the initial growth of the leaves and gradually declined but the level did not fall below 40 % . A similar observation was also made by Yokoyama (1962) who reported that with the maturity of the leaves crude fibre and mineral contents increased and water , protein and total sugar contents decreased . Quadar *et al.* (1991) reported that the moisture and crude protein contents gradually decreased and soluble carbohydrate increased with the progress of leaf maturity . This contradicts the observation of Askarov *et al.* (1985) who recorded that the total amount of amino acids in mulberry leaves increased as the plant matured.

The growth and development of the larvae and subsequent production of cocoon crop depend on the leaf quality , especially the nutrient contents (Ito, 1960 ; Ito and Arai , 1965 ; Bhuyian , 1981). Plants with higher protein contents were more readily accepted and supported growth better than varieties

with lower protein contents (Soo Hoo and Fraenkel , 1966). Zhang *et al.* (1991) also reported that increase of protein content shortened the larval duration , increased larval weight and digestibility . Moreover , the weight of pupae , fecundity and weight of eggs increased with the rise of protein content . There exits a high correlation between production efficiency of cocoon shell and nitrogen content of mulberry leaves (Sudo *et al.* 1981 ; Machii and Katagiri , 1990) . However , Gabriel and Rapusas (1976) observed that even if the protein content of the mulberry varieties were in higher order, the varieties did not show any significant improvement in the cocoon characters of the silkworm reared . Interestingly, Hamano and Tsuchida (1989) noticed that the mortality of larvae was lowered with the increase of protein content in diet. Leaf moisture content and moisture retention was reported to have positive influence on the growth of silkworm larvae (Narayan Prakash *et al.*, 1985 ; Chaluvachari and Bongale , 1995). Paul *et al.*(1992) also supported that the absolute consumption of food and growth rate of larvae increased with increasing levels of leaf moisture content . Li and Sano (1984) reported that lower values of leaf moisture and protein content in the food recorded lower rates of larval growth , body weight and cocoon weight . It was further observed that when larvae were fed on tender leaves containing high quantities of moisture and protein and low quantities of carbohydrate , the cocoon weight increased than when the larvae were fed with leaves containing high quantities of carbohydrate and low quantities of water and protein. Satyanarayan Raju *et al.* (1990) reported that the nutritive contents of S41 variety were higher than in all other mulberry varieties but the economic characters of silkworms were very poor when raised on this variety.

Pain (1965) obtained that the application of nitrogen fertilizer increased the protein and sugar contents in a leaves , but the other factors like moisture , starch , fibre and mineral contents in the leaves remained more or less unaffected . Quadar *et al.*, (1990) also reported that the use of NPK fertilizer followed by foliar spray of urea significantly increased the total leaf yield , moisture , crude protein , total sugar , reducing sugar , starch and soluble carbohydrate contents than obtained from the control plants . Almost a similar result was obtained by Rajanna *et al.* (1992) who after application of higher doses of nitrogen fertilizer obtained an increased moisture , total nitrogen and protein contents . However , Sengupta *et al.*, (1972) was of the opinion that there was no difference in the quality of leaf after application of fertilizer .

Morever , there was no significant effect on cocoon quality if the nitrogen fertilizer was used at a dose below 300 kg /ha . Minoru Kitano *et al.* (1988) are of the opinion that phosphorus containing fertilizer increased the growth rate of mulberry only when the total amount of phosphorus is high in the soil . Because, the availability of phosphorus to the mulberry plants is strongly affected by the amount of other elements contained in the fertilizer (such as nitrogen , potassium and calcium) . Again , Masae *et al.*, (1992) observed that the cultivation of mulberry in different soils and under different conditions of fertilizer management hardly affected the amount of the 16 amino acids constituting the proteins of mulberry leaves.

A positive correlation among leaf protein , moisture content and larval weight was recorded by Chaluvachari and Bongale (1995 , 1996) . Again , the total protein content of larvae was increased with the use in diet higher level of protein . Furthermore , the newly ecdysed 5th instar larvae fed with the sugar rich diet accumulated high concentrations of storage protein (Masao and Jun , 1990) which was in agreement with Watanabe and Horie (1979) who also added that ommission of sucrose from diet seemed to prevent utilization of amino acids in the larvae.

