CHAPTER - V

DISCUSSION

Mulberry is the sole food plant of silkworm and hence a decisive factor in production of quality cocoons, egg as well as healthy progeny. The researchers, therefore, have concentrated on various aspects like the improvement of mulberry quality and quantity, seasonal effects on crop performance and reproductive parameters etc. The qualitative and quantitative increase in mulberry productivity ultimately results in improvement of various characters of silkworm. Though there are lots of tests at laboratory level for testing the quality of leaf, the actual judgment is done by silkworm, which consumes leaf and converts into silk and lays eggs. Hence, the silkworm needs to satisfy the optimum level the nutrients of mulberry leaves which will in turn promote the growth and reproduction so as to get healthy and bountiful progeny. The bio-chemical components of mulberry leaves thus have a definite impact on the food ingested by silkworm larvae and quality of cocoons produced (Legay, 1958).

In recent years, new bivoltine silkworm breeds/hybrids and also new mulberry genotypes have been developed as an outcome of the research work of the CSR&TI, Mysore under Japanese International Co-operative Agency (JICA) assisted project. Therefore studies on the reproductive efficiency evaluation of elite bivoltine breeds as influenced by mulberry genotypes and season are of vital importance. Accordingly present study was conducted on evaluation of a new bivoltine breed CSR2 against seasons and selected mulberry varieties.

Animals depend upon plants for their existence either directly or indirectly and consequently a study of animal nutrition must necessarily begin with the plants itself. Generally the nutritional status of mulberry leaves which influences the economic characters of silkworm crop depends upon the levels of moisture, total protein, total carbohydrates and total minerals (Anonymous,
1975; Bongale et al., 1991). In this context three improved mulberry varieties viz., V1, S13 and MR2 and one local variety K2 were studied during different seasons to understand their influence on CSR2, a new bivoltine silkworm breed. The nutrients levels of mulberry and their effects on silkworm rearing, feed conversion studies on 5th instar larvae, silk gland and grainage parameters like fecundity, hatchability, leaf:egg recovery etc were studied. The results obtained were analysed statistically and discussed in the following pages.

The highest weight of male and female pupae was recorded in V1 variety fed larvae followed by S13 and MR2 whereas the lowest was recorded in K2 variety fed larvae. Among the variety V1 showed significantly highest level of values than other varieties. The weight of pupae was highest during winter followed by rainy and the lowest in summer. The present results corroborate with the findings of Mukerji et al. (1983); Gowda et al. (1988); Siddique et al. (1985); Singh and Prasad (1987); Nagalakshimamma et al. (1989), wherein the researchers have reported that the V1 variety having higher amount of moisture, soluble protein, soluble sugar and nitrogen content in its leaf which may be the reason leading to higher pupal weight. The present result however does not corroborates with the findings of Jayaswal et al. (1991); Shaheen (1992) who have reported high influence of female pupal weight on fecundity (1.459 g and 573) during winter season fig.5.1.1 & 5.1.2.

The highest weight of male and female moth was recorded as V1 variety fed larvae followed by S13 and MR2 whereas lowest weight of moth was recorded in K2. Among the varieties V1 showed significantly higher level of values than other varieties. The present result corroborates with findings of Fukuda et al. (1963) who have reported that number of eggs laid by moths are more influenced by mulberry leaves consumed during IV, and early and middle stage of V instar. Similar results were earlier reported by Engelmann (1970); Dewilde and Deloof (1973 a;b) Slanksy (1980a;b;1982). The investigatories found that the egg production depends on accumulation of sufficient nutrients during larval period and attainment of ideal weight and allocation of substantial
nutrient energy by adult for egg production. Moreover, the characteristic feature of V1 variety lies in its nutritional and keeping quality aiding to increased palatability (Dandin et al., 2003). The highest weight of male moth was recorded in winter followed by rainy season. In female moth highest weight was recorded in rainy season followed by winter whereas the lowest was recorded during summer for both the sexes. The present results are in agreement with the findings of Sugai and Takehashi (1981); Yamaka and Hirao (1981); Mathur et al., (1988) who have suggested that the temperature, humidity and photoperiod (season) are key factors for successful egg laying by female silk moth. The winter and rainy seasons where the moisture content in leaves are retained for longer time and leaf constituents viz., protein, carbohydrate, vitamins and minerals do not denature quickly, therefore supported grainage activities compared to that of summer season fig.5.1.3 & 5.1.4.

The maximum fecundity was recorded in V1 (550) followed by S13 (521) and MR2 (512) whereas in minimum was recorded in K2 (484). The highest fecundity was recorded in summer (531) followed by winter (515) and the lowest was recorded in rainy season (504). Among the varieties V1 showed significantly higher level of values than other varieties. Changalarayappa (2000) observed differential varietal response when the leaves of three varieties of mulberry viz., Mysore local, M5, S54 against to three silkworm breeds viz., NB4D2, NB18 and Pure Mysore of B. mori. Feeding with leaves of M5 followed by Mysore Local resulted in higher fecundity, more number of eggs / ovariole, longer ovariole length, less percentage of unfertile and dead eggs, and more moisture content. Among the silkworm breeds NB18 recorded higher fecundity, more number of eggs/ovariole, longer ovariole and less percentage of dead and unfertilized eggs compared to NB4D2 fig.5.1.5.