There have been no attempt for assessing the nutritive values of different mulberry varieties raised in the terai zone of West Bengal and their bearing on the performance of the bivoltine breeds of *B. mori* . This justifies the attempt for the present investigation .

2.2. Silkworm Breed and Rearing Seasons

Large scale production of silk in India is confined to cocoon of F1 hybrid due to suspension hybrid vigour of the races of *B.mori* . A large number of F1 hybrid of bivoltine silkworm has been evolved which have the capability of better cocoon yield even during adverse season. But at the farmers' end , qualitative cocoon yield normally is not improved to desired level due to lack of proper cultural knowledge required for high yielding varieties of mulberry , non-adoption of suitable region -specific hybrid vigour of different silkworm races and rearing technologies of silkworm. There were several attempts in India and abroad to investigate on this practical aspect of sericulture .

Performance of a hybrids namely PMxNB4D2,PMxNB18and PMxC.Niche was the best during winter months and very poor during summer months , while the hybrid PM x NB4D2 showed a superiority over others in Karnataka (Ravi ,

1967) . Three overlapping silkworm rearings of Japanese F1 hybrid race during February -April in Pakistan revealed that February season was favourable with regard to cocooning ratio, shell ratio (Muslin , 1986) . Under Marathwada conditions , relative performance of silkworm races among HM (MV) , NB7 , NB18 and NB4D2 (BV) and their reciprocals upto F1 and F2 generations showed superiority of F1 and F2 generations over others with regard to all economic traits (Tayade , 1987) . Rahman and Ahmed (1988) studied the rearing performance of six races during four rearing seasons in Bangladesh and revealed that October - November season was the most favourable season for commercial crop and BR-84 and NSRI -0 was the most stable and promising races suitable for rearing during both favourable and unfavourable season . The field performance of three hybrids (namely PM x NB4D2 , PM x NB18 and PM xC.Niche) in Karnataka throughout the year revealed that the performance was the best in December - January and was very poor in May. Furthermore , the hybrid PM xNB4D2 appeared superior to the hybrids PM x NB18 and PM x C.Niche (Visweswara Gowda *et al.*, 1988 a). Rearing performance of a pure bivoltine race (P5) at the farmers' level in West Bengal during six rearing periods viz . March -April ,May, July , August -September , September -October and November -December revealed that the performance was better during November-December and March -April (Annual Report of CSR &TI , 1988-89 b , p 103). Rearing performance of four bivoltine races viz , NB18 , P_5 , KPGB and NB 7 at Berhampur conditions during different seasons revealed that KPGB showed better performance followed by NB18 (Annual Report of CSR &TI,1988-89 b, p188). Seasonal effects on the relative performance of five bivoltine breeds of silkworm (viz.KPGA , KPGB, P_5, NB7 , NB18) in Malda revealed that October -November and January - February were the favourable seasons and May-June and August -September were unfavourable seasons ; KPGB recorded the best breed among the breeds taken (Das *et al.*,1995) . Aherkar *et al.*, (1991) reported that among the silkworm races viz., multivoltine pure race , bivoltine pure race and their multi x bi hybrids, PM x NB18 hybrid showed highest cocoon yield as well as less disease incidence when reared in Vidarbha, Karnataka . Studies on four popular races viz., KA , NB7 , NB18 and NB4 D2 over a period of nine years in Nilgiri hills (Tamil Nadu) revealed that the longer crop period , highest ERR in number , maximum silk ratio and highest yield were recorded in winter season (November-February), KA showed the highest cocoon yield than the others (Roychowdhury *et al.*, 1992). In

Nilgiri Hills , the silk yield was the best during October-December months with comparison to that in other months (Ramesh Babu *et al.*, 1992).

In sericulture , prevention of disease is better than taking curative measures after its occurrence . Rearing during congenial environment and with nutritionally good quality of leaves enable the silkworms to grow healthy and develop resistance to diseases . Prevention of secondary contamination by following sericultural hygine such as washing of hands and legs , cleaning of dress before entering a rearing house , use of proper concentration of disinfectants for the rearing room and rearing tools are of fundamental importance (Ullal and Narasimhanna , 1987).