The maximum hatching percentage was recorded in V1 (93.14%) followed by S13 (92.20%) and MR2 (91.89%) whereas minimum recorded in K2 (90.51%) superior performance of V1 could be due to higher nutrient
contents in its leaves. The highest hatching percentage was observed in winter (93.50%) followed by summer (91.35%) whereas lowest hatching percentage was observed in rainy (90.95 %). This is attributed to the effect of temperature and humidity on development of embryo which is congenial during winter season. Many workers have therefore worked out the temperature and humidity requirements for hatching of silkworm eggs like Krishnaswamy (1986a; b); Benchamin and Nagaraj (1987); Sengupta (1989); Datta (1992) and have suggested black boxing for synchronizing the hatching of eggs in commercial rearing of Bombyx mori fig.5.1.6.

The maximum leaf: egg recovery ratio was recorded in K2 (1:297.8) followed by MR2 (1:246.4) and S13 (1:241.5) while minimum was recorded in V1 (1:217.3). The highest leaf: egg recovery ratio was recorded in winter (1:269.7) followed by summer (1:246.7) and the lowest was recorded in rainy (1:232.8). Jagadesh et al. (2000) found that feed restriction during fifth instar in seed crop in two silkworm breeds viz. NB4D2 and PM in different seasons significantly reduced survivability, pupation rate and fecundity with 30 to 40% diet rationing in both the breeds in all the seasons. Whereas, in batches with 10% feed cut, the survivability, cocoon characters, egg recovery, egg/g and fecundity were not influenced significantly in all the seasons. Number and percentage of pairs, Number and percentage of dfls, total weight of dfls, weight of 1000 eggs and weight of one dfl was highest in treatments fed with V1 variety followed by S13 and MR2 whereas the lowest in K2. This could be attributed to the higher nutritional status of leaves of V1 variety compared to others fig.5.1.7

The relationship of larval weight with female pupal weight, weight of female moth, fecundity and weight of silk gland studied herein indicated that there was a positive and highly significant correlation between different pairs of possible combinations viz., weight of matured larvae and weight of female pupae (0.759); weight of female pupae with weight of female moth (0.991); Weight of female pupae with fecundity (0.552). There was a negative
correlation between weight of female moth with fecundity; fecundity with weight of silk gland. These results corroborate with the findings of Shamachary et al. (1980) and Gowda et al. (1988) who have reported a positive correlation between female pupal weight and fecundity in B.mori. Similarly Siddique et al. (1985) have reported highly significant positive correlation of fecundity with pupal weight in Antheraea mylitta. Similar observations were also made by Singh and Prasad (1987) in Philosamia ricini, Nagalakshimamma et al. (1988) and Kotikal et al. (1989) in Samia Cynthia ricini.

The highest leaf moisture and moisture retention capacity was recorded in V1 followed by S13 and MR2. The lowest was recorded in K2. The highest leaf moisture and moisture retention capacity recorded in rainy followed by summer and the lowest was recorded in winter season. Among the varieties V1 showed significantly higher level of values than other varieties. These findings are in agreement with those of Ajay koul et al. (1996) who screened nine promising mulberry varieties for leaf characters, dry matter and water retention during three seasons of spring, summer and autumn and observed significant differences in these characters among the varieties and season. Vijayan et al., (1997) recorded that out of 152 exotic and indigenous mulberry varieties screened for leaf moisture content only five varieties viz., Goshoerami, Rohachi, Morus indica, Nannyyapattu and onlam consistently exhibited higher moisture retention capacity in all the seasons. Similar findings were reported by Shankar et al. (1999); Satyanarayana and Rajashekara Gouda (2000); Mallikarjunappa etal. (2000 a) and Sujathamma et al.(2001) fig.5.2.1.1 & 5.1.1.2.

The maximum protein content in the leaf was recorded in V1 (21.35 %) followed by K2 (20.47%) and MR2 (20.06%) whereas minimum was recorded in S13 (19.76%). The maximum protein content in the leaf was recorded in winter (21.98 %) followed by summer (20.80 %) and minimum in rainy (18.46 %). Among the varieties V1 showed the significantly highest level of values than other varieties. Bongale and Chaluvachari (1993) evaluated four mulberry
varieties viz., M5, DD, S54 and TG and reported lower values of total soluble protein and chlorophyll contents in DD variety were associated with poor rearing performance of late age larvae compared to other varieties. The TG variety with highest protein and sugar contents of the leaf recorded highest shell ratios. Due to better physiological activities during winter and summer there is higher assimilation of nitrogen which in turn improves protein content in mulberry leaf (Narayana et al., 1966; Sidhu et al., 1969 and Krishnaswamy et al., 1971) fig.5.2.1.3.

The highest total soluble sugar content in the leaf was recorded in V1 (13.17%) followed by S13 (1.44 %) and K2 (10.70%) whereas the lowest was recorded in MR2 (10.36%). The highest total soluble sugar content in the leaf was recorded in winter (12.30 %) followed by rainy (10.98 %) and the lowest was recorded in summer (10.98%). Among the varieties V1 showed significantly higher level of values than other varieties. Verma and Kushwaha (1970) studied three exotic mulberry varieties besides a local variety for leaf nutritional status and bio-assay studies with the silkworm race „Bulu polu’. All the four varieties namely Catteneo, Burmese2, Tsukasakhu and Local were fairly good in crude protein. Tsukasakhu and the local had the maximum amount of starch and total carbohydrates. Local had less soluble sugars than Catteneo and Burmese2 was the poorest in soluble sugars whereas Tsukasakhu had highest soluble sugars. Burmese2 had the maximum amount of mineral content followed by Catteneo whereas the Local had the least. Similar findings are reported in different mulberry varieties by other workers (Tikku, 1998; Mallikarjunappa et al.,2000b). Mulberry leaves contain plenty of carbohydrates which are converted and stored in the silkworm mainly as glycogen and part of carbohydrates content of mulberry leaves is used for physiological combustion fig.5.2.1.4.

The highest nitrogen content in the leaf was recorded in V1 (3.75%) followed by K2 (3.61%) and MR2 (3.59%) whereas the lowest was recorded S13 (3.52 %). The maximum nitrogen content in the leaf was recorded in
summer (3.76%) followed by winter (3.71%) and the minimum was recorded in rainy (3.39%). Among the varieties V1 showed significantly higher levels of value than other varieties. Sujathamma and Dandin (2000) while evaluating the leaf quality in different mulberry genotypes found maximum moisture content in TR10 (76.94%) and total nitrogen content in TG (23.58%) confirming the varietal differences due to quality parameters. Seasonal differences in the nutrient content is attributed due to light intensity which was higher during summer compared to winter and rainy season fig.5.2.1.5.

The highest phosphorus content in leaf was recorded in K2 (0.37%) followed by MR2 (0.33%) and S13 (0.31%) and the lowest was recorded in V1 (0.31%). The highest phosphorus content in the leaf was recorded in rainy season (0.38%) followed by winter (0.33%) and the lowest was recorded in summer (0.27%). Among the varieties K2 showed significantly higher level of values than other varieties. Similar results recording varietal differences in seven mulberry genotypes viz., SKM20, SKM27, SKM33, SKM36, SKM48, Goshoerami and Ichinose have been reported (Khan et al., 2007). Variety Ichinose excelled in all twelve evaluation parameters viz., nitrogen, phosphorus, calcium, sulphur, magnesium, moisture and moisture retention percentage, yield/10000 larvae by weight, cocoon weight, cocoon shell weight, cocoon shell percentage and filament length studied, followed by Goshoerami which ranked first in eleven parameters followed by SKM27, SKM48 occupied 3rd and 4th rank as their performance was outstanding in 10 and 7 parameters respectively fig.5.2.1.6.

The highest potassium content in the leaf was recorded in V1 (1.92%) followed by S13 (1.86%) and MR2 and the lowest was recorded in K2 (1.493). The highest potassium content in the leaf was recorded in winter (1.83%) followed by summer (1.77%) and the lowest was recorded in rainy season (1.62 %). Among the varieties V1 showed significantly highest level of values than other varieties. Potassium is a key nutrient in maintaining mulberry leaf quality (Radha et al., 1985) and that moisture content of leaf, increases or decreases
proportionately with potassium content of leaf. Similar finding are reported earlier by Shankar (1990); Puttaswamy (1993); Shankar (1997) and Nagaraju (1997) who found that the increased levels of potassium in leaf resulted in increase nitrogen, crude protein, chlorophyll and moisture content of the leaf under rainfed and irrigated conditions. The intake of nutrients is influenced by season since higher transpiration pull during winter and summer season helps plant to increase the available nutrients fig.5.2.1.7.

The maximum larval weight was recorded in V1 (44.75 g) followed by S13 (42.01 g) and MR2 (40.21 g) and the minimum was recorded in K2 (37.35 g). The maximum larval weight was recorded in winter (43.06 g) followed by (40.67 g) in summer and the minimum was recorded in rainy season (39.505 g). Among the varieties V1 showed significantly higher level of values than other varieties. The present result corroborates with the findings of Thangamani and Vivekanandanan (1984) who reported that the leaves of different mulberry genotypes have significant influence on the growth and development of silkworm and cocoon production. Chaluvachari and Bongale (1995) evaluated ten tropical varieties of mulberry along with four varieties of temperate origin from germplasm bank for the leaf chemical analysis and bioassay moulting test during two seasons, rainy and summer. The results indicated that rainy season recorded significantly higher values of larval duration and larval weight associated with higher value of leaf nitrogen, protein and sugar content. On the other hand, summer season recorded lower values of larval duration and larval weight and was associated with lower values of leaf nitrogen, protein and sugar content. Similar results are reported by Narayananprakash et al. (1985) who observed that significant increase in the larval weight of silkworm with the increase in leaf moisture content fig.5.2.2.1.