Inspite of all these precautionery measures it has been experienced that sometimes diseases occurs to a good extent , resulting in heavy damage to silkworms . Fluctuation of climatic conditions, particularly the humidity and temperature aggravates the problem. High temperature combined with high humidity is responsible for the heavy losses due to diseases irrespective of quality of leaves and moisture content in them (Krishnaswami *et al.*, 1972). Satish (1987) observed that the grasserie , a viral disease , prevailed throughout the year but its prevalence was noticed during the period from March to July , the highest being during June-July in Banglore. Kuberappa and Jayaramaiah (1987) observed that the muscardine , a fungal disease , grew quickly and developed at the optimum temperature range of 20 -30^{o}C and relative range of 80 -90 % . Generally it has low incidence during the winter season but a heavy rain during winter may result in high atmospheric humidity leading to an outbreak and spread of this disease (Baig and Sengupta, 1988) . Survey of disease infection on silkworm in West Bengal during five rearing seasons viz. March-April , May -June, June -July , August -September and October-November revealed that the occurrence of flacherie was the highest during March -April , whereas that of grasserie during May-June (Annual Report , CSR &TI , p.196). Subba Rao *et al.*(1991) reported on a basis of incidence of disease at farmers level in West Bengal condition that total crop loss was found higher during the period from May to September and lower from October to March. In AndhraPradesh , studies on the incidence of different diseases namely , muscardine , grasserie and flacherie throughout the year revealed that the maximum incidence of grasserie , muscardine and non-bacterial flacherie were recorded during the rainy season

(July to October), winter season (November to February) and summer season (March to May) respectively (Swamy and Nagraj , 1992).

Bivoltine silkworm races are primarily suited for temparate climate . In India, bivoltine races are reared in temperate areas of Jammu and Kashmir and under subtropical condition prevailing in part of Uttar Pradesh , Himachal Pradesh, Punjab , West Bengal etc. But in the topical conditions in southern states and most other parts of the country where mulberry leaf growth is continuous , multivoltine silkworm races are reared traditionally.

Among the non-traditional areas under consideration for the extension of bivoltine sericulture , the terai region of West Bengal is productive zone for bivoltine sericulture extension . It is revealed that the bivoltine rearing can be performed in the district of Jalpaiguri almost throughout the year except May-June due to scarcity of suitable mulberry leaf (Subba Rao *et al.*, 1987).

2.3. Effect of fertilizer on mulberry plant and bearing upon silkworm rearing performance

Good responses to the application of nitrogen to mulberry crop in India have been reviewed by Kasiviswanathan and Iyenger (1965). The response of N, P and K fertilizers and their various combinations to mulberry crop as manifested in yield and nutritive value of leaves was discussed by Pain (1965). The highest leaf yield was obtained in NPK combination . Treatment where nitrogen was lacking gave poor yields although the yields were higher than those of without fertilizer control . With NPK combination at the proportion of N2 : P2O5 :K2O as 100 :80:100, the increase in leaf yield was as much as 108.30% over the control. It was also reported that application of nitrogen increases protein and sugar content in the leaves.

Feeding of silkworm with leaves grown with nitrogen fertilization , as observed by Narayan *et al.* (1966) , demonstrated that nitrogen fertilization significantly increased larval weight , single cocoon and shell weight , filament length and denier . Sengupta *et al.* (1972) found that high dose of nitrogen fertilization beyond 300 kg N /ha fairly and consistently increase about 5-6% in mean leaf yield for each additional 100 kg N/ha applied . There was no significant difference in the quality of leaf due to application of fertilizer and at least beyond 300 kg N/ha , there was no significant effect of levels of nitrogen fertilization on

cocoon quality . Sengupta *et al.* (1973) further emphasised that the levels of fertilizer indicate a definite effect on the improvement of cocoon production rather than on any significant improvement on individual cocoon quality . However , Fotedar *et al.* (1986) opined that increasing levels of nitrogen progressively increased the leaf yield upto a maximum level of 400 kg/ha/yr., the yield was raised even upto 54% of the control. Ahmed (1986) in Pakistan reported that leaf yield was increased by 55 , 100 and 120% by 100 , 200 and 300 kg/ha nitrogen (as urea) respectively . Kabir (1987) recommended 300 : 180 : 112 kg/ha/yr. of N:P:K level in four equal split doses , applied 20-25 days after each prunning /harvesting under irrigated condition and 100 : 50:50 kg/ha NPK in two equal split doses during June-July and Sept-Oct under rainfed conditions of West Bengal. Venugopala Pillai *et al.* (1987) reported that a dose of 900 kg Nitrogen/ha improved the feeding quality of the leaves and increased the growth rate , survival rate , cocoon yield , silk output and egg production of silk worm to a great extent.