The highest ERR by number and by weight (9566 & 16.507kg) was recorded in V1 followed by S13 (9273 & 15.200 kg) and MR2 (9226 & 14.753 kg) and the lowest was recorded in K2 (8940 & 13.227 kg). The highest ERR
by number and by weight was recorded in winter followed by summer and lowest was recorded in rainy. The present result corroborates with the findings of Chengalarayappa and Chinnaswamy (1999) who studied the performance of three mulberry varieties S54, M5 and Mysore local. Leaves of these varieties were fed in different feeding sequences to three silkworm breeds viz., NB4D2, NB18 and Pure Mysore starting from brushing to ripening of worms and their effect on growth and development of silkworm larvae were recorded. The results revealed that, highest larval weight (308.90 g/100 larvae) and effective rate of rearing (86%) were observed in S54 and Mysore local feeding sequence. While lowest larval weight (299.78 g/100 larvae) and effective rate of rearing (76.26%) were recorded when fed with the leaves of Mysore local variety. Feeding of M5 variety to chawkie worms and Mysore local to late age worms supported for better growth and development of all the silkworm breed tested. Similar findings were reported by Satyanarayana (2000), Datta et al. (2001) and Dandin et al. (2003). This may be due to enhanced nutrition and keeping quality of V1 leaves which remained fresh for longer time in the rearing bed and increasing its palatability. The result indicated that the highest ERR by number and weight was recorded during winter season (9775;15.685kg) followed by summer (9250;15.020 kg) and the lowest was recorded in rainy season (8739;14.060 kg) fig.5.2.2.2 & 5.2.2.3.

The highest single cocoon weight was recorded in V1 (1.678g) followed by S13 (1.611 g) and MR2 (1.545 g ) and lowest was recorded in K2 (1.457g). Among the varieties V1 showed significantly higher level of values than other varieties. The present result falls in line with Satyanarayana (2000); Masilamani et al. (2006) who have reported that V1 performs better than other popular varieties due to higher values of nutrients contents and moisture retention capacity. The highest cocoon weight was recorded in winter (1.693 g) followed by rainy (1.559 g) whereas the lowest was recorded in summer (1.467 g). Among seasons highest cocoon weight was recorded in winter than in other seasons. Bhargava et al. (1993) reported higher cocoon weight (1.77 g) in spring over summer (1.68 g) in NB4D2. The results of this study also revealed
that optimum cocoon weight can be achieved during winter. Govindan et al. (1987) observed that the cocoon weight obtained with mulberry variety S41 and S54 was higher than with variety S36. Bheemanna (1988) studied the seasonal performance of mulberry varieties and found S 41 and S 36 were very much suitable for winter season rearing and Kanva-2 for summer, S54 for both summer and rainy season, and Mysore local for rainy season and winter similar results are inconfirmity with Maribashetty (1991); Kalpana (1992) and Das and Vijayaraghavan (1992). These results support present findings wherein too winter season was in general favoured the performance of silkworm breed CSR2 fig. 5.2.2.4.

The maximum single shell weight was recorded in V1 (0.37 g) followed by S13 (0.35 g) and MR2 (0.33 g) and the minimum was recorded in K2 (0.31g). Among the varieties V1 showed significantly higher level of values than other varieties. These results fall in line with those reported by Masilamani et al. (2000b) wherein V1 mulberry genotypes in the hilly areas of Tamil Nadu recorded high leaf yield (10,404 kg/ha/ crop) than other varieties namely TR4, TR10 and MR2 and also ranked first in silkworm rearing performance with higher single cocoon weight (2.22 cg), shell weight (0.55 cg) and shell ratio (24.72%). Venkatesha and Rayer (2003) also reported that among mulberry varieties V1 supported different bivoltine with higher shell weight. The maximum shell weight was recorded in winter (0.37 g) followed by rainy (0.33 g) and the minimum was recorded in summer (0.32 g). The present results are in confirmation with the works of Bhargava et al. (1993); Suresh kumar et al. (2003) and Maqbool et al. (2005) fig.5.2.2.5.

The shell ratio recorded was highest in V1 (22.2%) followed by S13 (22.0%) and MR2 (21.9%) and the lowest in K2 (21.3%). The maximum shell ratio was recorded in winter (22.2 %) followed by summer (22.1%) while the minimum was recorded in rainy (21.1 %). These results corroborate with the findings of Chakravarthy et al. (2003). The performance of all parameters studied was superior during winter season this may be due to better leaf quality
as reported by Pillai and Jolly (1985). Similar findings were reported by Nazia Choudhary and Ravindrasingh (2006) who evaluated six polyvoltine breeds viz., BL67, BL68, 96A, 96E, 96H and PM, and six bivoltine silkworm breeds viz., CSR2, CSR3, CSR4, CSR12, CSR17 and NB4D2 in two different seasons i.e., during March- April and May –September for seven rearing parameters and confirmed that all the rearing and grainage parameters like fecundity, hatching percentage, pupation rate, yield/ 10000 larvae, cocoon weight, cocoon shell weight and cocoon shell percentage were superior during winter season as against summer. Tikader and Qadri (2009) who assessed the leaf quality of selected mulberry germplasm accession including checks V1 and Kosen using commercial bivoltine hybrid silkworm (CSR2 x CSR4) based on 8 economically traits viz., weight of 10 matured larvae, fifth age larval duration, pupation rate, cocoon yield by number and weight, single cocoon weight, single shell weight and shell percentage in different seasons and reported that significant variation existed for all rearing traits except silk percentage due to both mulberry genotypes and season significantly fig.5.2.2.6.

Pupation is an important rearing parameter which indicates the quality of cocoons. The highest pupation rate was recorded in V1 (95.6%) followed by S13 (92.7%) and MR2 (92.2%) and the lowest in K2 (89.4%). The maximum pupation rate was recorded in winter (97.7%) followed by summer (92.5%) while minimum in rainy (87.2%).The trend observed in the present study in respect of pupation rate is similar of that of other traits like shell weight, shell percentage, cocoon weight etc owing to the reasons already discussed in previous paras fig.5.2.2.7.

The highest silk gland weight was recorded in V1 (1.466 g) followed by S13 (1.367 g) and MR2 (1.357 g) and the lowest weight was recorded in K2 (1.197 g). Among the varieties V1 showed significantly higher level of values than other varieties. The maximum silk gland weight was recorded in winter (1.424 g) followed by summer (1.337 g) where as in minimum weight was recorded in rainy (1.279 g). The present result corroborates with the findings of
Koul et al. (1979) who investigated the varieties of mulberry for comparing their performance with regard to increase in larval body weight, silk gland weight and silk production. Similar findings have also been reported by Mathavan et al. (1984) and Gridhar et al. (1991). These findings are follow similar trend as observed in other economic traits of silkworm as discussed above. This could be attributed to the highest amount of protein content leaf in V1 particularly during winter season which in turn could increase the weight of silk gland.

The highest silk productivity of g / larva was recorded in V1 (0.056) followed by S13 (0.055) and MR2 (0.052) and the lowest silk productivity was recorded in K2 (0.048). The highest silk productivity was recorded in winter and summer (0.054) and the lowest silk productivity in rainy (0.051). Among the varieties V1 showed significantly higher level of values than other varieties. V1 performed well in all seasons with respect to silk productivity. This is attributed to superior leaf quality both in terms of nutrients and moisture contents during winter season. Similar results were reported by Venkatesha and Rayer (2003) with highest silk productivity in both the seasons, winter and summer. It is in agreement with the findings of Pillai and Jolly (1985).

The highest amount of food consumed was recorded in S13 (2.648 g) followed by V1 (2.541 g) and MR2 (2.358 g) and the lowest was recorded in K2 (2.253 g). The highest food consumption was recorded in winter (2.816 g) followed by rainy (2.391 g) and the lowest was recorded in summer (2.143 g). Among the varieties V1 showed significantly higher level of values than other varieties. The present results are supported with the findings of Dhar et al. (1988) who evaluated three improved Japanese cultivars of mulberry namely Ichinose, Goshoerami and Kokuso-27 for nutritional potential through feeding experiments and observed varietal difference in their performance with regard to consumption index and efficiency of conversion of ingested and digested food into body matter. The feeding on Ichinose leaves resulted in higher weight of mature larvae and improvement in economic traits of cocoons such
as cocoon and shell weights and silk percentage as compared to other two varieties. It could be explained on account of enhanced digestability due to higher protease and lipase activities corresponding to enhanced food intake (Trichilo and Mack, 1988; Snood et al. 1993) fig. 5.4.1.

The highest amount of food digested was recorded in V1 (0.981 g) followed by S13 (0.938 g) and MR2 (0.737 g) and the lowest amount of food digested was recorded in K2 (0.698 g). The highest amount of food digested was recorded in winter (1.114 g) followed by summer (0.729 g) and the lowest was recorded in rainy (0.671 g). Among the varieties V1 showed the higher level of values than other varieties. Similar type of varietal differences have been reported by Anantharaman et al. (1995 b) who studied that the effect of season and mulberry varieties on the feed conversion efficiency of different silkworm hybrids of B. mori L. and the productivity. They have reported S36 and S13 mulberry varieties to be superior over the other test varieties. Reddy (1981) also reported similar trend in other varieties studied by him. Yamamoto and Fujimaki (1982) and Aftab Ahamad (1994) reported that the dietary water content influences the metabolic activities related to food consumption, digestion and utilization. This could be one of the reason for superior performance of variety compared to others. Since the digestability differs in different breeds, the proportion of food intake and production of faecal matter also varied (Ramadevi et al., 1992). Excreta values progressively increased as growth advances and the production of excreta depends on availability of food, rate of food intake and absorption and also retention time of food in the gut. Superior quality of leaves with higher water content in the feed, has a direct regulation on the phagostimulation, digestion and efficiency of conversion (Paul et al., 1992; Rahmathulla et al., 2004). This very fact also explains the superiority of variety V1 studied herein for all the parameters related to CSR2 rearing and grainage fig. 5.4.2.