Kitano *et al.* (1988) showed that phosphorus containing fertilizer increases the growth rate of mulberry . The availability of phosphorus to the mulberry plants was strongly affected by the amount of other elements contained in the fertilizer (nitrogen , potassium and calcium) ; the amount of phosphorus uptake by the mulberry plants increased with increasing amount of phosphorus contained in the fertilizer . Quadar *et al.* (1990) reported that foliar spray of urea combined with NPK fertilizers in soil significantly increased total leaf yield , moisture , crude protein , total sugar , reducing sugar , starch and soluble carbohydrate contents and recommended for using 250 kg .N, 125 kg. phosphate and 100 kg. potassium per ha/yr. in combination with 0.5% foliar spray of urea solution for higher leaf yield and increased nutrient contents of mulberry leaves .Increase in nitrogen levels increased the leaf yield irrespective of methods and schedules of application (Rajanna and Dandin , 1992). Cultivation under different conditions of fertilizer management for 9 yrs. hardly affected the amount of the 16 amino acids constituting the proteins of mulberry leaves (Yamada *et al.*, 1992).

The moisture content , total nitrogen and protein contents in the leaves increased in the treatment where nitrogen was supplemented as urea super

granule as compared to other forms. Higher doses of nitrogen application increased the moisture content and total protein nitrogen contents (Rajanna *et al.* 1992) . Das *et al.* (1993) found that application of 150kg. N/ha yr., increased the leaf yield significantly over 50 and 100 kg N/ha /yr. Nutritional assessment of leaves through silkworm rearing indicated a significant improvement of leaf : cocoon ratio due to highest nitrogen level . NPK @ 300 : 120 :60 kg./ha/yr. improved leaf yield . But considering the interaction of variety (S36) with spacing (60 x 60 cm) and fertilizer level of 300 : 180 :120 NPK kg./ha/yr. it was revealed that the leaf yield was increased significantly over the control at the highest level in case of var. S54 , spacing 60 x 60 cm with NPK 300 :120 : 120 kg. /ha/yr. (Ghosh *et al.*, 1995).

The requirement of fertilizer for healthy growth of mulberry in the terai region is yet to be assessed. Furthermore , in order to adopt bivoltine silkworm rearing in the terai region round the year a suitable combination of fertilizer , season , mulberry variety and silkworm breed is to be worked out.

2.4. Nutritional Efficiencies

Various physiological activities of an organism are expresed in growth which results from the balance between matter assimilation and dissimilation by complicated phenomenon (Ueda and Suzuki , 1967) . Food ingestion , consumption and utilization patterns with relation to host plant and sex-specific differences observed in different insects have been studied quite extensively by many workers (Bailey , 1976 ; Biren *et al.,* 1987; Yamamoto and Fujimata , 1960 ; Senapati , 1989 ; Joshi , 1984 ; Slansky and Scriber ,1985).

The rate of food intake , the percentage digestibility and the efficiency of conversion of ingested (ECI) and digested food (ECD) to body matter are important in phytophagous insects . Other factors which appear to affect the overall nutritional efficiency with relation to particular plant are water content , protein content and possibly the fibre content . There appears to be in a good food plant an inverse correlation between food consumption and efficiency of utilization (Soo Hoo and Fraenkel , 1966) . Magadum *et al.* (1996) from the studies of 5 th instar larvae of nine bivoltine breeds of *Bombyx mori* through regression analysis indicated that the total amount of ingesta was related to the