The approximate digestability defined as how much of ingested food was actually digested. The maximum approximate digestability was noticed in
V1 (38.00 %) followed by S13 (35.59 %) and MR2 (31.19 %) where as it was minimum in K2 (30.88 %). The highest amount of approximate digestability was recorded in winter (39.19 %) followed by summer (34.35 %) and the lowest was recorded in rainy (28.21 %). Among the varieties V1 showed significantly higher level of values than other varieties. The present results corroborate with the findings of Magadum et al. (1996). Similar findings have also been reported by Gokulamma and Srinivasa Reddy (2005) who found that consumption and absorption was high in V1 compared to S36 and M5 varieties fig.5.4.3.

The reference ratio is an indirect expression of absorption and assimilation of food. The highest amount of reference ratio was recorded in S13 (1.576) followed by V1 (1.517) and MR2 (1.467) whereas the lowest was recorded in K2 (1.451). The maximum amount of reference ratio was recorded in winter (1.658) followed by summer (1.453) whereas minimum in rainy season (1.398). Among the varieties S13 showed significantly higher level of values than the other varieties. The present result thus corroborates with the findings of Anantharaman et al. (1993; 1994; 1995) who found that the reference ratio in feed utilization studies was influenced by the mulberry varieties and season and that the efficiency of converting the ingested and digested food in to body weight, cocoon with cocoon shell and ECI and ECD larvae varied when silkworms were fed with different varieties of mulberry leaves fig.5.4.4.

The consumption index also referred to as feeding rate at which nutrients enter into digestive system. The highest consumption index was recorded in K2 (0.733) followed by MR2 (0.716) and S13 (0.709) and where as the lowest consumption index was recorded in V1 (0.674). The highest consumption index was noticed in summer (0.750) followed by winter (0.713) and the lowest was noticed in rainy (0.661). Kanika Trivedi and Sashindran Nair (1999) reported that a significant variation existed in consumption index in different varieties and a variety is considered efficient if its consumption
index is minimum. This explains superior economic traits of test breed CSR2 studied here in when reared on variety V1 fig. 5.4.5.

The efficiency of conversion of ingested food (ECI) is over all measure of the ability of larvae to utilize the ingested food and convert to larval body matter. The highest efficiency of conversion of ingested food into body matter by larvae was recorded in V1 (24.259) followed by MR2 (21.650) and S13 (21.380) and the lowest in K2 (20.842). The maximum ECI was recorded in summer (23.048) followed by winter (21.996) and the minimum was recorded in rainy (21.060). Among the varieties V1 showed significantly higher level of values than the other varieties. The present results is in agreement with the findings of Ramadevi et al. (1992); Kanika Trivedi and Sashindran Nair (1999) who reported that all the improved silkworm hybrids were more efficient in converting the food into body matter. Present results are also supported with the findings of Chakravorthy et al. (2003) who reported that ECI and ECD was highest on V1 compared to other 13 improved varieties tested fig. 5.4.6.

The maximum efficiency of conversion of digested food (ECD) into body matter was recorded in MR2 (71.430) followed by K2 (68.926) and V1 (66.259) whereas minimum in S13 (61.372). The maximum efficiency of conversion of digested food into body matter was recorded in rainy (75.512) season followed by summer (68.607) and minimum in winter (56.971) season. Among the varieties MR2 showed significantly higher level of values than the other varieties. The present results are in agreement with the findings Chakravorthy et al. (2003) who reported that ECD was highest in V1 during spring and autumn seasons compared to other varieties. Gokulamma and Srinivasa Reddy (2005) have also reported similar findings confirming those observed in present study fig. 5.4.7.

The highest efficiency in converting the ingested food to cocoon was recorded in MR2 (29.170) followed by V1 (28.255) and S13 (27.680) and the lowest was recorded in K2 (26.446). The maximum efficiency in converting the ingested food to cocoon was recorded in summer (29.004) followed by rainy
(27.504) and minimum in winter (27.155). Among the varieties MR2 showed significantly higher level of values than the other varieties. Rahmathulla et al. (2002) reported that leaf–silk conversion (ECI and ECD to shell) rate is composed of three basic factors viz., digestibility, the ratio of transforming digested food to cocoon and shell ratio. Highly significant variation of ECI to cocoon percentage was observed in three CSR hybrids under different environmental conditions fig.5.4.8.

The highest efficiency in converting the digested food to cocoon was recorded in MR2 (97.031) followed by K2 (86.699) and V1 (80.394) and the lowest in S13 (79.476). The maximum efficiency of converting the digested food to cocoon was recorded in rainy (100.326) followed by summer (86.395) and minimum efficiency was recorded in winter (70.979). Among the varieties MR2 showed significantly higher level of values than the other varieties. Mathur et al. (2002) while studying the food consumption and conversion efficiency of new bivoltine hybrids have reported that nutritional efficiency parameters i.e ECI percentage and ECD percentage to cocoon and shell were significantly higher under stress feeding. The increase may be attributed to the physiological adaptations of silkworm under stress condition which explains higher values during summer season fig.5.4.9.

The highest efficiency of conversion of the ingested food to shell was recorded in V1 (14.142) followed by MR2 (12.630) and S13 (12.463) and the lowest was recorded in K2 (12.264). The maximum efficiency of converting the ingested food to shell was recorded in summer (13.868) followed by rainy (12.457) and minimum was recorded in winter (12.300). Among the varieties V1 showed significantly higher level of values than the other varieties. The present results could be related to the work of Deb et al. (2000) who investigated the consumption and conversion efficiencies of dry matter of mulberry leaves with different amounts of water into cocoon and shell by the fifth instar larvae of the multivoltine. Nistari race of B. mori during the adverse wet part of summer and found that the quantity of the food ingested and
digested increased with the increase in foliar water. Further weight of cocoon and the percentage of efficiency of conversion of ingested food (ECI percentage) and efficiency of conversion of digested food (ECD percentage) for cocoon increased with the increasing percentage of moisture fig.5.4.10.

The highest efficiency of converting the digested food to shell was recorded in MR2 (41.717) followed by K2 (40.411) and V1 (39.067) and the lowest was recorded in S13 (36.030). The maximum efficiency of converting the digested food to shell was recorded in rainy (44.512) followed by summer (41.535) and minimum in winter (31.872). Among the varieties MR2 showed significantly higher levels of values than the other varieties. Manimegalai and Aruna (2010) however reported that double hybrids exhibited significantly better growth indices and also better efficiency of conversion of digested food irrespective of season throughout the year on different varieties of viz.V1, S36 and MR2 of mulberry. This could be due to higher hybrid vigour expressed in hybrids as against pure breed CSR2 studied here which lacks hybrid vigour fig.5.4.11.

The highest ingesta per gram of cocoon was recorded in K2 (3.814) followed by S13 (3.724) and V1 (3.664) whereas the lowest was recorded in MR2 (3.436). Conversely highest digesta per gram of cocoon was recorded in variety V1 (1.357) followed by S13 (1.331) and K2 (1.175). The maximum ingesta per gram of cocoon was recorded in winter (3.758) followed by rainy (3.665) whereas minimum in summer (3.556). However the trend for digesta per gram cocoon was similar with highest value of 1.485 in winter but lowest value recorded in rainy. Lower ingesta and digesta required for producing a gram of body cocoon and cocoon shell is due to its efficiency in converting the feeds, which depends on the genotypic characters and its interaction with the biotic and abiotic factors (Anantharaman et al., 1994) fig.5.4.12 & 5.4.13.

The highest digesta per gram of shell was recorded in mulberry variety S13 (2.909) followed by V1 (2.829) and K2 (2.562) whereas the lowest in MR2 (2.502). The maximum digesta per gram of shell was in winter (3.276) followed
by summer (2.553) whereas the minimum was in rainy (2.274). Among the varieties S13 showed significantly higher levels of values than the other varieties. Trivedy and Nair (1999) observed that superior breeds need less ingesta and digesta to produce unit quantity of cocoon and cocoon shell and difference was highly significant when compared to the conventional one. This difference in food utilization capacity is also reflected in silkworm hybrid compared to that of pure breeds (Ramadevi et al., 1992; Benchamin and Jolly, 1984) fig.5.4.14 & 5.4.15.

In summer ingesta, digesta and AD% have been reported to be reduced, (Hidashi et al. 1982, and Sumioka et al. 1982a) due to increased metabolic activity however, efficiency of conversion of ingesta and digesta to larval weight was improved significantly. Muthukrishnan and Pandian (1987) reported that insects have evolved a variety of strategies to acquire and accumulate energy from nutrients and water from the available food in the given condition. However, Datta et al. (1996) reported that the season had no effect as far as food digestability is concerned in silkworms.

Different breeds require different quantum of feed under varied environmental conditions to produce one gram of cocoon and shell weight as reported by earlier workers (Remadevi et al., 1992 Benchamin and Jolly,1984 and Takano and Arai,1978). Rahmathulla et al. (2002) concluded that all the breeds during optimum temperature and humidity exhibit better nutritional indices. For the production of unit cocoon quantity and shell weight, required quantum of ingesta and digesta plays a vital role in economics of silkworm rearing since these two are directly and proximately related. Production of a given quantity of cocoon and shell with reduced ingesta is the need of the hour in the present day sericulture scenario.

Overall results of the present study discussed above therefore clearly brought out that the performance of V1 variety in terms of grainage parameters, rearing performances and feed conversion aspects with regard to CSR2 breed has been superior most compared to the other mulberry varieties evaluated.
namely, S13, MR2 and K2. The seasonal influence was also quite visible with most favourable results observed during the winter season followed by summer and rainy reason.
Fig. 5.1.1

Influence of varieties and seasons on weight of male pupae of CSR2

![Bar graph showing weight of male pupae across different varieties and seasons.]

Fig. 5.1.2

Influence of varieties and seasons on weight of female pupae of CSR2

![Bar graph showing weight of female pupae across different varieties and seasons.]