total amount of digesta , mature larval weight , larval duration , cocoon weight , shell weight and fecundity . Yamamoto and Gamo (1976) observed a high positive correlation between ingesta and cocoon weight , shell weight and larval weight. Again Yamamoto and Fujimaki (1982) reported a lower correlation of ingesta and AD for Japanese breeds and a high negative correlation was observed between the cocoon shell weight and ingested dry matter for the production of unit cocoon shell weight . Ding *et al.* (1991) observed that leaf silk ratio has close correlation with the amount of food ingested , amount of digestion , percentage of digestion and increased weight of the fifth instar larvae and also observed marked correlations with the cocoon shell percentage , net increased weight and co-efficiency of food ingested during the first three days of the fifth instar larvae. The rate of consumption of food , ability to digest and body weight gain were higher at 75% RH in comparison to 90% RH in the silkworm larvae and food utilization of fifth instar silkworm larvae was much influenced due to variation of RH in comparison to the fourth instar larvae (Mishra and Upadhyay , 1992).

The average daily consumption of energy was 0.18 and 0.17 Kcal/g fresh body weight for the male and female larvae respectively . Approximately , 25% of the energy absorbed was utilised for the formation of cocoon shell and 10% was accumulated in the eggs (Horie and Watanabe , 1985) . Horie and Watanabe (1986) observed that approximately 46% and 70% nitrogen ingested and digested were stored in the cocoon shell in the male and 48% and 68% of nitrogen ingested and digested were stored in the cocoon shell in the female respectively . Approximately 10% and 15% of nitrogen ingested and digested were used for egg formation . Kuribayashi (1990) reported that the total amounts of dry matter ingestion and digestion by the larvae in 5 th instar were about 5.8 g and 2.1 g respectively and digestibility of food ranged from 36 -37 %.

Pant (1986) reported that consumption index (CI) and growth rate (GR) were declined during the 5 th instar larval life, and CI and GR appeared inversely proportional to the gross efficiency. Remadevi *et al* . (1992) reported that low AD in *B . mori* is associated with high ECI /ECD and vice versa . The breeds also required different quantum of feed to produce one gram of body weight into cocoon and shell weights . Anantha Raman *et al.* (1992) reported that the

amount of dry matter ingested and digested in different instar were significantly different . The AD and ECI reduced gradually from 1st to 5 th instar . The ECD values fluctuated from 54.47 to 59.07% in different instar . Reports from interbreed differences in the food consumption and utilization efficiencies of nine bivoltine breeds in different seasons showed that CI was the highest in 36 pc (1.307) and lowest in MB1 (1.103). The AD varied from 30.34% (KA) to 41. 79% (36pc) . Most of the breeds had high AD values in the rainy seasons except 36 pc and NND 6 which showed higher AD in summer . The ECI (17.82) and ECD (46.26) were very low in 36 pc.

There is seasonal effect of nutritional efficiencies from mulberry leaves by the silkworm larvae . Petkov and Mircheda (1979) emphasized that the quantity taken in and utilization of energy from the ingested food depend on the age of silkworm , the norm of feeding and the season in which the silkworms are reared. The variety of mulberry plant has smaller effect ; silkworms take in greatest quantity of energy from mulberry leaves in the spring season. In spring, the coefficients of digestiability were higher in comparison to those in summer and fall seasons . Prabhakara *et al.* (1992) studied the indices of consumption , growth , digestibility , efficiency of conversion of ingested (ECI) and digested (ECD) food to body matter and coefficient of metabolism in three races of *Bombyx mori* (PM , NB18 and PM x NB18) with three varieties of mulberry (Mysore local , M5 and S54) . NB18 and M5 recorded lower CI and coefficient of metabolism , and higher GR , ECI and ECD . While PM , Mysore local and their combinations recorded higher AD , both on fresh and dry wt. basis. CI and coefficient of metabolism were negatively correlated with the characters like fecundity , larval duration , silk gland wt. and length, cocoon wt, shell wt, cocoon shell ratio , cocoon filament length and denier ; but positively related with floss content and number of breaks per cocoon while the reverse trend was established with GR , AD , ECI and ECD with the above character.

Nutritional efficiency of bivoltine silkworm , feeding on leaves of different mulberry varieties as well as on leaves of different levels of fertilizer enrichment in the terai region of West Bengal is yet to be explored. The information is essentially required for extension of bivoltine mulberry sericulture in this region.