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Fig. 5.1.3

Influence of varieties and seasons on weight of male moth of CSR2

Fig. 5.1.4

Influence of varieties and seasons on weight of female moth of CSR2
Fig. 5.1.5

Influence of varieties and seasons on fecundity of CSR2

Fig. 5.1.6

Influence of varieties and seasons on hatchability of CSR2
Fig. 5.1.7

Influence of varieties and seasons on leaf: egg recovery ratio of CSR2

![Graph showing egg recovery ratio of CSR2 across varieties and seasons.](image)

Fig. 5.2.1.1

Influence of varieties and seasons on moisture content in leaf of CSR2

![Graph showing moisture content across varieties and seasons.](image)
Influence of varieties and seasons on moisture retention content in leaf of CSR2

Fig. 5.2.1.2

Influence of varieties and seasons on total soluble protein content in leaf of CSR2

Fig. 5.2.1.3
Fig. 5.2.1.4

Influence of varieties and seasons on total soluble sugar content in leaf of CSR2

![Bar Chart]

Fig. 5.2.1.5

Influence of varieties and seasons on nitrogen content in leaf of CSR2

![Bar Chart]
Influence of varieties and seasons on phosphorus content in leaf of CSR2

Fig. 5.2.1.6

Influence of varieties and seasons on potassium content in leaf of CSR2

Fig. 5.2.1.7
Fig. 5.2.2.1

Influence of varieties and seasons on weight of 10 matured larvae of CSR2

![Bar chart showing weight (g) of 10 matured larvae across different varieties and seasons.]

Fig. 5.2.2.2

Influence of varieties and seasons on effective rate of rearing by number of CSR2

![Bar chart showing numbers of larvae reared across different varieties and seasons.]

Varieties:
- V1
- S13
- K2
- MR2

Seasons:
- Summer
- Rainy
- Winter
Fig. 5.2.2.3

Influence of varieties and seasons on effective rate of rearing by weight of CSR2

![Graph showing weight (kg) for different varieties and seasons.]

Fig. 5.2.2.4

Influence of varieties and seasons on cocoon weight of CSR2

![Graph showing weight (g) for different varieties and seasons.]

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Fig. 5.2.2.5

Influence of varieties and seasons on shell weight of CSR2

![Graph showing weight (g) of shells for different varieties and seasons.]

Fig. 5.2.2.6

Influence of varieties and seasons on shell ratio of CSR2

![Graph showing percentage (%) of shells for different varieties and seasons.]
Fig. 5.2.2.7

Influence of varieties and seasons on pupation rate of CSR2

![Bar chart showing the percentage of pupation rate across varieties and seasons.]

Fig. 5.2.2.8

Influence of varieties and seasons on leaf:cocoon ratio of CSR2

![Bar chart showing the ratio of leaf:cocoon across varieties and seasons.]

Varieties: V1, S13, K2, MR2

Seasons: Summer, Rainy, Winter
Fig. 5.3.1

Influence of varieties and seasons on silk gland weight of CSR2

![Bar chart showing the influence of varieties and seasons on silk gland weight of CSR2.]

Fig. 5.3.2

Influence of varieties and seasons on silk productivity of CSR2

![Bar chart showing the influence of varieties and seasons on silk productivity of CSR2.]

Varieties: V1, S13, K2, MR2
Seasons: Summer, Rainy, Winter
Fig. 5.4.1

Influence of varieties and seasons on ingesta of CSR2

![Bar chart showing the influence of varieties and seasons on ingesta of CSR2.](chart1)

Fig. 5.4.2

Influence of varieties and seasons on digesta of CSR2

![Bar chart showing the influence of varieties and seasons on digesta of CSR2.](chart2)
Influence of varieties and seasons on approximate digestability of CSR2

![Graph showing the influence of varieties and seasons on approximate digestability of CSR2.](image)

Influence of varieties and seasons on reference ratio of CSR2

![Graph showing the influence of varieties and seasons on reference ratio of CSR2.](image)
Fig. 5.4.5

Influence of varieties and seasons on consumption index of CSR2

![Bar chart showing consumption index for different varieties and seasons.]

Fig. 5.4.6

Influence of varieties and seasons on efficiency of conversion of ingesta to larvae of CSR2

![Bar chart showing efficiency of conversion for different varieties and seasons.]

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Fig. 5.4.7
Influence of varieties and seasons on efficiency of conversion of digesta to larvae of CSR2

Fig. 5.4.8
Influence of varieties and seasons on efficiency of conversion of ingesta to cocoon of CSR2
Fig. 5.4.9

Influence of varieties and seasons on efficiency of conversion of digesta to cocoon of CSR2

![Graph showing percentage efficiency for different varieties and seasons.]

Fig. 5.4.10

Influence of varieties and seasons on efficiency of conversion of ingesta to shell of CSR2

![Graph showing percentage efficiency for different varieties and seasons.]

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Fig. 5.4.11

Influence of varieties and seasons on efficiency of conversion of digesta to shell of CSR2

![Bar chart showing the influence of varieties and seasons on efficiency of conversion of digesta to shell of CSR2.](chart1.png)

Fig. 5.4.12

Influence of varieties and seasons on ingesta per gram of cocoon of CSR2

![Bar chart showing the influence of varieties and seasons on ingesta per gram of cocoon of CSR2.](chart2.png)